START MAR 1988

R.D. STENNER

NPL CANDIDATE

Update #

Received: SEP 1 4 1987

Facility name: U.S. DOE Hanford 1100 Area

Location: Hanford Site, Benton County, Washington

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: 8-12-87

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 1100 Area contains a sand pit west of the 1171 Building that was used for disposal of waste battery acid and a 5000-gallon underground tank in the 1171 Building that was used to dispose of waste antifreeze. The 1171 Building is part of the maintenance operation facility that is located adjacent to the Richland City limits. The groundwater route is the route of major concern for the sites in the 1100 Area. Upon examining the SE/4 Richland Quadrangle Map, no overland route can be found to the nearest surface water. Also, the sources in the 1100 Area are covered sites that would not lend themselves to the dispersing of contaminants directly to a surface water via an overland route. Thus, the surface water route was not evaluated.

Scores: $S_M = 36.34$ ($S_{gw} = 62.86$ $S_{sw} = 0.00$ $S_a = 0.00$)

S_{FE} = NA

S_{OC} = NA

QA 12/30/87 Kathleen Hallory

FIGURE 1
HRS COVER SHEET

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National Priorities List

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

HANFORD 1100-AREA (USDOE)
Benton County, Washington

The Hanford 1100-Area is approximately 1 mile north of the City of Richland, Benton County, Washington, in the southeast section of the 570-square-mile Hanford Site. 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) conducts maintenance operations in the 1100-Area. The area covers less than 1 acre and contains a sand pit, an underground tank, and other areas of potential contamination. An estimated 15,000 gallons of waste battery acid were disposed of in the pit; the tank, which was used to store waste antifreeze, was suspected of leaking.

Ground water occurs at 24 feet, with highly permeable sand and gravel overlying the aquifer; these conditions facilitate movement of contaminants into ground water. To date, USDOE has not detected any contaminants in ground water in the 1100-Area. Richland has wells within 3 miles of the 1100-Area that draw drinking water from the shallow aquifer. The nearest well is 2,640 feet from the disposal area. Almost 70,000 people obtain drinking water from wells within 3 miles of the 1100-Area.

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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Scores: $S_M = 36.34$ ($S_{gw} = 62.86$ $S_{sw} = 0.00$ $S_a = 0.00$)

S_{FE} = NA

S_{DC} = NA

QA 12/30/87 Kathleen Holloway

FIGURE 1
HRS COVER SHEET

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HRS Ground Water Route Work Sheet

Site: U.S. DOE Hanford 1100 Area 8/12/87

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	0	1	0	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.

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
2. Route Characteristics					3.2
Depth to Aquifer of Concern	3	2	6	6	
Net Precipitation	1	1	1	3	
Permeability of the Unsaturated Zone	3	1	3	3	
Physical State	3	1	3	3	
Total Route Characteristics Score			13	15	
3. Containment	3	1	3	3	3.3
4. Waste Characteristics Chemical					3.4
a. Toxicity/Persistence	18	1	18	18	
Hazardous Waste Quantity	3	1	3	8	
Total Waste Characteristics Score			21	26	
5. Targets					3.5
Ground Water Use	3	3	9	9	
Distance to Nearest Well/ Population Served	35	1	35	40	
Total Targets Score			44	59	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)			36036	57330	
7. Line 6/57330 * 100	Sc(gw)= 62.86				

12/30/87

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HRS Surface Water Route Work Sheet

ROUTE NOT SCORED

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	0	1	0	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	0	1	0	18	
Hazardous Waste Quantity	0	1	0	8	
Total Waste Characteristics Score			0	26	
5. Targets					4.5
Surface Water Use	0	3	0	9	
Distance to a Sensitive Environment	0	2	0	6	
Population Served/Distance to Water Intake Downstream	0	1	0	40	
Total Targets Score			0	55	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)			0	64350	
7. Line 6/64350 * 100 Sc(sw)= 0.00					

12/30/87
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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.

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
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

12/30/87
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	S	S^2
Groundwater Route Score (S_{gw})	62.86	3951.37
Surface Water Route Score (S_{gw})	0.00	0.00
Air Route Score (S_a)	0.00	0.00
$S_{gw}^2 + S_{sw}^2 + S_a^2$	-	3951.02
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$	-	62.86
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$ / 1.73 = S_M =	-	36.34

FIGURE 10
WORKSHEET FOR COMPUTING S_M

12/30/87
KCA

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 1100 Area

LOCATION: Hanford Site, Benton County, Washington

DATE SCORED: 8-12-87

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 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.

COMMENTS OR QUALIFICATIONS:

The surface-water route was not scored because the sources in the 1100 Area are covered sites that would not lend themselves to the dispersing of contaminants directly to a surface water via an overland route. Also, there is no viable route to the river that liquid contaminants could use in migrating over land from the site.

QA 12/30/87 Kathe Galloway

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GROUND WATER ROUTE

1 OBSERVED RELEASE

No information was found to indicate that any measurements of ground-water contamination by hazardous substances sufficient for HRS purposes have been made at or in the vicinity of the site.

Contaminants detected (5 maximum):

Not applicable.

Rationale for attributing the contaminants to the facility:

Not applicable.

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifer(s) of concern:

The aquifer of concern is the unconfined aquifer which is comprised of the glacio fluvial sediments of the Hanford formation and the lake deposits of the Ringold formation. It generally slopes downward from west to east; depth to ground water is from 10 to 15 meters (34 to 48 feet). 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 approximately 43 m in this area of the Hanford Site and pinches out along the flanks of the basalt anticlines.

Recharge to the unconfined aquifer originates from several sources. 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 recharge from precipitation directly on the Hanford Site because of a high rate of evapotranspiration under native soil and vegetation conditions. Large scale artificial recharge occurs from offsite agricultural irrigation and liquid-waste disposal in the operating areas at Hanford.

12/30/87

Underlying the surface sands is a mixture of sand and gravel extending to a depth of about 40-60 meters. Basaltic rock starts at that depth and extends downward over 1.9 miles (3000 meters).

Reference 1, page 2.5; Reference 15; Reference 16

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

Using Well 3000-D, which is approximately 1/2 of a mile (2640 feet) away, the depth from ground surface to highest seasonal level is 24 feet. Well 3000-D is one of the Richland City Recharge wells. Information on these wells was obtained directly from the Richland City Engineer.

Reference 2; Reference 3; Reference 12 ; Reference 15

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

The depth from the ground surface to lowest point of the waste disposal is 10 feet. This depth is based on the depth of the battery acid pit near the 1171 Building (approximately 12-foot diameter, 10 feet deep) which is filled with sand and river rock. This results in 14 feet for the depth to aquifer of concern (24 feet - 10 feet = 14 feet).

Reference 4; Reference 12

12/30/87

Net Precipitation

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

The seasonal (November-April) precipitation for the area is 6.52 inches.

Reference 5

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

The mean annual lake evaporation equals 40 inches; however, it would be more conservative to use a seasonal evaporation period of November - April for sites in Eastern Washington. The adjusted seasonal lake evaporation is equal to 20% of the 40 inches, which is equal to 8 inches.

Reference 5

Net precipitation (subtract the above figures):

6.52 inches minus 8.00 inches = -1.48 inches

Reference 6, page 788

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

The surface geology of the site is characterized by a surface layer of light brown, fine, slightly silty, wind-deposited sand, sparsely covered by vegetation. Underlying the surface sands is a mixture of sand and gravel extending to a depth of about 200 feet (60 meters). Basaltic rock starts at that depth and extends downward over 1.9 miles (3000 meters).

Reference 7, pages 2.1-2.3

Permeability associated with soil type:

Using Table 2 of 40 CFR 300 Appendix A, the permeability of a sand and gravel mixture results in a value of greater than 10^{-3} cm/sec.

Reference 6, page 789

Physical State

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

Liquid battery acid associated with batteries retired from service was poured into the battery acid pit, and liquid antifreeze (ethylene glycol) was poured into the waste storage tank for disposal purposes.

Reference 4; Reference 8, Site No. UPR-1100-4 and UPR-1100-1

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3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Liquid battery acid was disposed of in an unlined disposal pit that had sand and gravel placed in the bottom, and used antifreeze (ethylene glycol) was disposed of in a large tank that is suspected to have leaked directly to the ground underneath.

Reference 4; Reference 8, Site No. UPR-1100-4 and UPR-1100-1

Method with highest score:

A containment value of 3 was assigned to the disposal pit because it was unlined. A containment value greater than zero was assigned to the large tank because it had no liner underneath.

Reference 6, page 794

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:

The constituents associated with the 1100 area site are sulfuric acid, lead and ethylene glycol. The sulfuric acid and lead are from the battery acid pit and the ethylene glycol is from the waste antifreeze storage tank. The battery acid pit received waste electrolyte from old storage batteries. A storage battery is constructed of alternate plates of spongy lead and lead dioxide, separated by wood or glass fiber spacers, and immersed in an electrolyte, an aqueous solution of sulfuric acid.

Reference 4; Reference 8, Site No. UPR-1100-4 and UPR-1100-1; Reference 14, page 419.

Compound with highest score:

Lead has a score of 18 which is the highest. Sulfuric Acid and ethylene glycol both have a score of 9.

Substance	Toxicity Score	Persistence Score	TOTAL Score
Lead	3	3	18
Sulfuric Acid	3	0	9
Ethylene Glycol	2	1	9

Reference 6, pages 794-797

12/30/87

The total quantity of hazardous substances associated with the 1100 Area is made up from the quantities of hazardous substance in the 1171 Building Battery Acid Pit and the 1171 Building Waste Antifreeze Tank. The following table shows the breakdown of these wastes.

Site	Waste Type	Years	Estimated Volume	No. of Cubic Yards	Reference
1171 Battery Acid Pit	Waste battery acid containing lead	1957-1976	15,134 gal	74.9	Ref. 4
1171 Waste Antifreeze Storage Tank	Waste antifreeze (ethylene glycol)		5,000 gal (max. capacity of the tank)	24.8	Ref. 8
				99.7	

Basis of estimating and/or computing waste quantity:

The total quantity of waste for the 1100 Area comes from the aggregation of the quantity of waste battery acid disposed in the battery acid pit located just west of the 1171 Building and the 5000-gallon waste antifreeze tank located in the 1171 Building. The quantity of waste battery acid disposed was estimated by personnel responsible for operation of the site. It was estimated by reviewing equipment files and battery procurements to establish an annual usage and then the annual usage was multiplied by the number of years the site was used. The quantity of the waste in the tank containing the waste antifreeze was assumed to be the maximum capacity of the tank.

Reference 4; Reference 8, Site No. UPR-1100-4 and UPR-1100-1

12/30/87

5 TARGETS

Ground Water Use

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

Drinking Water:

The City of Richland drinking water recharge wells are within 3 miles of the site and draw water from the aquifer. There are 14 of these recharge wells having depths that range from 40 feet to 134 feet. The recharge wells are part of the city of Richland's water supply system. These 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 holding ponds then filters through the soil column to the aquifer where it is pumped by the recharge wells to the city's supply system. The water drawn from the recharge wells then becomes mixed with the total water in the Richland system (i.e., water from the river water treatment system) and is distributed through out the city.

Reference 2; Reference 3

Irrigation Water:

The Battelle Farm Operations irrigation well (RRC well located in Section B-3 of Reference 9.1) is within 3 miles of the 1100 Area site.

Reference 3; Reference 9

Distance to Nearest Well

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

The nearest well that draws from the aquifer of concern is the Richland Recharge Well 3000-D.

Reference 2; Reference 3

Distance to above well or building:

The Richland Recharge Well 3000-D is located approximately 1/2 of a mile (2640 feet) from the 1171 building where the two waste sites are located.

Reference 2; Reference 3

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

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

There are 14 Richland recharge wells located within 3 miles of the site that draw water from the aquifer. As discussed above, the recharge wells are used by the city to supplement the water supply during peak periods. The water from the wells is mixed in with the water in the system from the Columbia River and distributed through out the city. Thus, the population of Richland is used for the population served by the wells. Based on the 1980 sensus, the Richland population is 33,578 people.

The population of Kennewick, Washington, is also considered because the Richland City Water Supply System has an emergency water intertie to the Kennewick Water Supply System. The population of Kennewick is 34,387.

The 300 Area worker population is also considered because the 300 Area has an emergency intertie with the Richland City Water System. The population of the 300 Area workers is 3,110 (see page 5b).

The Benton Franklin District Health Department was contacted in an effort to establish the locations of any wells (drawing from the unconfined aquifer) across the Columbia River from the site that might be in the 3-mile range of the site. The total number of wells within the defined 3-mile radius boundary is 5 private dwelling wells. It is estimated that 19 people are served by these private single dwelling wells.

No data were available regarding the depth and screen intervals of these private wells; therefore, the population associated with these wells was not counted in the total.

Reference 2; Reference 10, Figure 4.11, pages 4.32-4.33; Reference 11, page 3; Reference 13.

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

The Battelle (BNW) Farm Operations RRC well, which has a depth of 50 feet, is located within 3 miles of the site. The farm operations draw water from the well and from the river to irrigate the forage crops that are grown. The PNL irrigation operations cover a total of 168 acres. Using the 1.5 people per acre criteria, this results in an affected population of:

(168) (1.5) = 252

Reference 9; Reference 3

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

The total population served is the result of summing the population associated with the city of Richland intake, the across river wells and the estimated population associated with the Battelle Farm Operations irrigation well. The total estimated affected population is:

33,578 + 34,387 + 252 = 68,217

12/30/87 KCP

The 3110 workers in the 300 Area were not added into total population estimate because these workers would be included in the population estimate numbers for the City of Richland and City of Kennewick. This was done to avoid double counting of populations.

12/30/87

SURFACE WATER ROUTE

1 OBSERVED RELEASE

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

The surface-water route was not scored because the sources in the 1100 area are covered sites that would not lend themselves to the dispersing of contaminants directly to a surface water via an overland route. Also, there is no viable overland migration route from these sites to the nearest surface water.

Rationale for attributing the contaminants to the facility:

Not applicable.

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:

Not applicable.

Name/description of nearest down slope surface water:

Not applicable.

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.

Is the facility completely surrounded by areas of higher elevation?

Not applicable.

12/30/87

1-Year 24-Hour Rainfall in Inches

Not applicable.

Distance to Nearest Down slope Surface Water

Not applicable.

Phvsical State of Waste

Not applicable.

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Not applicable.

Method with highest score:

Not applicable.

12/30/87
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4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

Not applicable.

Compound with highest score:

Not applicable.

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):

Not applicable.

Basis of estimating and/or computing waste quantity:

Not applicable.

5 TARGETS

Surface Water Use

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

Not applicable.

12/30/87

Is there tidal influence?

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.

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

Not applicable.

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:

Not applicable.

12/30/87
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Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

Not applicable.

Total population served:

Not applicable.

Name/description of nearest of above water bodies:

Not applicable.

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

Not applicable.

9 2 1 2 2 2 1 3 3 6

12/30/87
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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, not 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

Reactivity and Incompatibility

Most reactive compound:

Not applicable.

Most incompatible pair of compounds:

Not applicable.

12/30/87

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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.

12/30/87

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?

Not applicable.

12/30/87
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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 1100 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER ____________

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
1	Environmental Monitoring at Hanford for 1986, PNL-6120,
	May 1987
2	Personal Communication from Michael Gillum to KH Cramer
	regarding Richland Water System (info, maps and data sheets)
	August 6, 1987
3	U.S.G.S. Maps Showing 1100 Area Surroundings
4	Internal memo from WHC Fleet Maintenance Dept to file about
	waste quality estimates for the 1100 Area Battery Acid Pit,
	August 11, 1987 (R. A. Evanoff)
5	Climatic Atlas of the United States, U.S. Department of
	Commerce, June 1968 (w/EPA Region X info on seasonal
	evaporation)
6	Uncontrolled Hazardous Waste Site Ranking System; A Users
	Manual, 40 CFR 300 Appendix A
7	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, July 1986, Vol. 1
8	Draft Phase 1 Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, Vol. 3
9	Battelle Farm Operation Drawings, RC-486 and RC-1147
10	Disposal of Hanford Defense High-Level, Transuranic and Tank
	Wastes, March 1986, DOE/EIS-0113, Vol. 1
11	Hanford Reservation Area Workers Census, BNWL-2298, July 1977

12/30/87
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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 1100 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
12	Hanford Wells, PNL-5397, February 1985
13	Memo to file from R.D. Stenner Regarding Franklin County
	Drinking Water Wells based on conversation with C.L. Bates
	August 26, 1987
14	General College Chemistry, 4th Edition, C.W. Keenan and
	J.H. Wood, Harper & Row, Publishers
15	Geology and Hydrology of Radioactive Solid Waste Burial
	Grounds at the Hanford Reservation, Washington, USGS 1976
	open file: 075-625
16	Waste Management Operations; ERDA 1538

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9212321391

REFERENCE 1

Environmental Monitoring at Hanford for 1986

PNL-6120, May 1987

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

REFERENCE 2

Personal Communication with Michael Gillum, City of Richland, regarding Richland Water System (info, maps and data sheets)

9212172183 94

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.

509 943-9161

MICHAEL GILLUM
Associate Engineer
Utility Administration Division
Water & Waste Utilities Department

505 SWIFT BOULEVARD BOX 190 RICHLAND WASHINGTON 99352

C I T Y   O F   R I C H L A N D

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

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.

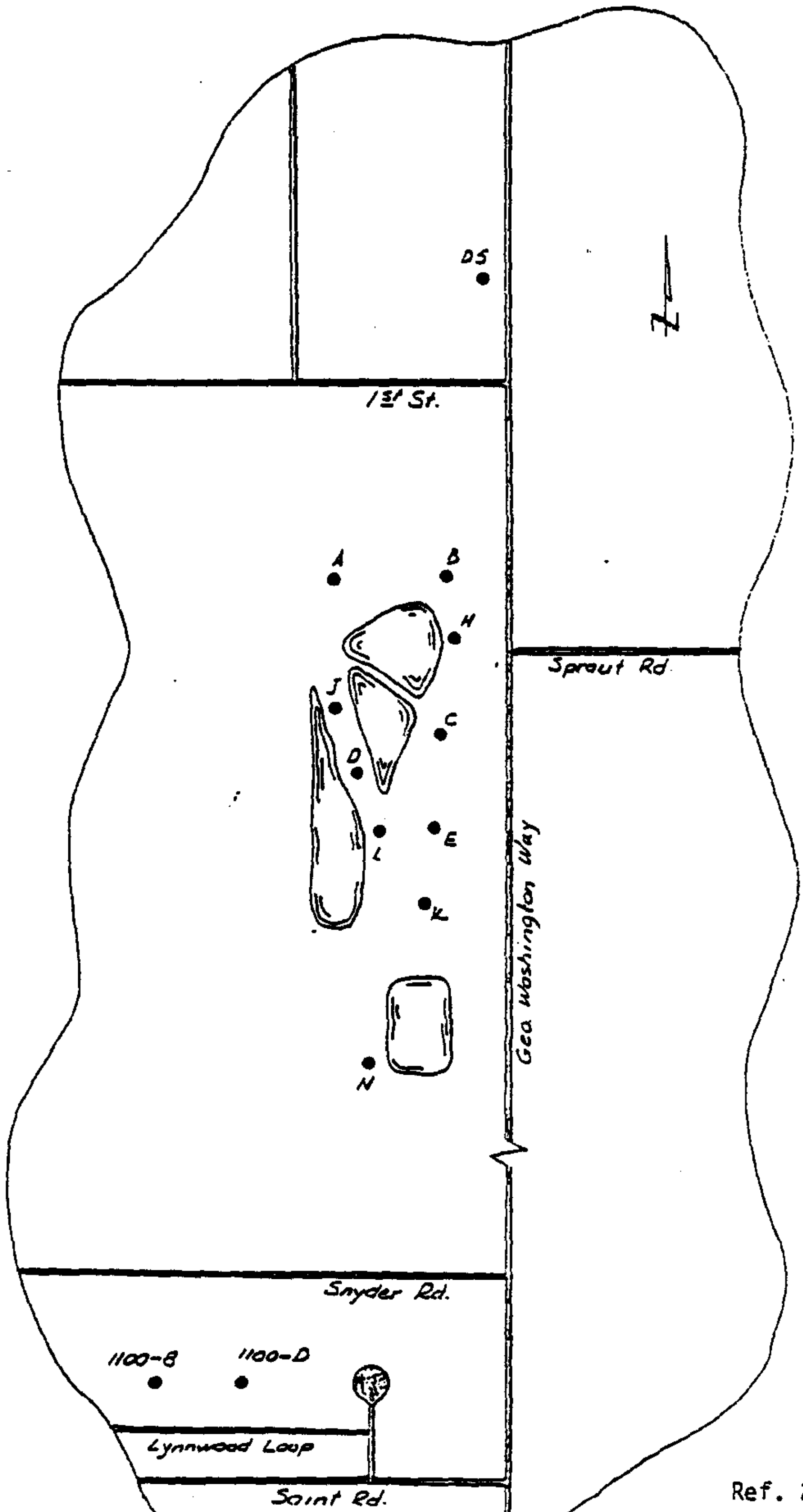
The third pressure zone is supplied by (1) a pumping station off High Meadows Street and currently serves the majority of homes on High Meadows Street, Hillview Drive and all homes west of Orchard Court on Orchard Way and Greenview Drive, and (2) a pumping station on Keene Road at Country Ridge and serves the Country Ridge/ Keene Village area.

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'

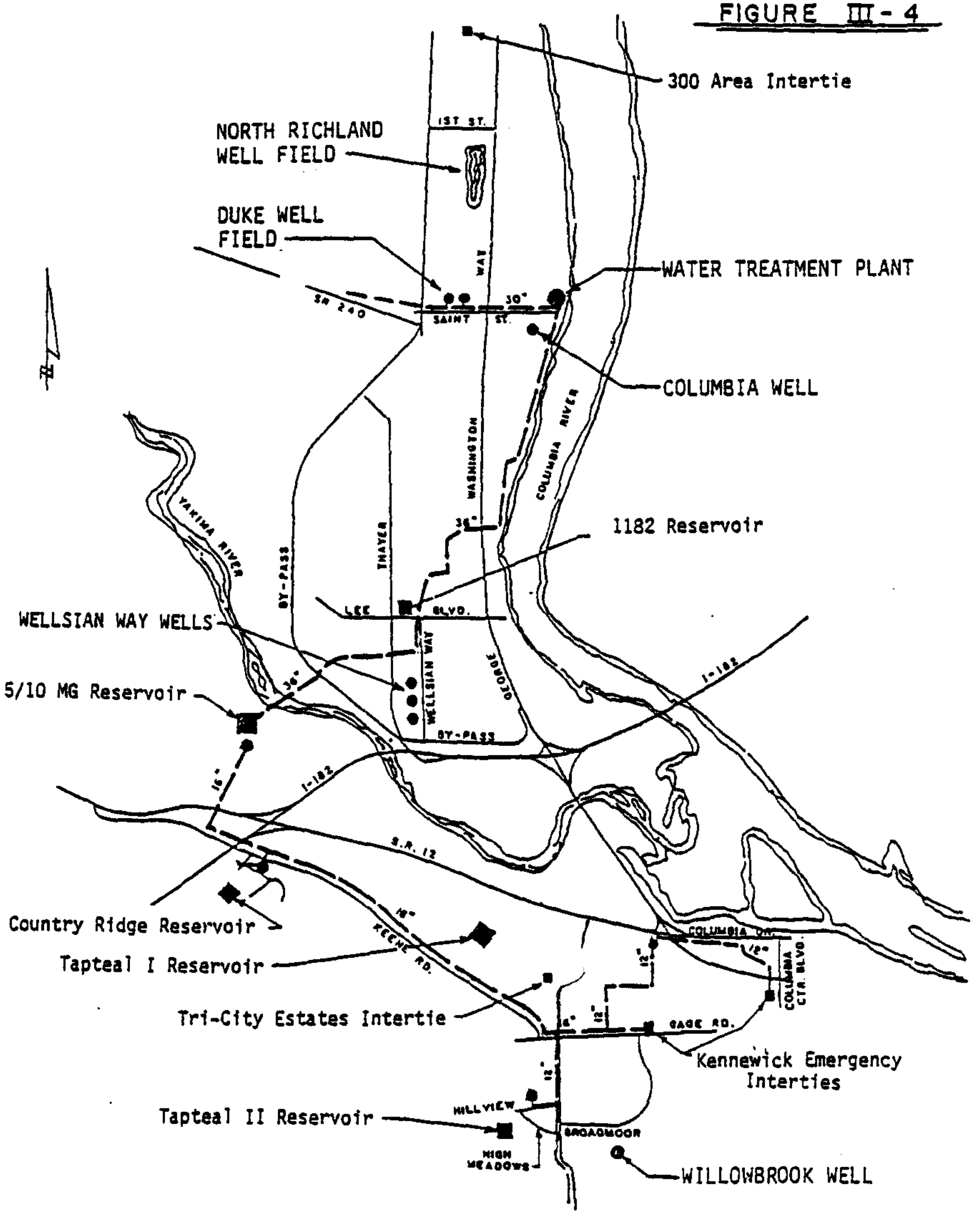
Ref. 2.4

9212 21398

Page 33 of 119

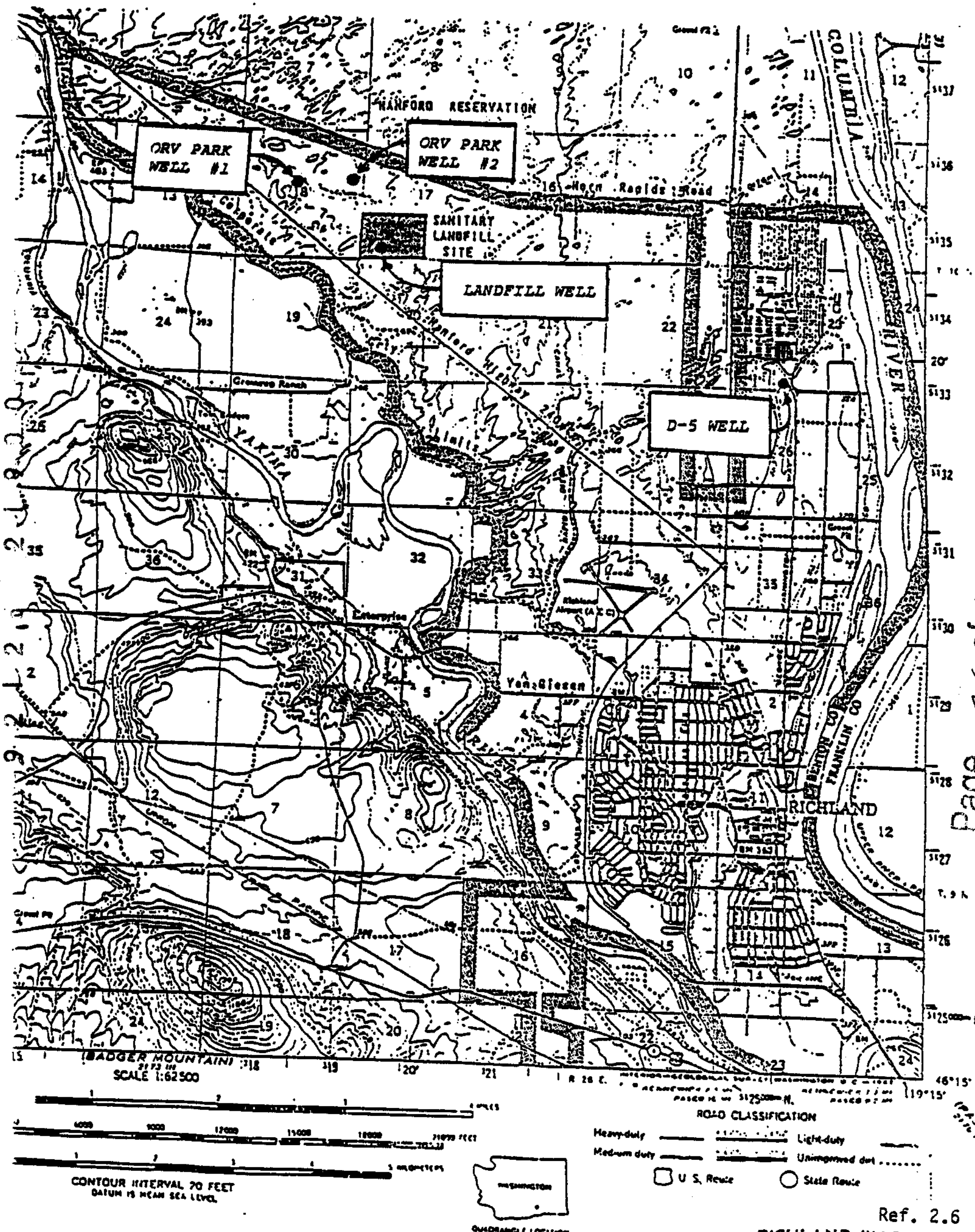
9212521399

FIGURE III - 4



CITY OF RICHLAND

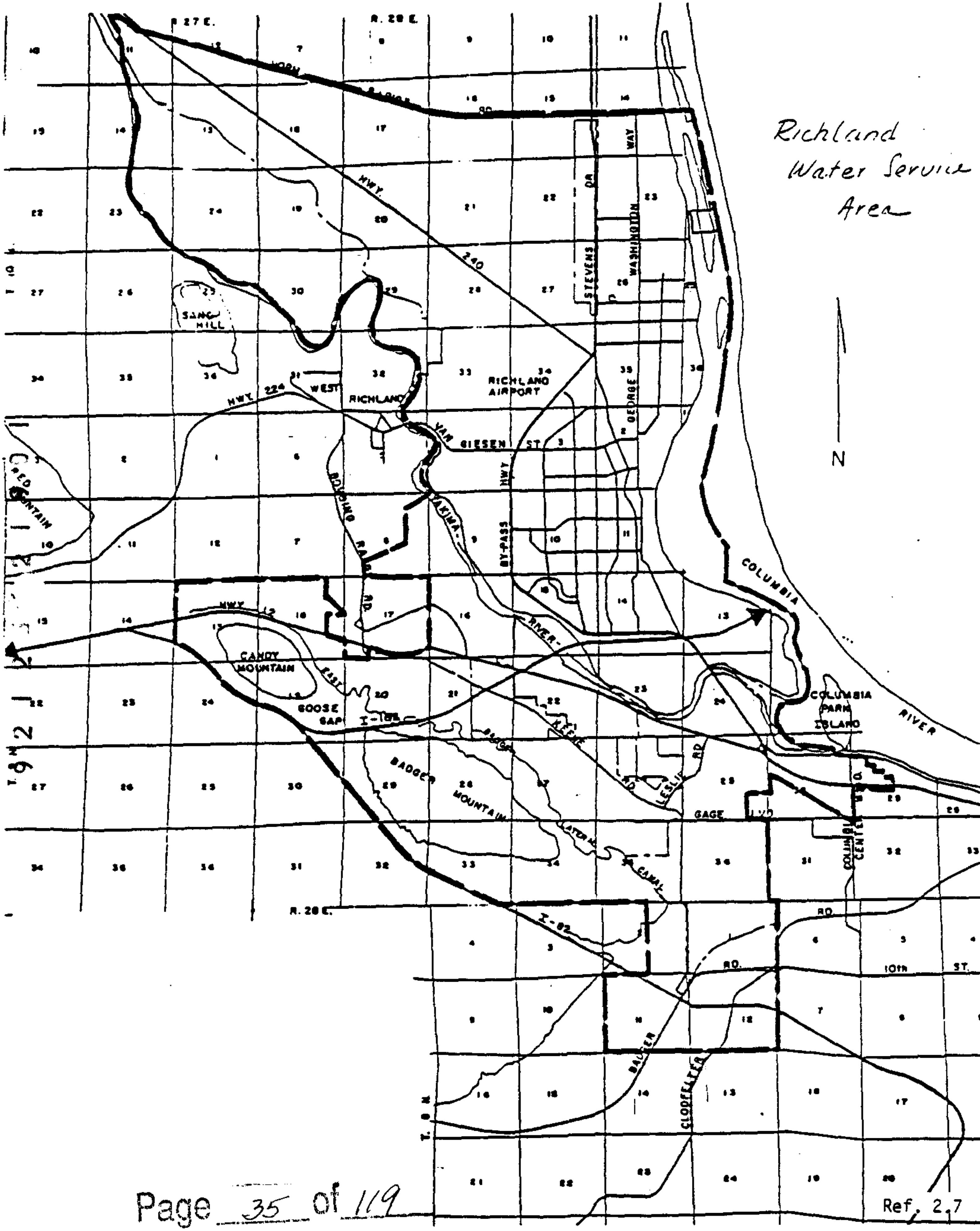
WATER SYSTEM SOURCE and STORAGE FACILITIES LOCATION MAP



HANFORD RESERVATION
ORV PARK WELL #1
ORV PARK WELL #2
SANITARY LANDFILL SITE
LANDFILL WELL
D-5 WELL
Horn Rapids Road
Hanford Highway
COLUMBIA RIVER
YAKIMA
Enterprise
Van Giesen
RICHLAND
BENTON CO
FRANKLIN CO
BADGER MOUNTAIN
SCALE 1:62500
ROAD CLASSIFICATION
Heavy-duty
Medium duty
Light-duty
Unimproved dirt
U. S. Route
State Route
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
WASHINGTON
QUADRANGLE LOCATION
RICHLAND, WASH

Ref. 2.6

Richland Water Service Area



Ref. 2.7

REFERENCE 3

U.S.G.S. Maps Showing 1100 Area Surroundings

Richland, Wash 7.5 Minute Map
Columbia Point, Wash 7.5 Minute Map

24 000

1 MILE

4000 5000 6000 7000 FEET

1 KILOMETER

IVAL 10 FEET
TICAL DATUM OF 1929

IAL MAP ACCURACY STANDARDS
COLORADO 80225, OR RESTON, VIRGINIA 22092
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

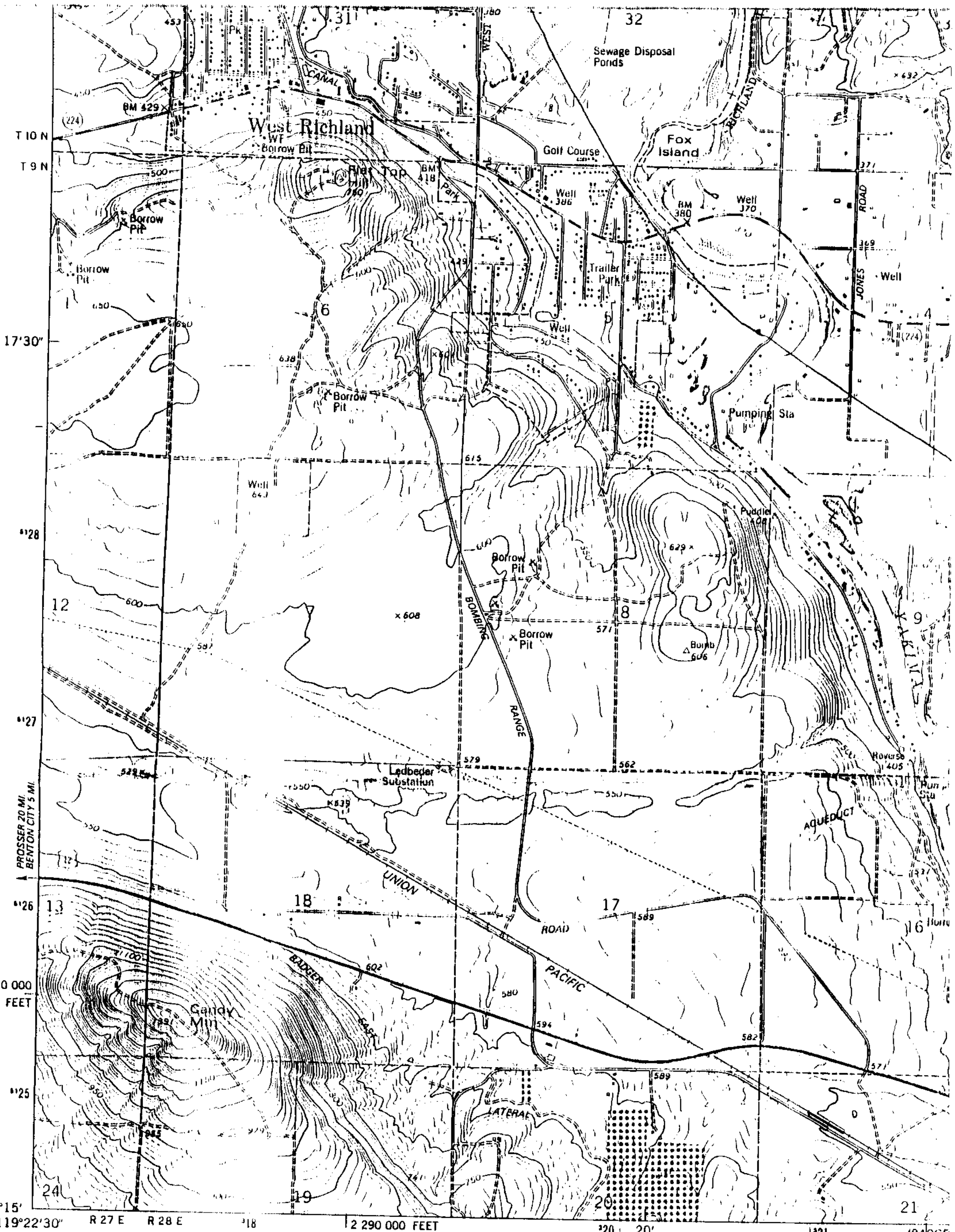
(KENNEWICK) 2176 II NW

RICHLAND, WASH.
SE/4 RICHLAND 15' QUADRANGLE
N4615--W11915/7.5

1978

AMS 2176 IV SE—SERIES V891

Page 32 of 119



Mapped, edited, and published by the Geological Survey

Control by USGS, NOS/NOAA, and USCE

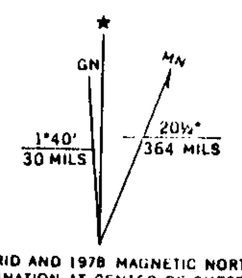
Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974. Map edited 1978

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



UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1

CONTOUR INTE

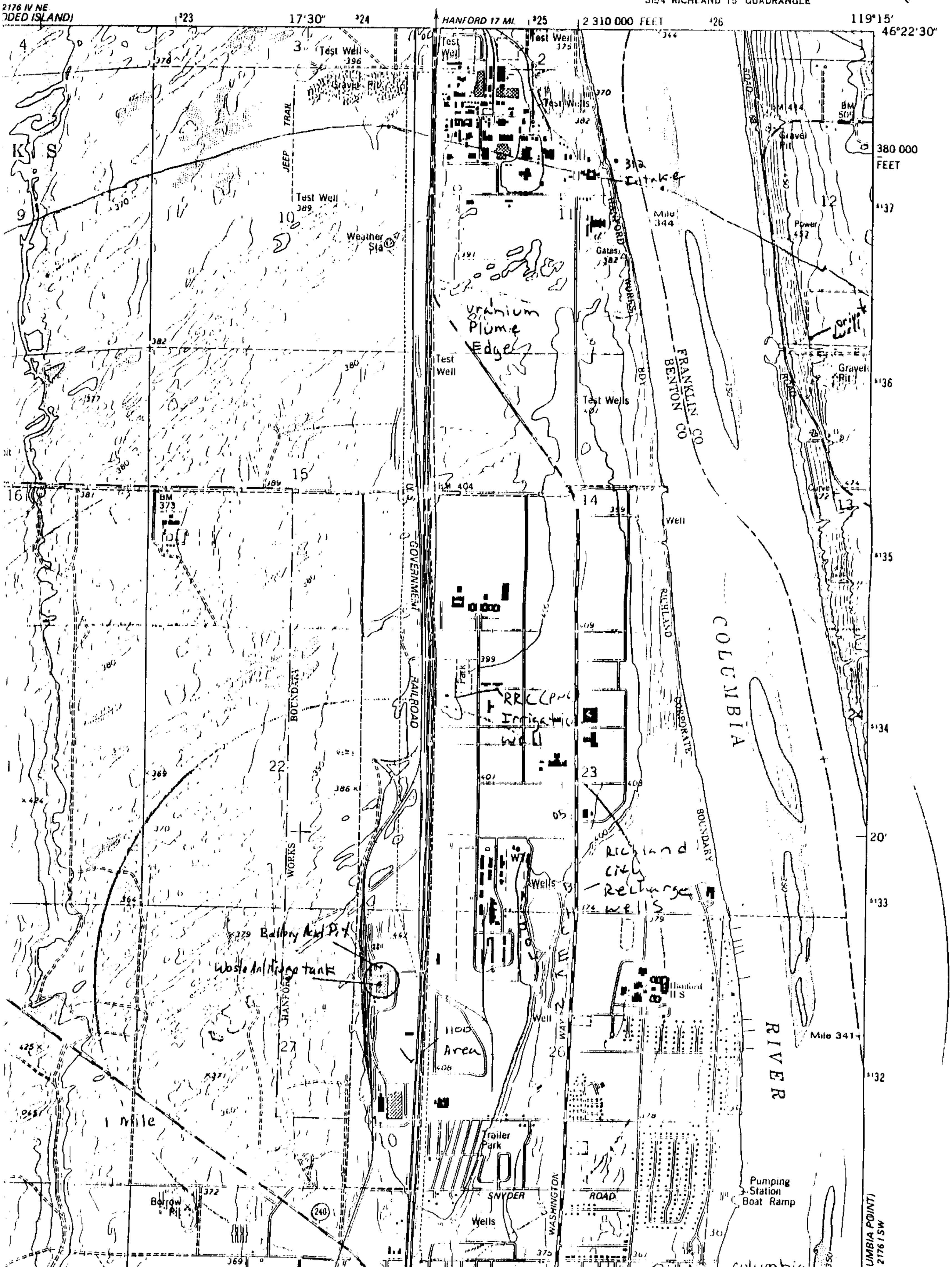
NATIONAL GEODETIC VE

THIS MAP COMPLIES WITH NATIO

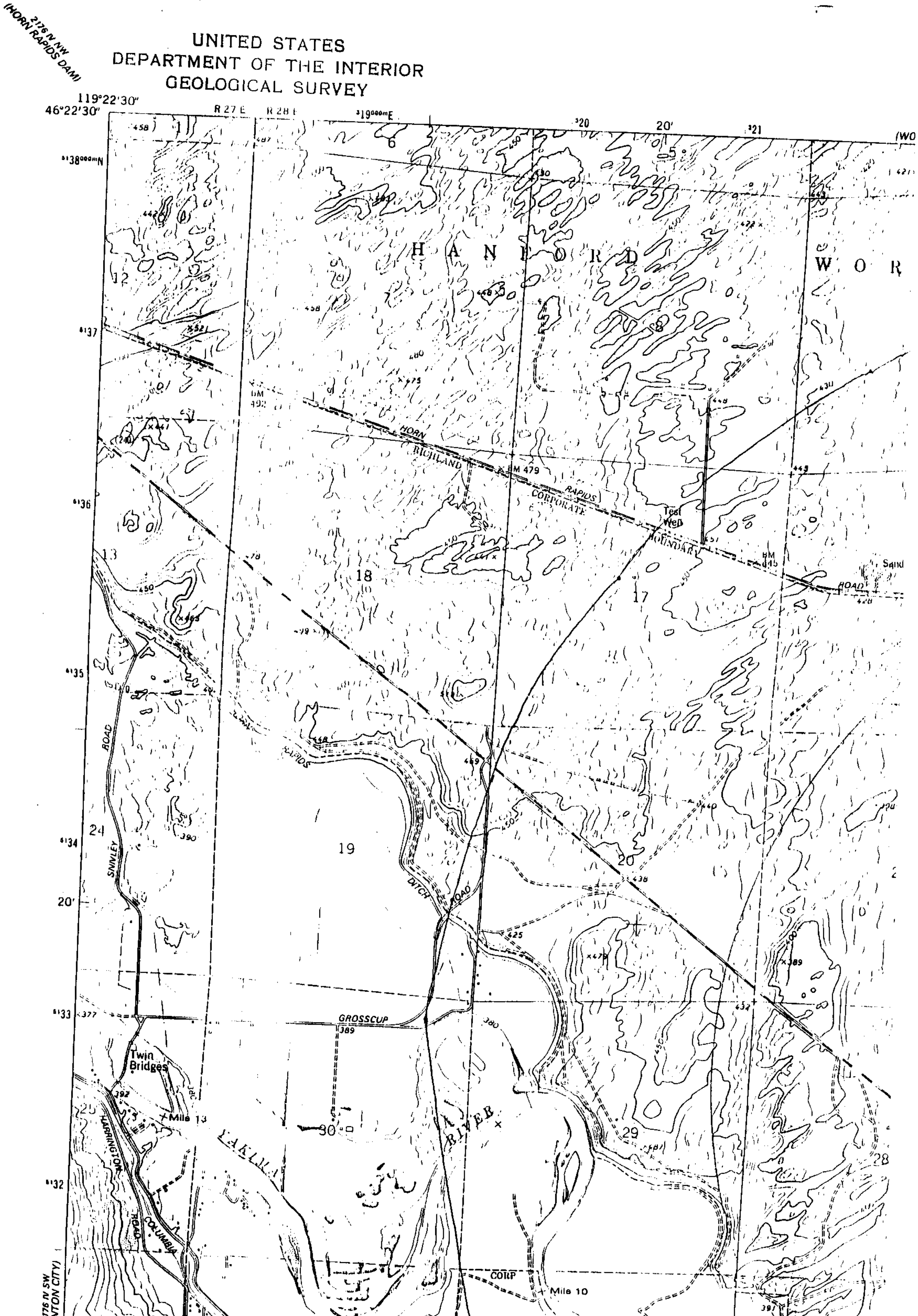
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER

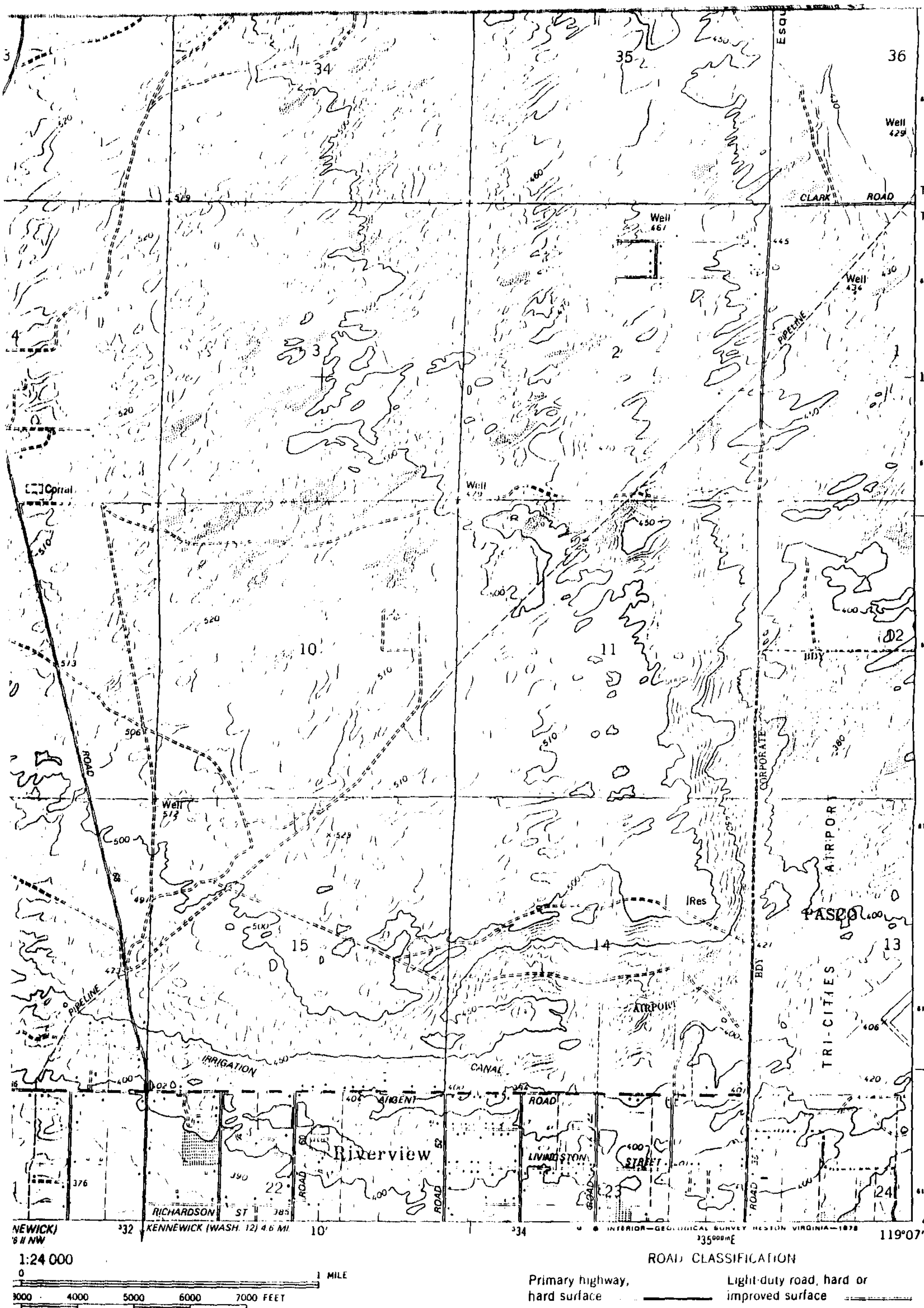
A FOLDER DESCRIBING TOPOGRAPHIC MAPS

RICHLAND QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE/4 RICHLAND 15' QUADRANGLE



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY





1:24 000

0 — 1 MILE

3000 4000 5000 6000 7000 FEET

0 — 1 KILOMETER

ERVAL 10 FEET
ERTICAL DATUM OF 1929

IONAL MAP ACCURACY STANDARDS
ER, COLORADO 80225, OR RESTON, VIRGINIA 22092
'S 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

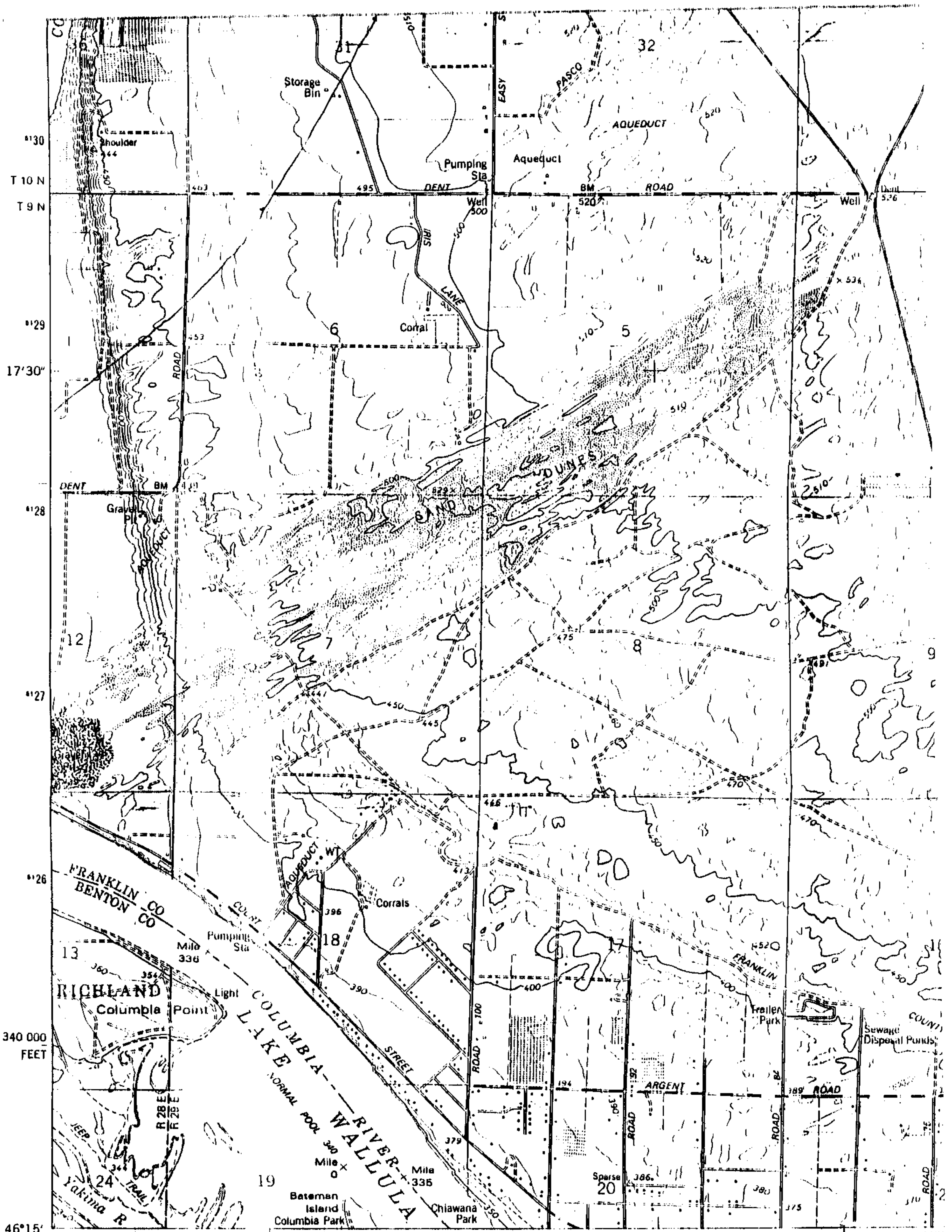
(PASCO) 2176 II NE

COLUMBIA POINT, WASH.
SW/4 ELTOPIA 15' QUADRANGLE
N4615—W11907.5/7.5

1978

AMS 2176 I SW—SERIES V891

Page 38 of 119



(BADGER MTN.)
2176 III NE

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

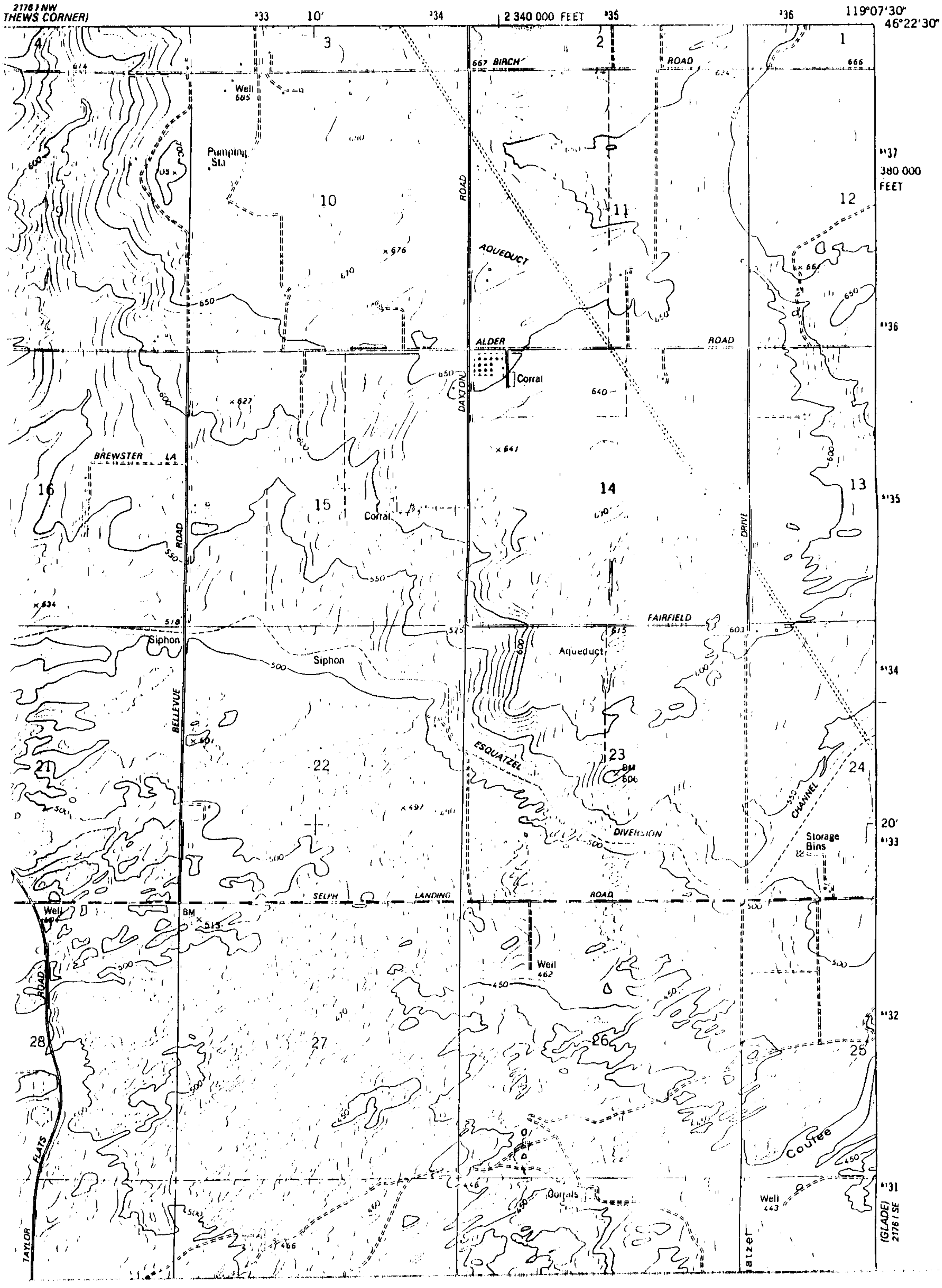
UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE
1000 0 1000 2000

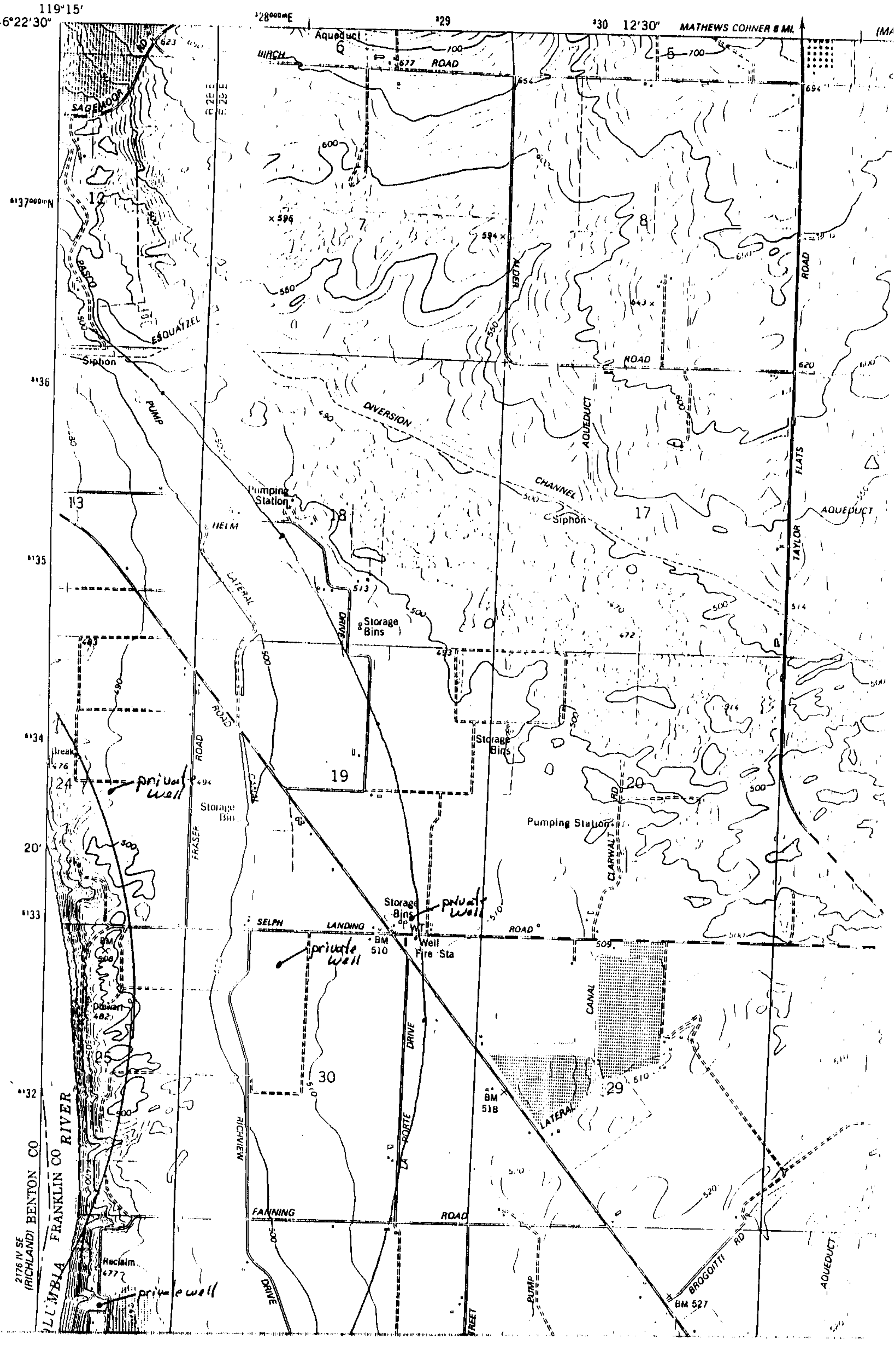
CONTOUR INT
NATIONAL GEODETIC V

THIS MAP COMPLIES WITH NAT
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENV
A FOLDER DESCRIBING TOPOGRAPHIC MA

COLUMBIA POINT QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 ELTOPIA 15' QUADRANGLE



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



REFERENCE 4

Internal Memo from Westinghouse Hanford Company to file regarding waste quality estimates for the 1100 Area Battery Acid Pit, August 11, 1987 (RA Evanoff)

9212521995

Westinghouse
Hanford Company

Internal Memo

From: Fleet Maintenance Department
Phone: 6-6680 1171/1100
Date: August 11, 1987
Subject: BATTERY ACIDS DISPOSITION

To: File

cc: AD Poor 1171/1100

The following information was obtained by discussion with personnel, review of equipment files and review of battery procurements during the 12 month period ending July 1987. During the approximate period of 1957 through 1976, 20 years, batteries were emptied of fluid into a dry sump located near the auto body repair shop at the 1171 Building. The sump was approximately 12 foot in diameter, 10 foot deep, and filled with river rock and sand.

In 1976 the vehicle fleet was approximately 2,000 units and the fleet is currently approximately 3,000 units. In estimating the volume of fluid emptied into the dry sump, it is assumed that the 12 month period through July 1987, is a representative base period, that usage would be directly proportional to fleet size, batteries were full when emptied, and that battery fluid capacities in the period 1957 through 1976 were equivalent to current capacities.

During the 12 month period ending July 1987, 843 batteries were used with a total fluid capacity of 1,135.1 gallons. This equates to a total volume of fluid dumped into the dry sump during the 20 year period of 1,135.1 gal/yr X 20 yrs X 2/3 = 15,134 gallons.

R. A. Evanoff, Manager
Fleet Maintenance
Department

mlf

9212321976

REFERENCE 5

Climate Atlas of the United States,

U.S. Department of Commerce, June 1968

(w/EPA Region X info on seasonal evaporation)

9212521977

Month	Net Precipitation	
November	1.27	inches
December	1.48	"
January	1.26	"
Febuary	.98	"
March	.86	"
April	.67	"
Total	6.52	inches

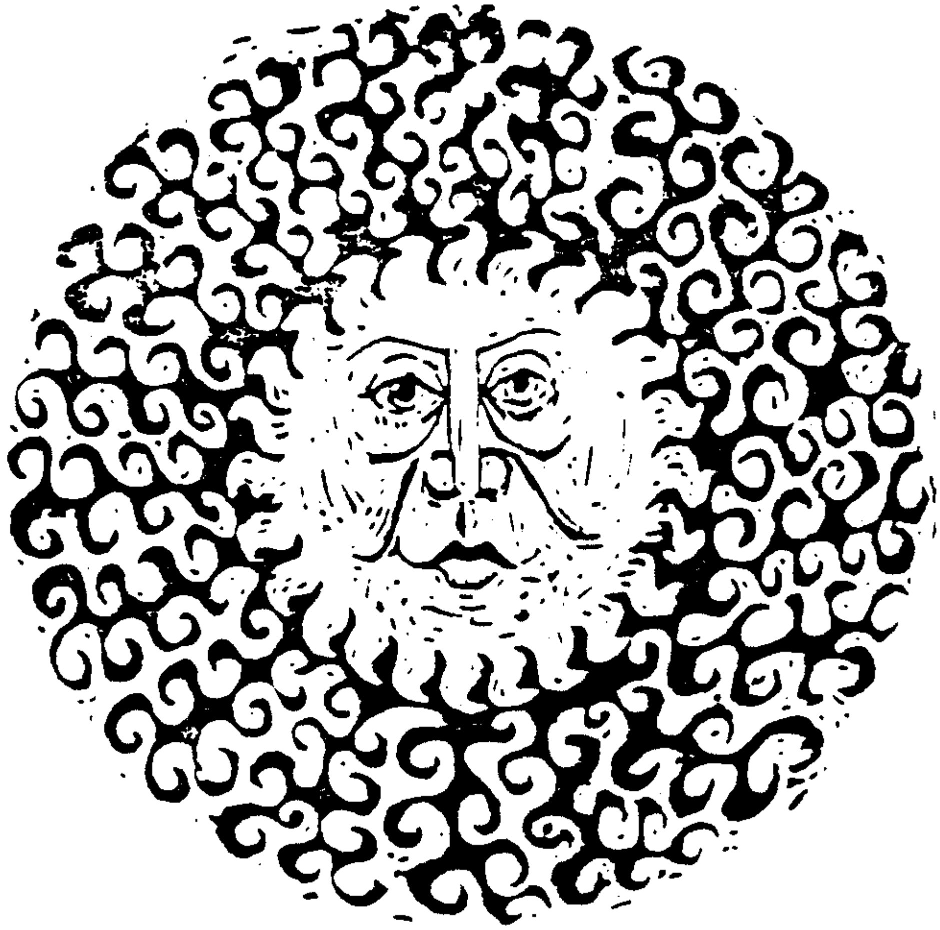
November - April evaporation in percent of annual = 20%
Mean Annual Lake Evaporation = 40 inches

20% of 40 inches = 8 inches

  6.52 inches
− 8 "
− 1.48 inches

Score HRS: 1

NOTE: INFORMATION RECEIVED FROM D. BENNETT, REGION X EPA, REGARDING SEASONAL EVAPORATION FOR EASTERN WASHINGTON. RECEIVED 8/6/87



CLIMATIC ATLAS OF THE UNITED STATES

Ref. 5.2

U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Robert M. White, Administrator

ENVIRONMENTAL DATA SERVICE
Woodrow C. Jacobs, Director

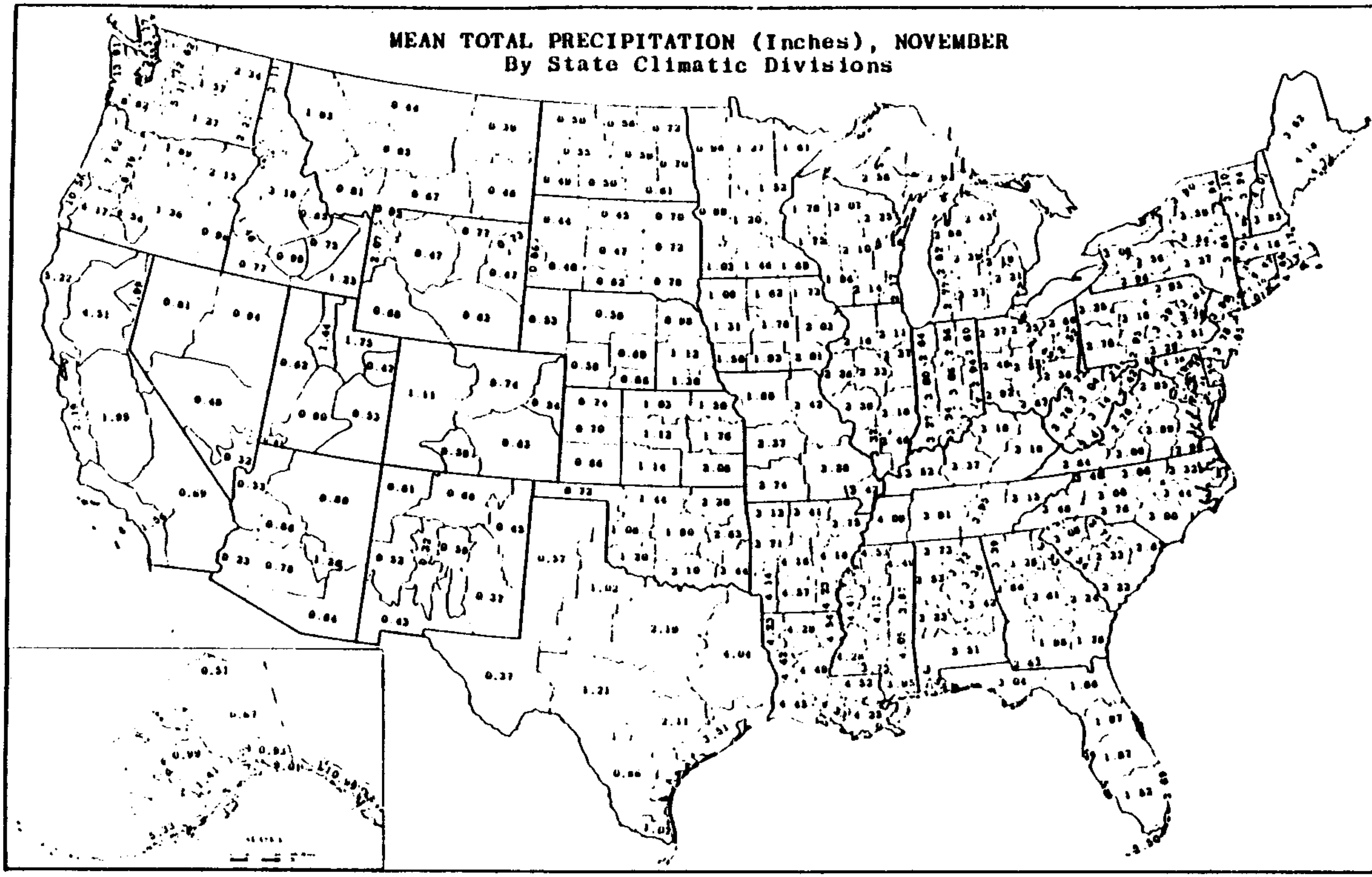
JUNE 1968

REPRINTED BY THE

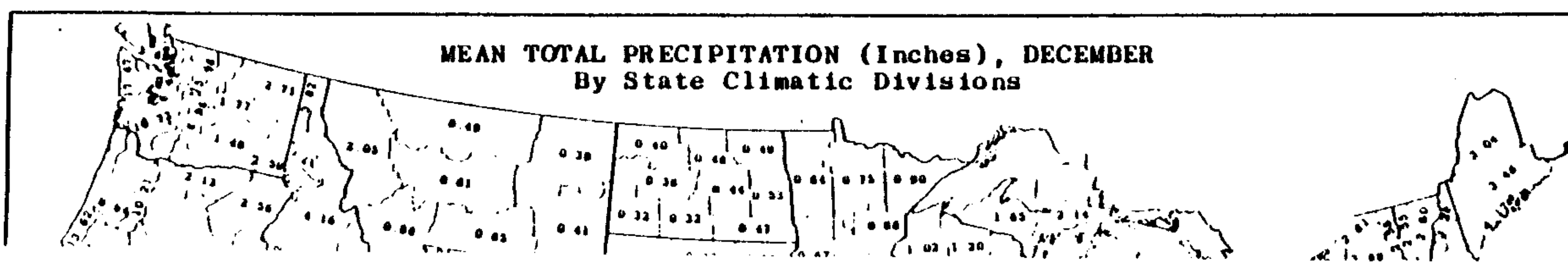
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

1979

BY S TE CLIMATIC DIVISIONS, SEPTE ER-DECEMBER



MEAN TOTAL PRECIPITATION (Inches), NOVEMBER
By State Climatic Divisions

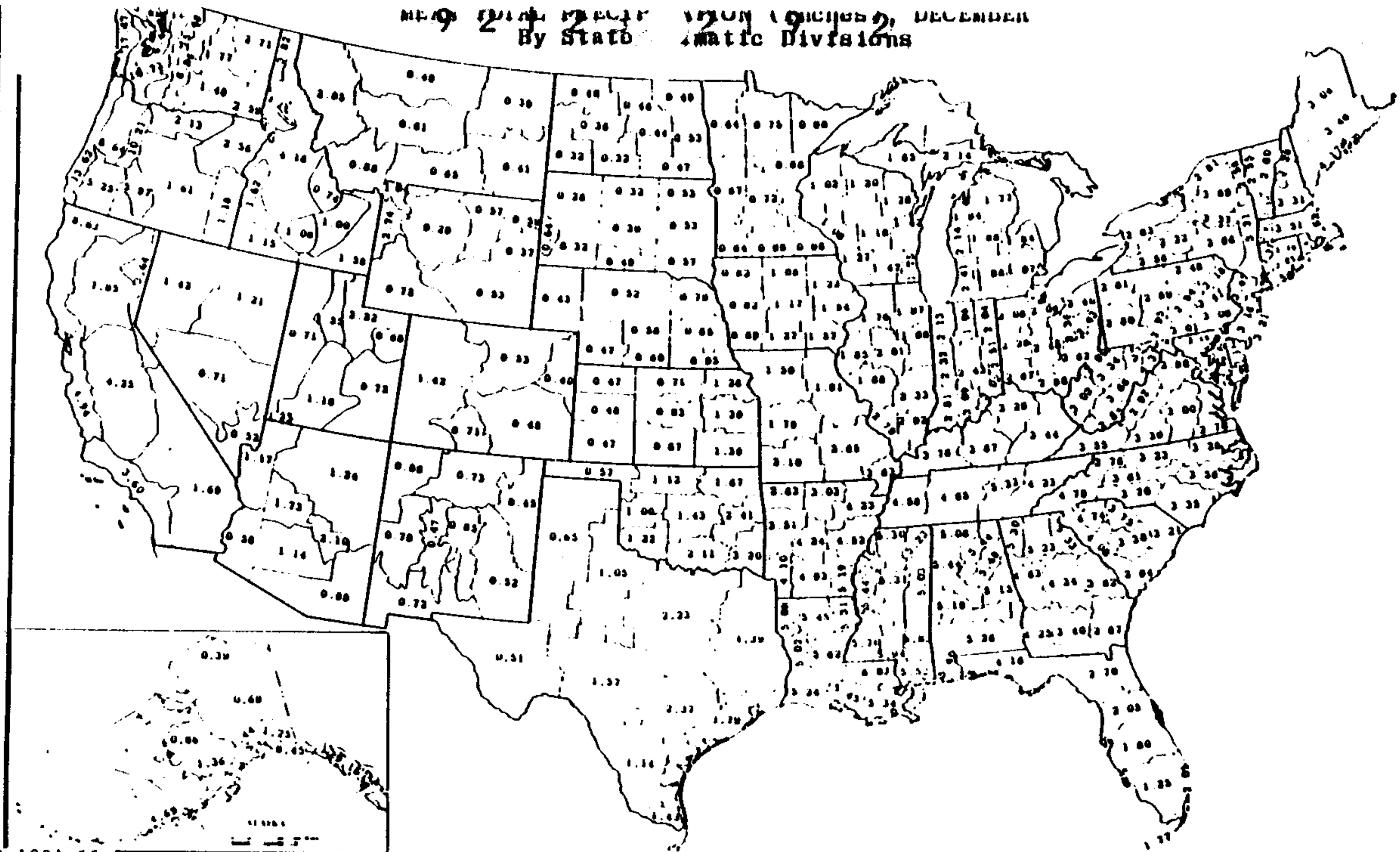


MEAN TOTAL PRECIPITATION (Inches), DECEMBER
By State Climatic Divisions

Page 45 of 119

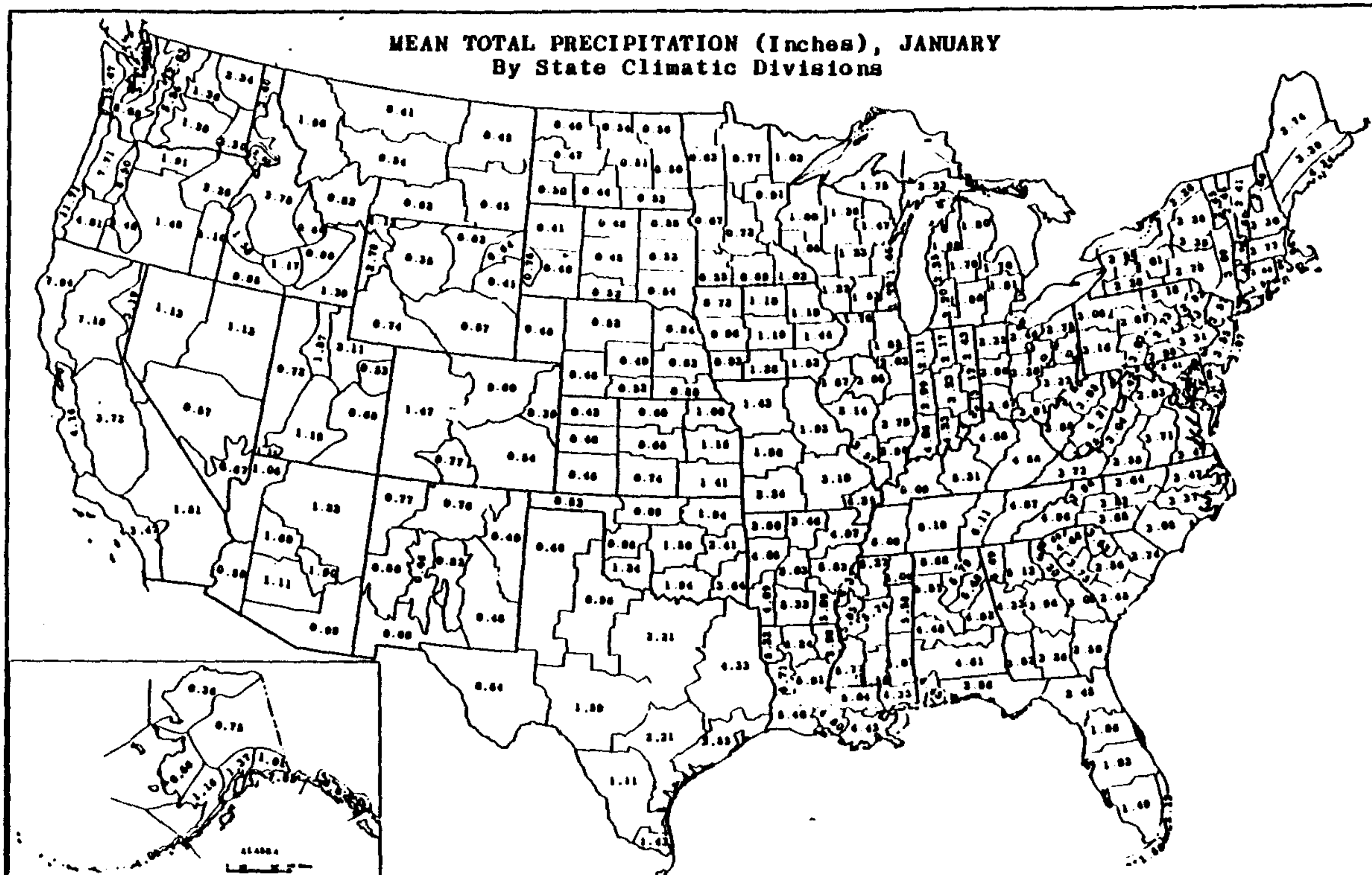
Ref. 5.4

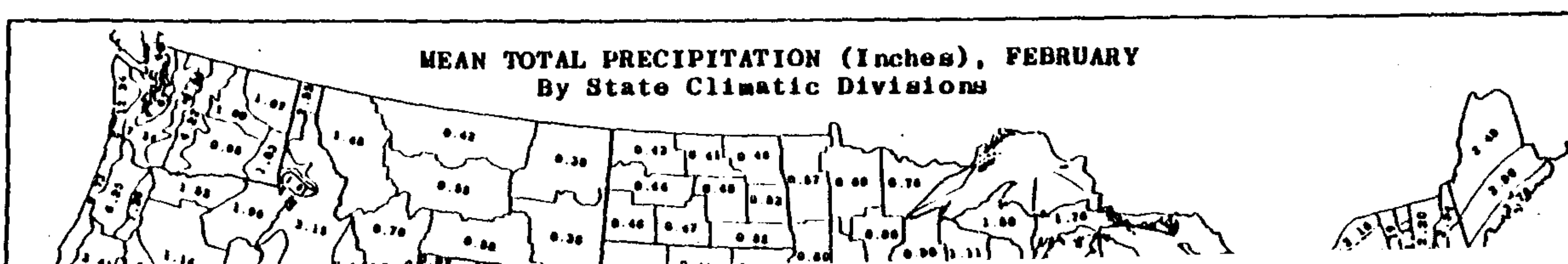
MEA... TOTAL PRECIP...TION (INCHES), DECEMBER
By State ...matic Divisions



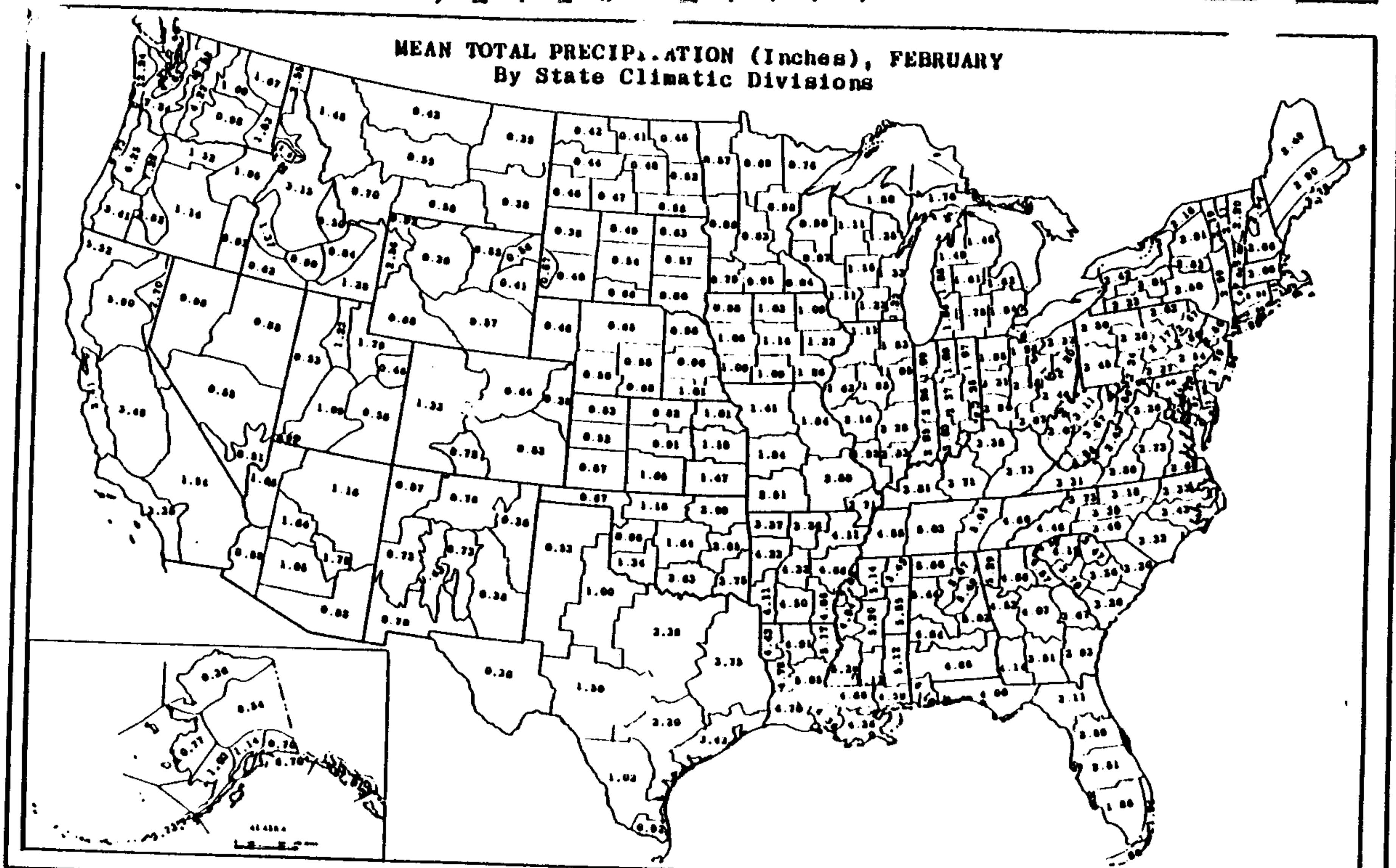
...on Period 1931-55.

MEA' MONTHLY PRECIPITATION (inch BY ST

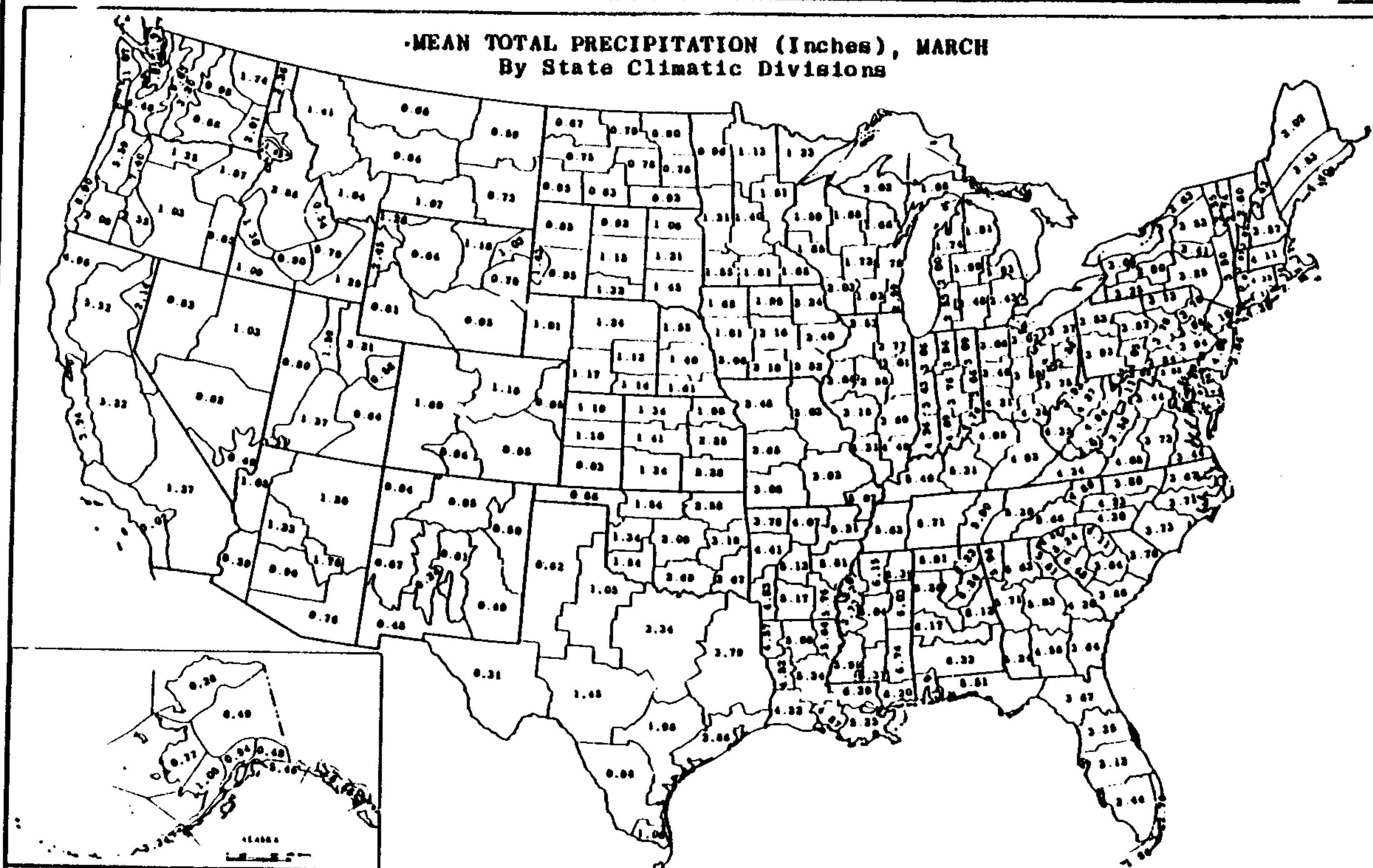




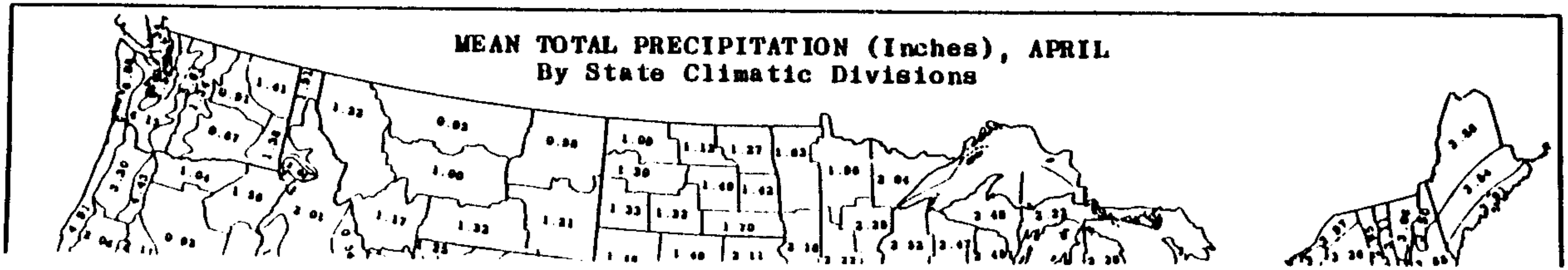
MEAN TOTAL PRECIPITATION (Inches), FEBRUARY
By State Climatic Divisions



Based on Period



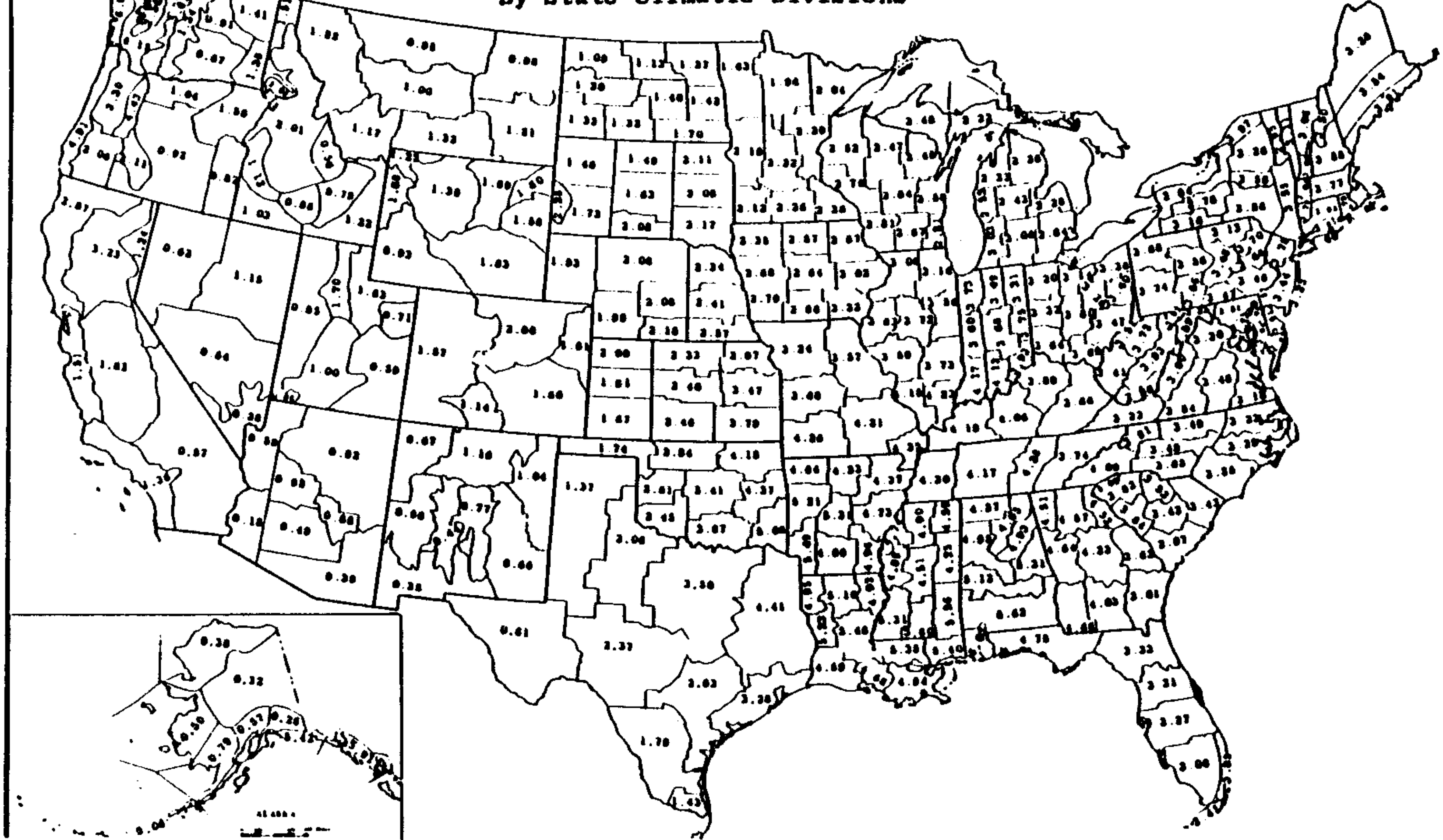
MEAN TOTAL PRECIPITATION (Inches), MARCH
By State Climatic Divisions



MEAN TOTAL PRECIPITATION (Inches), APRIL
By State Climatic Divisions

9 2 1 2 5 7 2 1 9 1 6

MEAN TOTAL PRECIPITATION (Inches), APRIL
By State Climatic Divisions

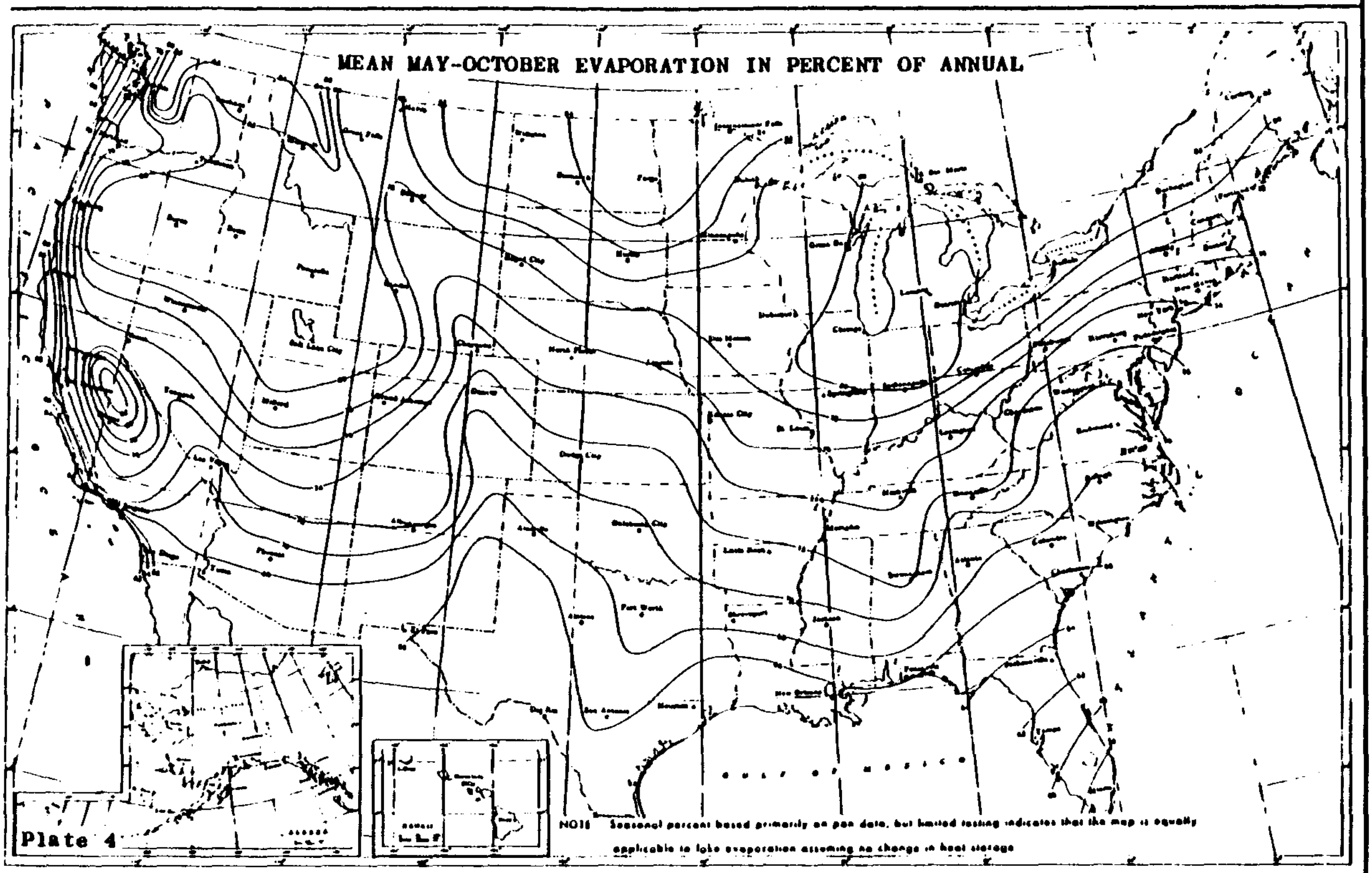


Period 1931-55.

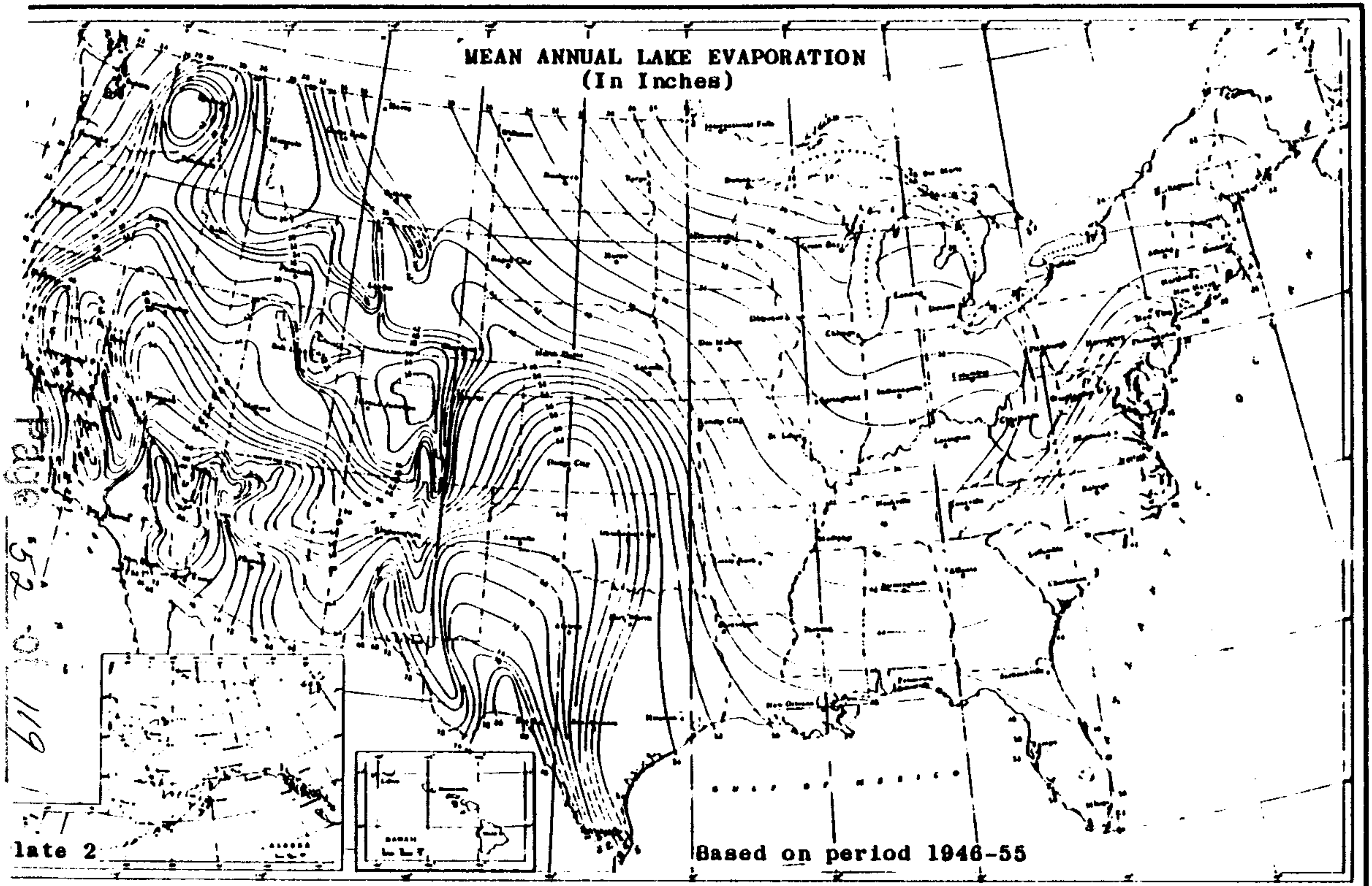
Page 50 of 119

Ref. 5.9


Plate 2
Ba d on period 1946-55


MEAN MAY-OCTOBER EVAPORATION IN PERCENT OF ANNUAL
Plate 4
NOTE Seasonal percent based primarily on pan data, but limited testing indicates that the map is equally applicable to lake evaporation assuming no change in heat storage

KE EVAPORATION



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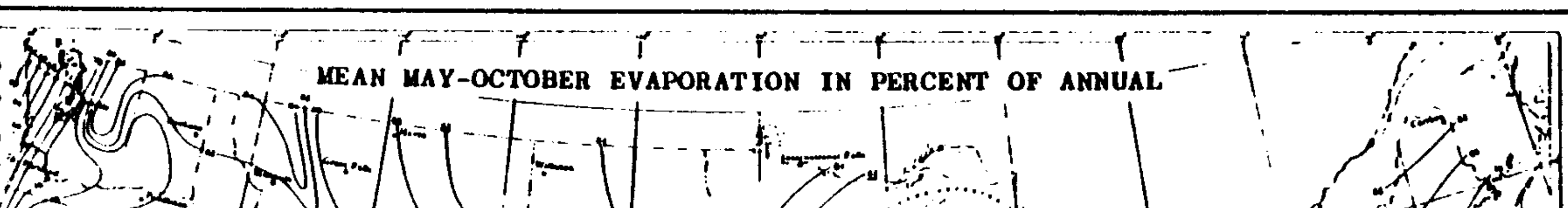
Page 52 of 119



Ref. 5.11

REFERENCE 6

Uncontrolled Hazardous Waste Site Ranking System;

A Users Manual, 40 CFR 300 Appendix A

9 2 1 2 3 ' 2 1 9 1 9

Where there are no data for a factor, it should be assigned a value of zero. However, if a factor with no data is the only factor in a category (e.g., containment), then the factor is given a score of 1. If data are lacking for more than one factor in connection with the evaluation of either S_{gw}, S_{sw}, S_a, S_{fe}, or S_{dc}, that route score is set at zero.

The following sections give detailed instructions and guidance for rating a facility. Each section begins with a work sheet designed to conform to the sequence of steps required to perform the rating. Guidance for evaluating each of the factors then follows. Using the guidance provided, attempt to assign a score for each of the three possible migration routes. Bear in mind that if data are missing for more than one factor in connection with the evaluation of a route, then you must set that route score at 0 (i.e., there is no need to assign scores to factors in a route that will be set at 0).

3.0 Ground Water Migration Route

3.1 *Observed Release.* If there is direct evidence of release of a substance of concern from a facility to ground water, enter a score of 45 on line 1 of the work sheet for the ground water route (Figure 2), then you need not evaluate route characteristics and containment factors (lines 2 and 3). Direct evidence of release must be analytical. If a contaminant is measured (regardless of frequency) in ground water or in a well in the vicinity of the facility at a significantly (in terms of demonstrating that a release has occurred, not in terms of potential effects) higher level than the background level, then quantitative evidence exists, and a release has been observed. Qualitative evidence of release (e.g., an oily or otherwise objectionable taste or smell in well water) constitutes direct evidence only if it can be confirmed that it results from a release at the facility in question. If a release has been observed, proceed to "3.4 Waste Characteristics" to continue scoring. If direct evidence is lacking, enter a value of 0 on line 1 and continue the scoring procedure by evaluating *Route Characteristics*.

3.2 *Route Characteristics. Depth to aquifer of concern* is measured vertically from the lowest point of the hazardous substances to the highest seasonal level of the saturated zone of the aquifer of concern (Figure 3). This factor is one indicator of the ease with which a pollutant from the facility could migrate to ground water. Assign a value as follows:

Distance (feet)	Assigned value
> 150	0
76 to 150	1
21 to 75	2
0 to 20	3

Net precipitation (precipitation minus evaporation) indicates the potential for leachate generation at the facility. Net seasonal rainfall (seasonal rainfall minus seasonal evaporation) data may be used if available. If net precipitation is not measured in the region in which the facility is located, calculate it by subtracting the mean annual lake evaporation for the region (obtained from Figure 4) from the normal annual precipitation for the region (obtained from Figure 5). EPA Regional Offices will have maps for areas outside the continental U.S. Assign a value as follows:

Net precipitation (inches)	Assigned value
< −10	0
−10 to +5	1
+5 to +15	2
> +15	3

Permeability of unsaturated zone (or intervening geological formations) is an indicator of the speed at which a contaminant could migrate from a facility. Assign a value from Table 2.

TABLE 2—PERMEABILITY OF GEOLOGIC MATERIALS[1]

Type of material	Approximate range of hydraulic conductivity	Assigned value
Clay, compact till, shale; unfractured metamorphic and igneous rocks	$< 10^{-7}$ cm/sec	0
Silt, loess, silty clays, silty loams, clay loams; less permeable limestone, dolomites, and sandstone; moderately permeable till	$< 10^{-5} > 10^{-7}$ cm/sec	1
Fine sand and silty sand; sandy loams; loamy sands; moderately permeable limestone, dolomites, and sandstone (no karst); moderately fractured igneous and metamorphic rocks, some coarse till	$< 10^{-3} > 10^{-5}$ cm/sec	2
Gravel, sand; highly fractured igneous and metamorphic rocks; permeable basalt and lavas; karst limestone and dolomite	$> 10^{-3}$ cm/sec	3

[1] Derived from: Davis, S. N., *Porosity and Permeability of Natural Materials in Flow-Through Porous Media*, R.J.M. DeWiest ed., Academic Press, New York, 1969; Freeze, R.A. and J.A. Cherry, *Groundwater*, Prentice-Hall, Inc., New York, 1979.

Page 54 of 119

Ref. 6.1

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 if: (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.

	Assigned value
A. Surface Impoundment	
Sound run-on diversion structure, essentially non-permeable liner (natural or artificial) compatible with the waste, and adequate leachate collection system	0
Essentially non-permeable compatible liner with no leachate collection system, or inadequate freeboard	1
Potentially unsound run-on diversion structure, or moderately permeable compatible liner	2
Unsound run-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

TABLE 3—CONTAINMENT VALUE FOR GROUND WATER ROUTE—Continued

Assign containment a value of 0 if: (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.

	Assigned value
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. Landfill	
Essentially non-permeable liner, liner compatible with waste, and adequate leachate collection system	0
Essentially non-permeable compatible liner, no leachate collection system, and landfill surface precludes ponding	1
Moderately permeable, compatible liner, and landfill surface precludes ponding	2
No liner or incompatible liner; moderately permeable compatible liner; landfill surface encourages ponding; 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	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	3	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	3	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	*0	*0
Chlorobenzene	2	2	3	0
Chloroform	3	3	0	0
Cresol-O	3	1	2	0
Cresol-M&P	3	1	1	0
Cyclohexane	3	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
Hydrochloric 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	[illegible]	3	2
Naphthalene	2	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	[illegible]	1	2
PCB	3	3	[illegible]	[illegible]
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	2	2	1	0
Xylene	2	1	3	0

[1] Sax, N. I., *Dangerous Properties of Industrial Materials*, Van Nostrand Reinhold Co., New York, 4th ed., 1975. The highest rating listed under each chemical is used.

[2] JRB 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.

Δ Professional judgment based on existing literature.

TABLE 5—PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS[1]

Value = 3 Highly Persistent Compounds	
aldrin	heptachlor
benzopyrene	heptachlor epoxide
benzothiazole	1,2,3,4,5,7,7-heptachloronorbornene
benzothiophene	hexachlorobenzene
benzyl butyl phthalate	hexachloro-1,3-butadiene
bromochlorobenzene	hexachlorocyclohexane
bromoform butanol	hexachloroethane
bromophenyl phenyl ether	methyl benzothiazole
chlordane	pentachlorobiphenyl
chlorohydroxy benzophenone	pentachlorophenol
bis-chloroisopropyl ether	1,1,3,3-tetrachloroacetone
m-chloronitrobenzene	tetrachlorophenyl
DDE	thiomethylbenzothiazole
DDT	trichlorobenzene
dibromobenzene	trichlorobiphenyl
dibutyl phthalate	trichlorofluoromethane
1,4-dichlorobenzene	2,4,6-trichlorophenol
dichlorodifluoroethane	triphenyl phosphate
dieldrin	bromodichloromethane
diethyl phthalate	bromoform
di(2-ethylhexyl)phthalate	carbon tetrachloride
dihexyl phthalate	chloroform
di-isobutyl phthalate	chlorodibromomethane
dimethyl phthalate	dibromodichloroethane
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
atrazine	trans-2-ethyl-4-methyl-1,3-dioxolane
(diethyl) atrazine	guaiacol
barbital	2-hydroxyadiponitrile
borneol	isophorone
bromobenzene	indene
camphor	isoborneol
chlorobenzene	isopropenyl-4-isopropyl benzene
1,2-bis-chloroethoxy ethane	2-methoxy biphenyl
b-chloroethyl methyl ether	methyl biphenyl
chloromethyl ether	methyl chloride

Page 55 of 119

Ref. 6.2

TABLE 5—PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS[a]—Continued

[illegible]	[illegible]

Value = 1 Somewhat Persistent Compounds

[illegible]	[illegible]

Value = 0 Nonpersistent Compounds

[illegible]	[illegible]

[a] [illegible]

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 6—SAX TOXICITY RATINGS

0 - No Toxicity[a] (None)[b]

[illegible]

1 - Slight Toxicity[a] (Low)[b]

[illegible]

2 - Moderate Toxicity[a] (Mod)[b]

[illegible]

TABLE 6—SAX TOXICITY RATINGS—Continued

2 - Moderate Toxicity[a] (Mod)[b]

[illegible]

3 - Severe Toxicity[a] (High)[b]

[illegible]

[a] See N. I. Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., New York, New York, 4th edition, 1975.

[b] See N. I. Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., New York, New York, 5th edition, 1979.

TABLE 7—NFPA TOXICITY RATINGS[a]

0	[illegible]
1	[illegible]
2	[illegible]
3	[illegible]
4	[illegible]

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

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 = 4 drums and for the purposes of converting bulk storage, 1 drum = 50 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

3.5 *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 usable	1
Drinking water with municipal water from alternate unthreatened sources presently available (i.e., minimal hookup requirements); or commercial, industrial or irrigation with no other water source presently available	2
Drinking water; no municipal water from alternate unthreatened 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

Page 56 of 119

Ref. 6.3

REFERENCE 7

Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, July 1986, Vol. 1

9 2 1 2 3 4 2 1 9 2 3

2.0 DESCRIPTION OF HANFORD SITE

This section provides a summary of environmental conditions at the Hanford Site and a brief discussion of the Site's purpose and history. It also describes specific environmental features and the the process history of each operational area (i.e., the 100, 200, 300, 400, and 600 Areas).

2.1 ENVIRONMENTAL SUMMARY

The semiarid Hanford Site, operated by the DOE, occupies about 1,476 square kilometers (570 sq mi) of the southeastern part of Washington State north of where the Yakima River flows into the Columbia (see Figure 2.1). The Site lies about 320 kilometers (200 mi) east of Portland, Oregon, 270 kilometers (170 mi) southeast of Seattle, Washington, and 200 kilometers (125 mi) southwest of Spokane, Washington.

Environmental conditions common to all areas at Hanford Site are summarized below. Descriptions of these environmental aspects are based on several recent reports (U.S. DOE 1984; Sommer et al. 1981; Yandon 1977; U.S. ERDA 1975).

2.1.1 Geology and Soils

The Hanford Site lies in the Pasco Basin, a structural and topographic basin of eastern Washington and the Columbia River Basalt Plateau. The region is underlain by three geologic units. In ascending order these are: 1) the sequential beds of basaltic lavas and interbed sediments of the Columbia River Basalt Group at the base; 2) the Pliocene-age Ringold Formation (lacustrine formation), consisting of well-rounded pebbles and cobbles with interstitial spaces filled with medium sand; and 3) the Hanford Formation, consisting of the Pasco (glaciofluvial) gravels and associated sediments of the late Pleistocene age lying at the surface.

The surface geology of the Site is characterized by a surface layer of light brown, fine, slightly silty, wind-deposited sand, sparsely covered by vegetation. Although the surface soil is fertile, it has little agricultural value without irrigation. Underlying the surface sands is a mixture of sand

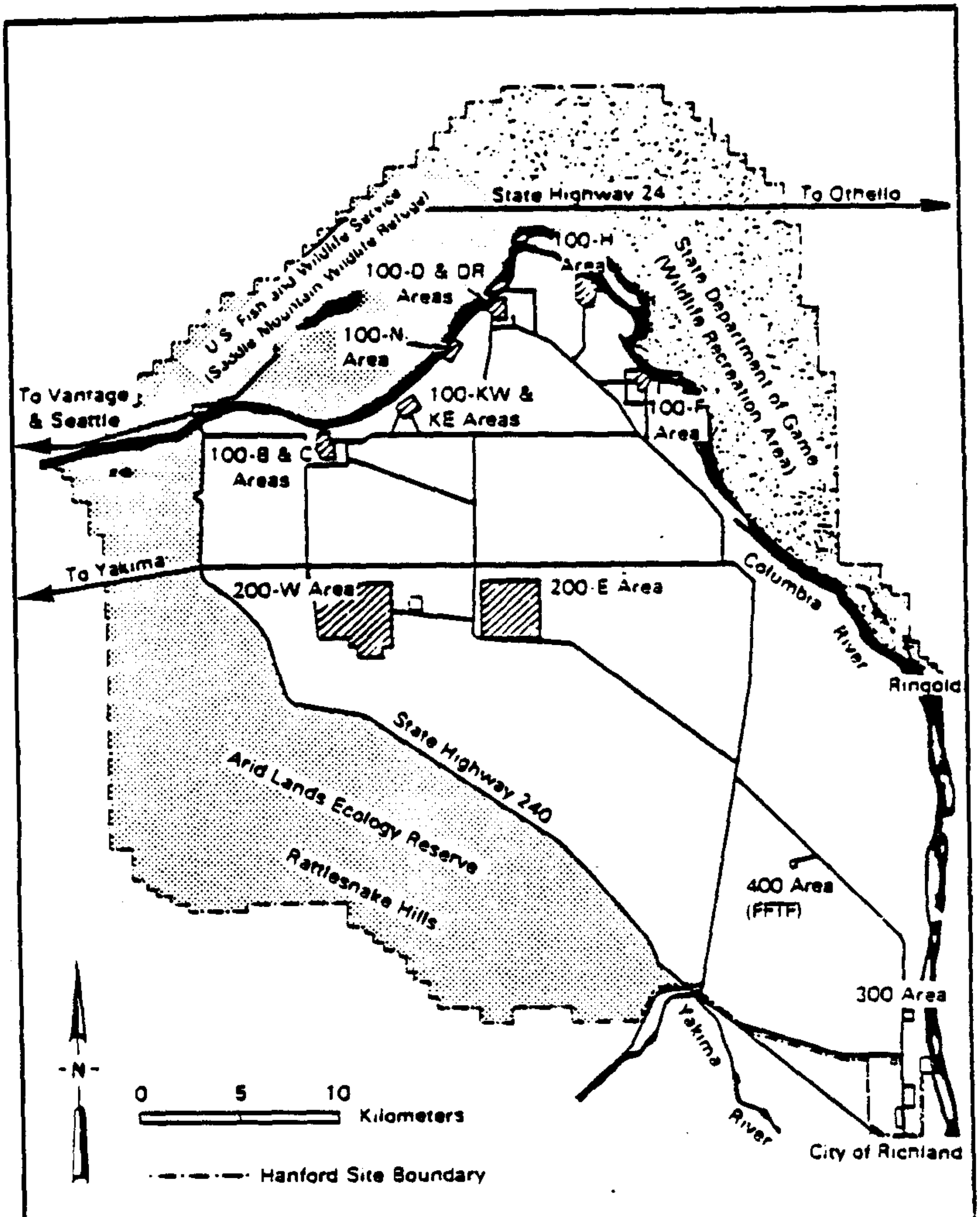


FIGURE 2.1 Features of the Hanford Site.

and gravel extending to a depth of about 60 meters (200 ft). Basaltic rock starts at that depth and extends downward over 3000 meters (1.9 mi).

Elevations range from a low of about 105 meters (345 ft) above mean sea level (MSL) in the southeastern part of the Hanford Site to a maximum of 1,091 meters (3,579 ft) at the crest of Rattlesnake Mountain to the west. (See Section 2.3 for a discussion of geologic features peculiar to each operational area.)

2.1.2 Meteorology

The Site lies east of the Cascade Mountains and, as a result, has a semiarid climate reflecting the rainshadow effect of the mountains. The average annual precipitation for the Site is about 160 millimeters (6.3 in.). Ten percent of this amount falls from July through September, and 42% falls from November through January. The greatest amount of rainfall recorded in a 12-hour period was 47.8 millimeters (1.9 in.).

Because of the limited rainfall, surface runoff from the Hanford Site is minimal. The annual precipitation mostly evaporates, resulting in small amounts of water available for runoff or infiltration.

2.1.3 Hydrology and Hydrogeology

The Columbia River (the fifth largest river by volume in North America) is the dominant aquatic ecosystem on the Hanford Site. Numerous dams have been built on the river. The only free-flowing section in the United States is between Priest Rapids Dam and McNary Reservoir, along the Hanford Site. No significant tributaries enter the stream in this section.

The Columbia has a long-term annual average flow of about 3,600 cubic meters per second (127,000 cfs). [The Yakima River, by comparison, flows an average of about 90 cubic meters per second (3,180 cfs).] The flow rates of the Columbia are influenced by water usage and upstream reservoir projects. The reservoirs provide active storage of more than 4.6×10^{10} cubic meters (37,000,000 acre-feet) of water.

The uppermost aquifer in the Pasco Basin is an unconfined system within the Hanford and Ringold Formations. The elevation of this aquifer ranges from

REFERENCE 8

Draft Phase 1 Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Vol. 3

9212129?7

SITE ID NO.: UPR-1100-4

ALIAS:

DIMENSIONS:

ELEVATION: 380 feet

WATERTABLE: 45 feet

Length:
Width:
Depth:

LOCATION: 1100 Area
COORDINATES:

DESCRIPTION OF RELEASE

Antifreeze was disposed of in a 5000-gallon underground tank in the 1171 Building bus garage.

DATE OF OCCURANCE: Pre-1978

DESCRIPTION OF WASTE

Antifreeze of unknown quantity.

EXTENT OF CONTAMINATION

There was no known release.

INTERIM REMEDIAL ACTION

The tank was retired as a suspected leaker but no cleanup action was taken.

Additional corrective action may have been provided.

REFERENCES:
Documents:

Photographs:

Drawings:

SITE ID NO.: UPR-1100-1

ALIAS:

DIMENSIONS:

ELEVATION: 380 feet

WATERTABLE: 45 feet

Length:
Width:
Depth:

LOCATION: 1100 Area
COORDINATES:

DESCRIPTION OF RELEASE

A sand pit west of the 1171 Building was used for battery acid disposal.

DATE OF OCCURANCE: 1954-1977

DESCRIPTION OF WASTE

An unknown quantity of sulfuric acid.

EXTENT OF CONTAMINATION

There was no known releases and the quantity of acid disposed of is unknown.

INTERIM REMEDIAL ACTION

Periodically, when the sand was saturated, it would be scraped off and new sand added to the pit.

Additional corrective action may have been provided.

REFERENCES:

Documents: Personal communicated from Walt Haerer to Don Elle

Photographs:

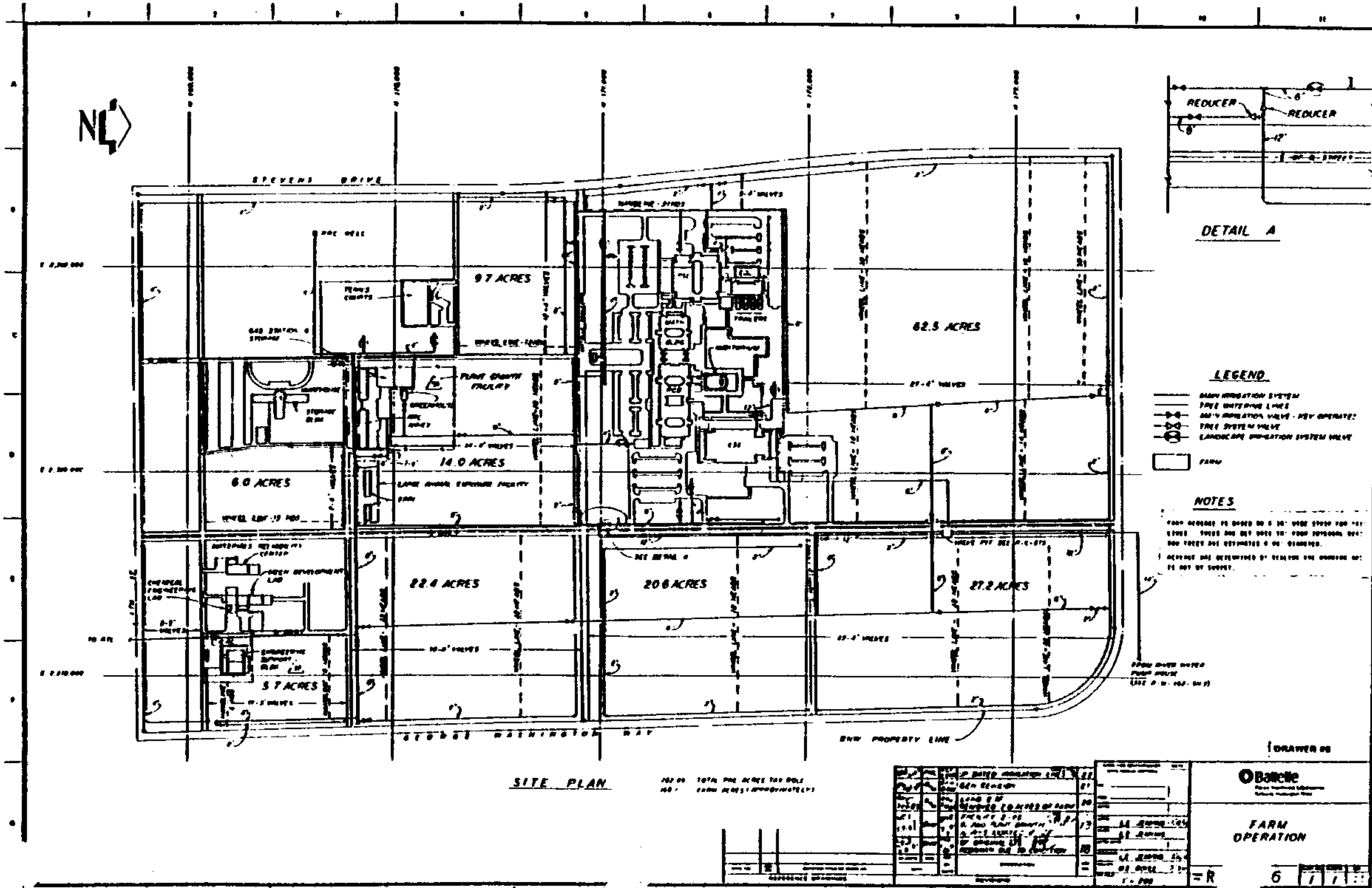
Drawings:

REFERENCE 9

Battelle Farm Operation Drawings, RC-486 and RC-1147

Ref. 9.1

Page 65 of 119



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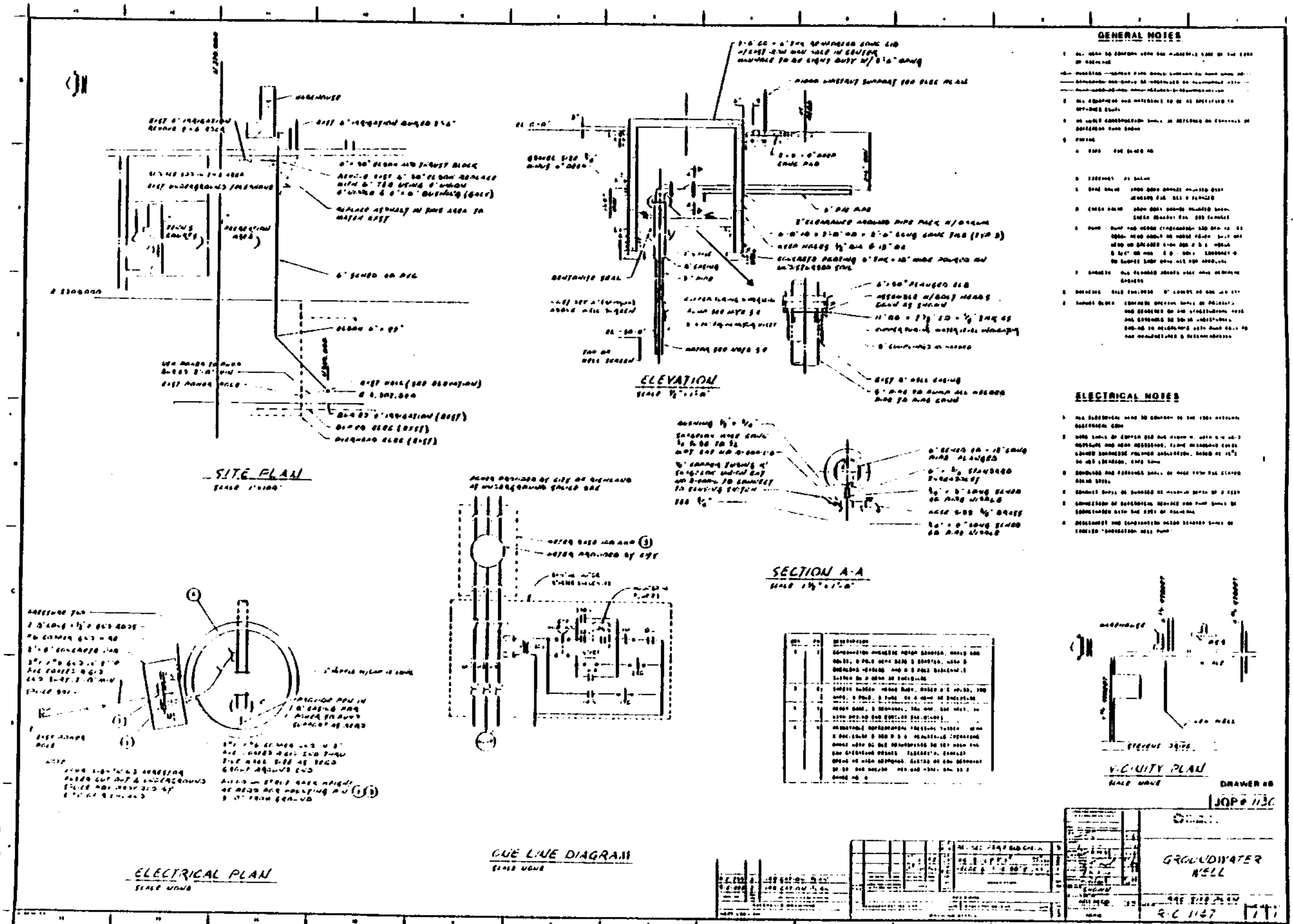

Page 66 of 119

Ref. 9.2

REFERENCE 10

Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes,

March 1986, DOE/EIS-0113, Vol. 1

has been designated a Metropolitan Statistical Area (MSA)[a] by the Bureau of the Census. A detailed review of area socioeconomics is given in DOE (1982), NRC (1982), Piott and Schau (1983) and Watson et al. (1984).

4.8.1 Economy and Work Force

The primary economic bases of the Tri-Cities MSA are the activities at Hanford, services, wholesale and retail trade and manufacturing (NRC 1982; Piott and Schau 1984). Dominant sectors of the economy in 1983 include services (27% of nonagricultural employment), wholesale and retail trade (20%), manufacturing (18%) and government (17%). The contract construction work force declined from 13,550 in 1981 (21% of the nonagricultural total) to 5,620 (10% of the nonagricultural total) in December 1983 (Piott and Schau 1983, 1984). Much of this decline was due to the completion, deferral, or cancellation of nuclear power plant construction. The Washington Public Power Supply System (WPPSS), the major non-DOE-related employer at Hanford, had about 2,200 employees as of March 1984. This is expected to decline to about 1,600 after Unit 2 becomes fully operational. About 13,000 persons are employed on DOE-related projects at Hanford (July 1983). Agricultural employment in Benton and Franklin Counties varies seasonally from a low of about 2,000 to a high of about 6,000 (Piott and Schau 1983).

The average annual per capita income, including agricultural payrolls, was about $8,300 in 1982. As of September 1985, the unemployment within the Tri-Cities was 7.8% compared with 7.2% for the state and 6.9% for the nation (personal communication, Schau 1985).

Certain projects possibly could compete for workers employed in disposal of Hanford high-level and transuranic wastes. These include the construction of a basalt waste isolation facility for disposing of commercially generated radioactive waste (and perhaps defense waste), with a projected peak force of 1,100, and the expansion of Priest Rapids and Wanapum Dams, with a projected peak work force of 1,100.

From 1970 to 1982, housing units increased 94.3%, following increased population and employment that accompanied WPPSS projects in the mid-1970s (Watson et al. 1984). The number of housing units grew at an annual average rate of 7.8% from 1973 through 1981. Richland, Pasco, and Kennewick all have experienced sharp declines in housing growth since 1981 (Watson et al. 1984). Housing units in 1982 in the Tri-Cities totaled about 58,000 with 69% being single-family units, 20% multifamily units, and 11% mobile homes (Tri-Cities Real Estate 1983). The total vacancy rate in the Tri-Cities MSA in 1983 was about 8.6%, or 5,000 vacant housing units (Watson et al. 1984).

4.8.2 Population

There were about 340,000 people residing within an 80-km radius of the 200 Areas according to estimates based on the 1980 census (Figure 4.11). The projected population within an 80-km radius of the 200 Areas for 1990 is about 420,000 (Sommer et al. 1981).

(a) An MSA is a designated population nucleus and surrounding areas that are part of the same economic and social structure. It comprises a single city of 50,000 population or more plus the surrounding associated areas or is a generally urbanized area of more than 100,000 population. The MSA usually follows county boundaries.

9 2 1 2 2 1 9 3 4

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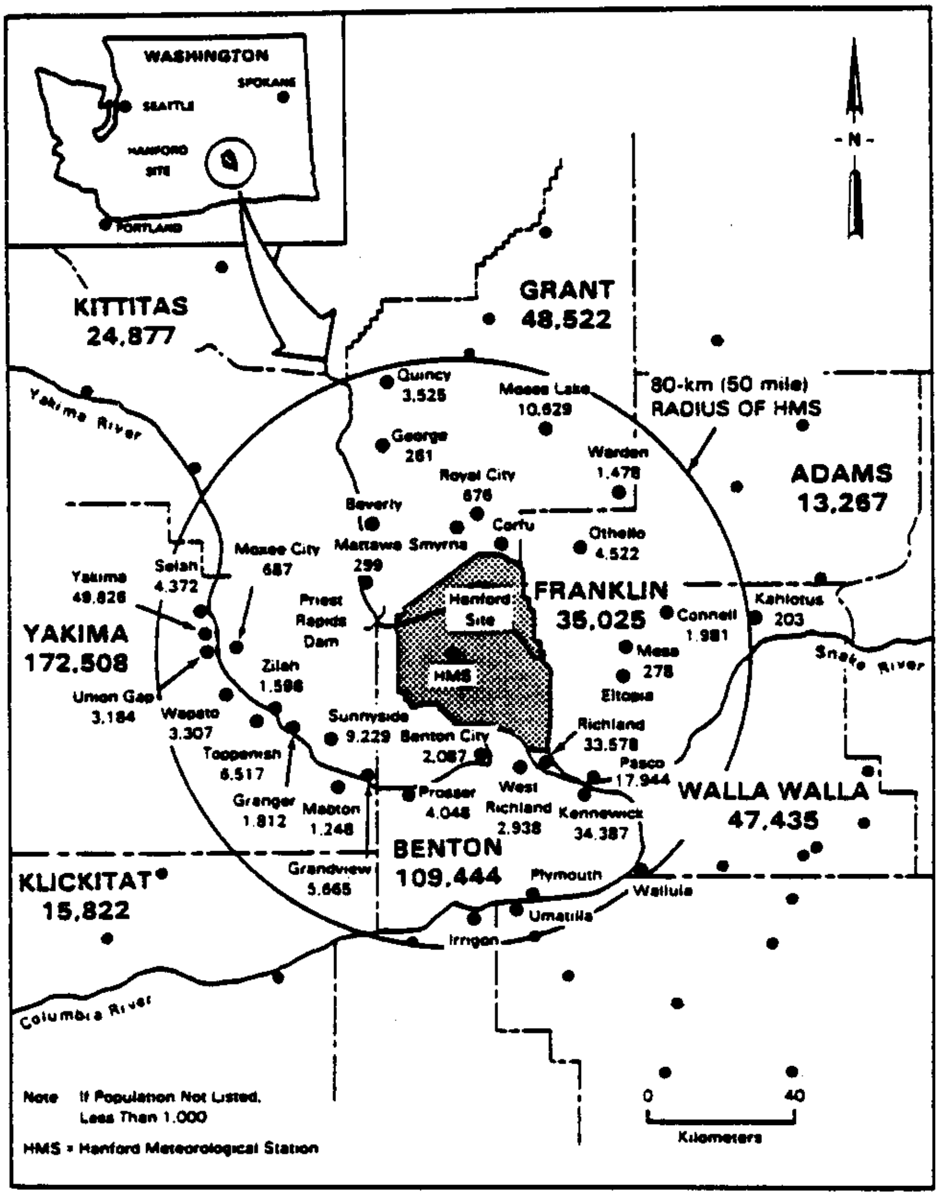
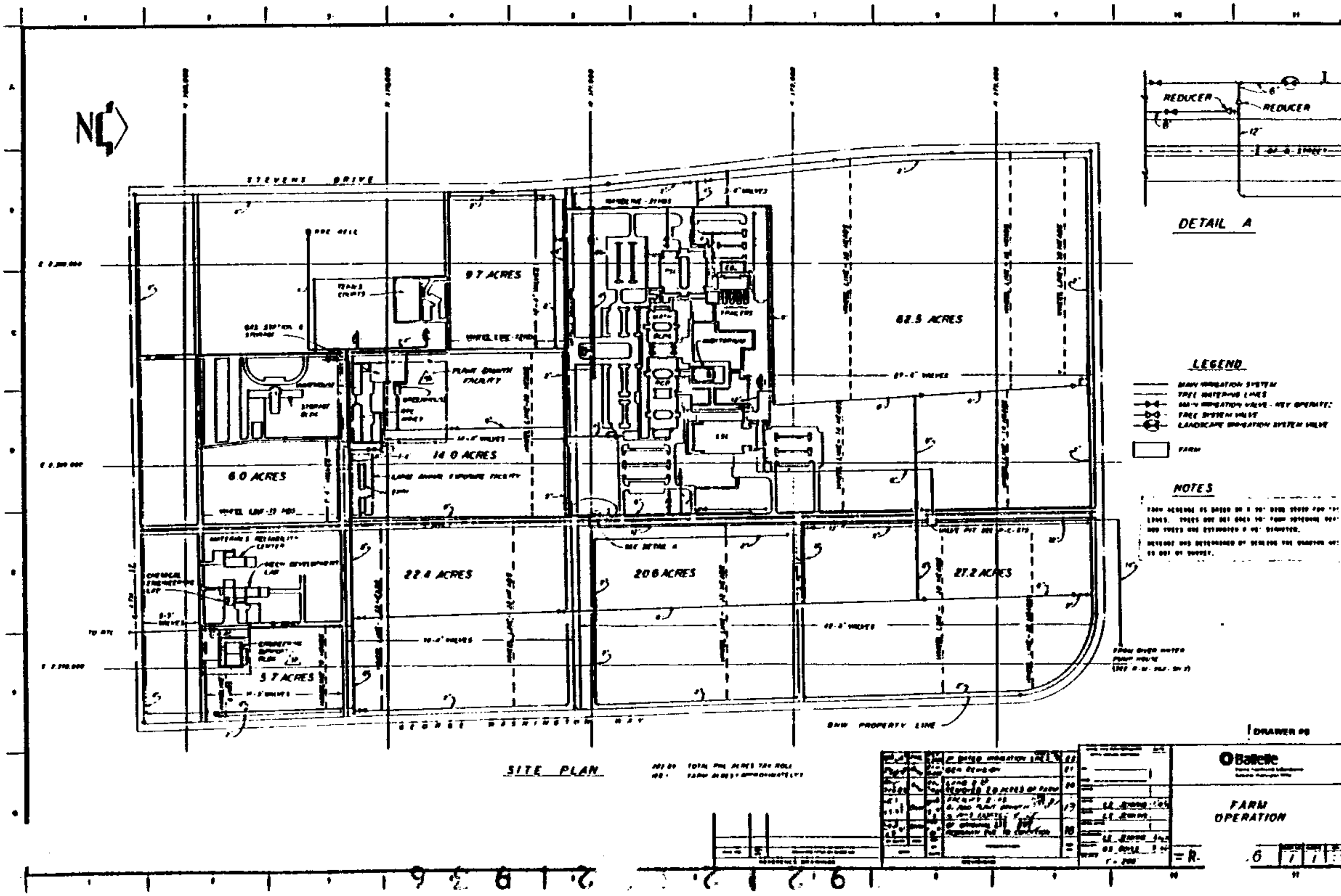


FIGURE 4.11. **U.S. Census Populations for 1980 of Cities Within 80 km of the Hanford Meteorology Station** (DOE 1982a)

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).


STEVENS DRIVE
9.7 ACRES
62.5 ACRES
6.0 ACRES
14.0 ACRES
PLANT GROWTH FACILITY
TENNIS COURTS
22.4 ACRES
20.6 ACRES
27.2 ACRES
5.7 ACRES
GEORGE WASHINGTON WAY
BNW PROPERTY LINE
REDUCER
REDUCER
DETAIL A
LEGEND
FARM
NOTES
SITE PLAN
DRAWER #8
Battelle
FARM
OPERATION

REFERENCE 11

Hanford Reservation Area Workers Census, BNWL-2298, July 1977

9212...2193 7

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.

REFERENCE 12

Hanford Wells, PNL-5397, February 1985

9 2 1 2 5 / 2 1 9 4 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
1199 36 10	N 035550 R E 010196	371.71	26		36.0	26		0- 0	F-20	COVERED OVER
1199 36 19	N 035800 R E 019000	368.51	29			29		0- 0	F-51	COVERED OVER
1199 37 8	N 037250 R E 007600	373.67						0- 0	F-43	COVERED OVER
1199 37 13	N 037890 R E 013300	406.28	52			52		0- 0	F-49	COVERED OVER
1199 37 19	N 036589 R E 010771	373.71			36.0			0- 0	F-11	COVERED OVER
1199 38 11	N 037856 R E 010621	362.26	90		6.0	90		9-44	3000-D-4	
1199 39 10A	N 038585 R E 009526	367.15	100		6.0	100		9-44	3000-D-3	
1199 39 10B	N 039072 R E 010160	362.61	54		6.0	54		8-44	3000-D-2	
1199 39 16A	N 038031 R E 015904	368.82	62		17.0	63	22 - 50	8-48	3000-E	
1199 39 16B	N 038800 R E 015848	371.01	110		8.0	110		3-48	3000-5	
1199 39 16C	N 039097 R E 015621	385.77	75	24	20.0	75	41 - 71	5-48	3000-D	
1199 39 16D	N 039300 R E 015945	371.17	64	10	20.0	64	32 - 62	5-48	3000-C	

301

Page 95 of 112

Ref. 12.1

REFERENCE 13

Memo to file from RD Stenner Regarding Franklin County Drinking Water Wells based on conversation with CL Bates, August 26, 1987

MEMO TO FILE

Date: 8/26/87

From: R. D. Stenner

Re: Franklin County Private Wells that Fall Woiithin the 3-Mile Radius of the 1100 Area

Mr. Clifford L. Bates of the Benton Franklin District Health Department was contacted by a representative of the HRS evaluation team regarding information on the number of wells within the subject boundary. 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 to him.

The number of wells, as determined from the above referenced map, within the 3-mile radius of the 1100 Area Site is 5. These are all private single dwelling wells. Using the 3.8 people/private well factor, the total number of people served by these 5 wells is 19.

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REFERENCE 14

General College Chemistry, 4th Edition, Harper & Row

How much electricity will be required to decompose 1 lb (454 g) of water by electrolysis? The overall reaction is:

$$2H_2O \longrightarrow 2H_2 + O_2$$

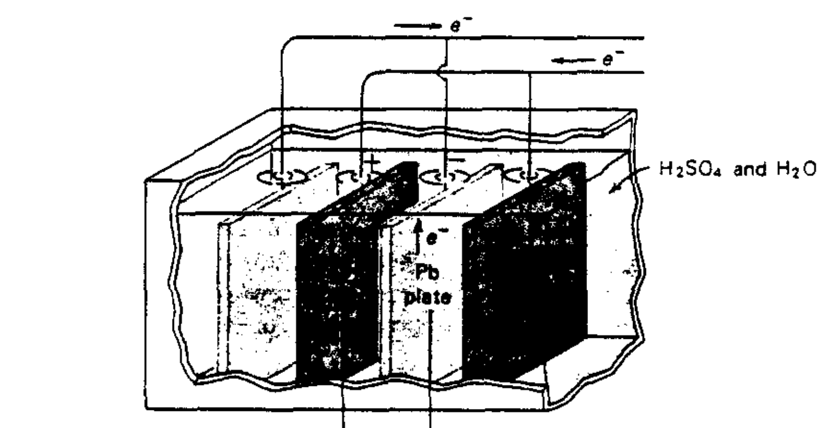
SOLUTION

One mole of water (18 g) contains 2 equivalents of hydrogen (2 g) and 2 equivalents of oxygen (16 g). The equivalent weight of water is therefore 9 g. This weight of water will be decomposed by the passage of 1 faraday of electricity (yielding 1 g of hydrogen and 8 g of oxygen). To decompose 1 lb of water, the following amount of electricity is needed:

$$\frac{454\ g}{9\ g} \times 1\ \text{faraday} = 50.4\ \text{faradays}$$

The production of electric power by chemical reaction is familiar to us in examples such as the automobile lead storage battery[5] or the flashlight battery. During the discharge of a battery, spontaneous reactions occur and the action is that of a voltaic cell. If a battery can be recharged, forced reactions of electrolysis occur which regenerate the original reactants.

LEAD STORAGE CELL. **The storage battery of an automobile can be recharged, so it acts both as a voltaic cell and an electrolytic cell. The battery is constructed of alternate plates of spongy lead and lead dioxide, separated by wood or glass fiber spacers, and immersed in an electrolyte, an aqueous solution of sulfuric acid (Fig. 18-8). When the battery supplies current, the lead plate, Pb, is the negative pole and the lead dioxide plate, PbO_2, is the positive pole. The following changes take place.**



$$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O \qquad Pb \rightarrow Pb^{2+} + 2e^-$$

$$Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4 \qquad Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$$

Schematic representation of the lead storage battery.

[5] The word *battery* was originally used to designate a series of voltaic cells, but it is now popularly used to denote any voltaic source of current, either a single dry-cell "battery" or the several cells of an automobile "battery."

REFERENCE 15

Geology and Hydrology of Radioactive Solid Waste Burial Grounds at the Hanford Reservation, Washington

USGS 1976 open file: 075-625

Dispersion brought about by such ground-water movement may account for the tritium in the ground water at the west end of Gable Butte. Although the tritium in the 200 Areas is not shown as being connected with the tritium north of Gable Butte and Gable Mountain, it is conceivable that tritium could move into this area by ground-water flow around the west end of Gable Butte northward through the gap between Gable Butte and Gable Mountain. The Columbia River water that enters the ground is unlikely to be the source of the tritium concentrations that are mapped. The river water has a tritium concentration on the order of 2 pico curies per mililiter (pCi/mℓ) (Bromson and Corley, 1972, p. 1), whereas wells 699-72-88, -72-92-0, -72-98, which define the extent of tritium contamination at the east end of Gable Butte have water with tritium concentrations of 20 to 30 pCi/mℓ (Kipp, 1973, p. 22).

Conditions at the Solid Waste Burial Grounds

The burial grounds and other solid waste storage sites can be divided into two categories: (1) those lying in the low terraces adjacent to the Columbia River mainly at the 100 Areas and the 300 Area, and (2) those lying on the high terrace south of Gable Mountain in the 200 Areas. The burial grounds in the first category are inactive except for 2 sites in the 100 F Area, one in the 100 K Area, and one in the 300 Area where mainly laboratory wastes are being buried, and the 100 N Area where fuel element spacers are stored. Most solid wastes are now being buried in the 200 Areas.

The waste material contents (including radionuclide activity) of the burial grounds are not well known for all burial grounds, because precise

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records of disposed materials were not kept until recent years. Karagianes (1972) describes the inventory of radionuclides in the solid wastes on the basis of records and indirect estimates.

Included in the present report, as appropriate, for each area containing burial grounds, are:

(1) Site maps of production areas, showing facilities, which were obtained from Vitro Engineering Division. Added to these maps by the authors were burial grounds, wells and test borings, water-table contours, lines of geologic sections and grid lines for the Hanford Plant and other special coordinate systems. These site maps, as obtained, are not accurate as to scale. They are not available for those burial grounds outside of production or laboratory areas.

(2) Plan drawings showing grid lines, burial grounds, wells, and lines of cross sections, which were used as a basis for constructing geologic cross sections.

(3) Geologic cross sections showing profiles of the land surface and water table, and the character of the geologic materials as indicated by well records.

Monitoring well data on ground-water contamination are also discussed. These data were reviewed with the intention of determining their suitability for defining the movement of radionuclides that may occur from solid waste burial grounds. Monitoring well data for the period 1967 to the present are tabulated in the Battelle Northwest files by well number and were available to the project. Prior to 1967, the data are recorded on laboratory analytical reports by sample batches. Most of the monitoring data collected prior to 1957 had been placed in permanent storage in a federal records repository at Seattle, Washington. None of these data in permanent storage was inspected. It proved impractical to follow the monitoring history of more than a few selected wells in detail through the period 1957 to the present because of the difficulty of extracting data for individual wells from the records.

Some general observations can be made on the utility of the monitoring data with regard to the solid waste burial grounds. The monitoring wells on the Reservation were constructed with the intention of detecting movement of radionuclides from cribs, swamps or sumps, and other liquid waste disposal facilities. However, with the exception of 9 monitoring wells (designated by the prefix S6-E4) near the 300 North Burial Ground, where a crib is also located, the placement of a monitoring well near a solid waste disposal site was only by happenstance, or the result of geographic proximity or superposition of solid and liquid waste disposal areas. Only about 5 wells (other than the S6-E4 and 200 Area wells) are situated so as to intercept contaminants leached from the solid waste burial grounds. It appears, however, that any contaminants that may have been leached from solid waste burial facilities are masked by the contaminants from liquid waste disposal.

At few wells was monitoring carried through a long period of time for more than one chemical constituent or type of radioactive determination.

The records are fragmentary apparently because multiple types of analyses were only continued long enough to trace the passage of a particular plume of contaminants that was anticipated to pass a well. The number of analyses was reduced as the level of concentration of the contaminant decreased. Tritium content, beta activity, and nitrate concentration are the most commonly analyzed characteristics or constituents. The detection limits of tritium and beta activity have varied over the years making comparisons within one record difficult. Tritium should be an indicator of liquid wastes from both reactor and fuel reprocessing plants. Beta activity may have either liquid or solid wastes as the source. Alpha activity, which is only selectively analyzed near some cribs, may be from either solid or liquid wastes. Nitrate in large concentrations is associated with liquid wastes, but is naturally present in the ground water in low concentrations. Some nitrate may also be present from agricultural fertilizers, used mainly prior to building of the Hanford Works. The spectrum of analytical data appears to be inadequate to define selectively the materials that may be leached from the burial grounds.

100 B Area

The 100 B Area, the most westerly of the reactor areas, is approximately centered on Hanford coordinates N70,000 and W80,000. It contains three burial grounds, one east of the 105-B reactor, one east of the 105-C reactor, and in the southwestern part of the area (fig. 11). The burial ground east of the 105-C reactor is considered terminated and

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is monumented. The other two burial grounds are unused but as of January 1973 were not officially considered terminated. The locations shown for these latter two burial grounds are approximate within an error of about 50 feet.

Surficial materials in the 100 B area are sand and coarse gravel and the burial grounds are backfilled with the same material. The two burial grounds east of the 105-B and 105-C reactors are on flat or gently sloping ground with no prominent surface drainage.

At the burial ground in the southwestern part of the area, individual burials are marked by concrete posts with brass identification plates. The general land slope is to the north. There are no prominent surface drainage features at or near the burial ground. A small area immediately north of the burial ground is 6-8 feet higher than the northern end of the burial ground. It is possible that runoff could accumulate on the surface at the north end of the burial ground and infiltrate into the ground.

Water-level data are insufficient to define the slope of the water table and the direction of ground-water movement. Although the figure 8 water-table shows no contours in this area, the approximate position of the 400-feet water contour is shown in figure 11. The regional direction of flow is generally toward the river in a northern or northwesterly direction. During times when the Columbia River is at high stage, bank storage entering the ground reverses the gradients and water flows away from the river.

The geologic units underlying the 100 B area along section F-F (fig. 12) are shown in figure 15.

The burial grounds are 50 to 70 feet above the water table, which lies within the glaciofluvial deposits as shown in figure 13. Except when the river is at high stages, it is probable that radionuclides carried downward to the water table by percolating soil water, would move to the Columbia River through the permeable glacial deposits. The Yakima Basalt lies at altitudes of about 100 to 200 feet below sea level. There is a 500- to 600-foot thickness of Ringold sediments including the lowest "blue clay" zone between the glaciofluvial deposits and the Yakima Basalt. It is unlikely that radionuclides from the 100 B Area burial grounds would enter the basalt in the immediate area before being discharged to the Columbia River.

Ground-water samples to monitor radionuclide concentrations were collected at wells 199-B-3-2 and 199-B-4-4. At well 199-B-3-2, 4 water samples collected in 1956-57 showed Beta activity on the order of 10^3 pCi/ℓ, which probably was the detection limit at that time. A later series of samples beginning in 1967 and collected at intervals varying from monthly, quarterly, to semi-annually, with an 18-month period of no record during 1967-69, showed maximum concentrations of about 5×10^3 pCi/ℓ which declined during 1969 and 1970 to about 10^{-2} pCi/ℓ. Several samples taken since 1962 contained 1 to 3 ppm nitrate. As this well is close to a crib and detention basins (107-B, 107-C), it is presumed that the radioactivity resulted from reactor cooling water

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building. Segment G is south of the 105-DR building. The DR Gas Loop site south of the 105-DR building is also considered as a solid-waste burial by Karagianes (1972, fig. 14).

Surface materials at all burial grounds in the 100 D area are sand and coarse gravel, containing cobbles, with a sparse vegetation of weeds. Burial ground no. 1 is marked by monuments, and surface drainage is east and northeast to a swale southeast of the 105-DR building. Burial ground no. 2 is monumented. Its surface is smooth to gently rolling and has no prominent drainage features. Water could collect in subtle depressions on the surface. In general, surface drainage from burial grounds no. 3 and 4 would be southerly to a swale southeast of 105-DR building. Within burial ground no. 3 are bladed-up mounds of soil and an apparently active trench at its east end.

The water-level data for 2 wells in the area indicate that the water table slopes northerly (fig. 16). Ground water that receives any radionuclides from the burial grounds should move to the Columbia River within a few thousand feet of the burial grounds during low and normal stages. When the 107-D and 107-DR detention basins were operated, a ground-water mound doubtless was built up to sufficient altitude to cause ground water to move easterly and southeasterly to the Columbia River at the opposite side of its bend around the reservation.

The character of the materials underlying the area along section line G-G' (fig. 15) are shown in figure 16. The bottoms of the burial grounds are about 55-65 feet above the water table. The saturated zone extends 5-15 feet above the base of the glaciofluvial deposits. Radionuclides reaching the water table from the burial grounds would move to the river mainly through the glacial deposits. The surface of the Yakima Basalt is indicated to be at an altitude of about 100 feet by Brown (1962, fig. 6). It is unlikely that radionuclides leached from the burial grounds would enter the basalt at or near the 100 D area before the ground water discharges to the Columbia River.

Wells 199-D-2-5 and -D-5-12 have been monitored for Beta activity, tritium, and nitrate in the ground water. These wells possibly intercept radioactivity moving from burial grounds nos. 1, 3, and 4. Beta activity at well 199-D-2-5 was monitored on a monthly to quarterly basis from 1967-69. A single sample taken prior to this monitoring period had a Beta activity of about 5×10^4 pCi/ℓ. This and two samples taken during March and April 1967 showed a greater level of Beta activity than the other samples, which consistently had a Beta activity of about 10^2 pCi/ℓ. At well 199-D-5-12 Beta activity was monitored from mid-1967 to present. Unfortunately, the record at this latter well does not extend back through the period when the relatively high Beta activity was obtained at well 199-D-2-5. The character of the fluctuations in Beta activity at 199-D-2-5 suggest either that a minimum of two small slugs of contaminants passed that well in a short period of time or that the samples were contaminated during collection. The Beta activity at well 199-D-5-12 has been rather uniform within the range >10^2 to 5 x 10^2 pCi/ℓ. The tritium and nitrate content of water samples from these two wells were determined for 1971 and 1972. At well 199-D-2-5 tritium rose from about 4 x 10^3 to 10^4 pCi/ℓ and nitrate rose from 2 to about 75 ppm during 1971 and 1972. At well 199-D-5-12 tritium fluctuated between 6 x 10^3 and 10^4 pCi/ℓ during 1970-1972 and nitrate rose from about 10 to about 65 ppm from 1971-1972. Both monitoring wells almost certainly are intercepting wastes moving northeastward from the 100 N area where a ground-water mound has been built up by discharged waste water. Such a direction of movement is indicated by figures 9 and 10. It appears that the contaminants reaching these wells from the 100 N Area make the record obtained from them of little value in evaluating the possibility that radionuclides may be entering the ground water from the solid waste burial ground.

100 F Area

The 100 F Area is on the eastern limb of the bend of the Columbia River at Hanford Plant coordinates N79,000 and W31,000. Terminated and monumented burial grounds nos. 1, 2, and 3 are in the southwest quarter of the area (figs. 17 and 18). Battelle Pacific Northwest Laboratories operates a burial ground for radioactive refuse from biological experiments at the south side of inactive burial ground no. 1. Battelle PNL also operates the so-called Sawdust Repository, east of the 100 F area, where litter from animal pens containing small amounts of radioactivity is buried as a land fill.

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The soil material at the inactive burial grounds is sand and coarse gravel. Vegetation is sparse. The surfaces of the burial grounds are graded fairly smooth. At burial ground no. 2, the land surface is several feet above swales and linear depressions bordering it. Wind deflation appears to have removed some of the soil cover from an area on burial ground no. 2.

The water table is not clearly defined by the ground-water level information for the area but it appears to slope northeasterly toward the Columbia River. There may be a low ground-water mound built up in the vicinity of the 107 basin as a result of waste water discharge from the Battelle laboratory operation.

The water table lies within the glaciofluvial deposits, as shown in figure 19, and is within 10 feet of the land surface at the southwest part of the 100 F area. The depth to water increases northeasterly across the area, mainly because of a rise in the land surface. The water table is close to the surface in the area where burial grounds nos. 1 and 2 are located. Conceivably the water table could rise into burial ground nos. 1 and 2 as a result of a high stage of the Columbia River. Burial ground no. 3 and the Sawdust Repository are on higher ground and the depths to the water table are somewhat greater. The water table lies within the glaciofluvial deposits, through which the ground water from the vicinities of the burial grounds can move freely to the Columbia River within distances of a few thousand feet. The Yakima Basalt lies at about sea level beneath the 100 F Area, and 300 feet or more of the Ringold Formation lies between it and the glaciofluvia deposits. It is unlikely that radionuclides leached from the burial grounds would enter the basalt before reaching the river.

Monitoring records of radioactivity at wells 199-F-5-1 and 199-F-8-1 were inspected. Water sample analyses on both these wells are sparse. Thirteen samples analyzed for Beta activity from well 199-F-5-1 from 1956 to 1962 indicate that some contaminants reached this well in 1958 and persisted through 1962. Source of these radionuclides probably was the 107 detention basin or a nearby crib. Samples analyzed for Beta activity in 1967-68 were at laboratory detection levels. Tritium and nitrate analyses for 1971-72 indicate that negligible concentrations, if any, of these contaminants were in the ground water at this well. It is improbable that continued surveillance would provide any data useful in evaluating the burial grounds. The well is too far from the abandoned burial grounds and not in the path of ground water moving below the Sawdust Repository, but samples from it may show if radionuclides move away from the crib.

Well 199-F-8-1 is near burial ground no. 3 but the well appears to have been installed to monitor liquid waste discharge to a crib between it and well 199-F-8-2. Few analytical data were found for this well. Four analyses for nitrate in 1962-63 indicated that the water in the well was contaminated (11 ppm) in June 1962, but the other 3 samples contained about 1 ppm. A later series of analyses for 1971-72 showed nitrate concentrations varying between 55 and 75 ppm.

Tritium content for this same period was fairly constant at about 2×10^4 pCi/ℓ. Well 199-F-8-1 reflects the contaminants in a large body of polluted ground water which partly underlies the 100 F area. This body of polluted ground water is shown in figures 9 and 10. The source of the polluted water may not be the 100 F area. This water may have moved eastward from the reactor areas on the western limb of the bend on the Columbia River, or it may have moved northward between Gable Butte and Gable Mountain from the 200 Areas and then eastward. Monitoring records of nitrate north of Gable Mountain are too few to define the source of this body of water. Beta activity was not determined for the wells in the 100-F Area so it is not known if radionuclides other than tritium are associated with the high nitrate concentrations. The value of well 199-F-8-1 is suspect in monitoring radionuclide movement from the burial grounds because of the possibility that contaminants from another source have moved into this area.

100 H Area

The 100 H Area is the most northerly of the reactor areas and is well within the bend of the Columbia River. The Hanford plant coordinates N95,000 and W40,000 intersect within the area (fig. 20). Burial grounds nos. 1 and 2 are about 1,000 feet southwest and about 1,200 feet west, respectively, of the 105 reactor building. Both of these burial grounds have been terminated and are marked by monuments. They are built up a few feet above the apparently original land surface by a fill of sand and coarse gravel. Burial ground no. 1 is bounded by broad swales. Shallow closed basins have been formed in these swales by artificial fill for a road cutting across the burial ground and by fill for the railroad line to the east. Burial ground no. 2 is in a flat area which appears to have been modified from the original topography. A few small shallow depressions lie along its margins.

The geologic materials along a line J-J' across the area (fig. 21) are shown in cross section in figure 22. The slope of the water table is not defined by the limited water-level data in the area. The water table probably is at about an altitude of 375 feet and lies within the glaciofluvial deposits. A significant ground-water mound was built up by water discharged to the 107 detention basin in years prior to 1965. Only two wells (199-H-3-1 and 199-H-4-2) are presently monitored for water-level altitude. Well 199-H-4-2, the deeper of the two, is described by K. L. Kipp, Jr. (written communication, 1973) as tapping confined ground water, presumably water in the Yakima Basalt. The water-level altitude in this well appears to be significantly higher than the water table.

The depth to the water table beneath the burial grounds is about 10 to 20 feet. Under present conditions, any radionuclides reaching the water table would generally follow a direct easterly course to the Columbia River through a distance of 3,000 to 4,000 feet. At times of high river stage, however, the direction of ground-water movement may be reversed for a time.

There is a scanty radiological monitoring record available for well 199-H-3-1. However, data from this well are not significant with regard to the solid-waste burial grounds. Ground water flowing beneath the burial grounds would not reach this well as long as the former ground-water mound existed around the 107 basin. Three analyses made during 1962-63 showed tritium to be about 10^5 pCi/ℓ and nitrate to be 10 ppm which probably were caused by local waste discharges. Beta activity, based on 10 samples, during 1967-68, was 10^2 pCi/ℓ, with one sample of 3×10^3 pCi/ℓ, which probably was contaminated during collection or was poorly analyzed. Samples were again taken from the well during 1971-72 for tritium, which was about 10^4 pCi/ℓ and nitrate, which was about 8-10 ppm. It would appear from figures 11 and 12 that these recent samples contain contaminants that entered the 100 H area by moving northeastward from the 100 N area.

100 K Area

The 100 K Area is located at Hanford plant coordinates N76,000 and W69,000. Facilities within the area have been surveyed by a land grid specific to the area. Both the Hanford plant and the 100 K grids are shown in figures 23 and 24. There is one large burial ground in that area at Hanford coordinates N77,000 and W67,000. This burial ground is not in use but is considered active and is fenced.

The burial ground is on the high river terrace on which the principal facilities of the 100 K Area are located. The surface materials

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and backfill at the burial ground are mainly sand and coarse gravel. These materials have been graded to a fairly smooth surface, which drains northward toward a large effluent basin. There is a burning pit a short distance north of the southeast corner of the burial ground. This burning pit is 20-25 feet deep at its center.

The water table is inadequately defined by two observation wells in which water levels are monitored. With the shutdown of the 105 KE in January 1971 and 105 KW reactors in February 1970, the ground-water mound built up by discharge of waste water to the ground began to decay. An experiment during 1973 at the 100 K Area required the pumping of a large quantity of river water. If any of this water were discharged to the ground, the water table was again modified. It is possible that, at the burial ground, the water table lies at an altitude of about 390 feet, which is about 60 feet below the bottom of the burial ground. The water table is in the conglomerate zone of the Ringold beneath the southern part of the burial ground and in the glaciofluvial deposits beneath its northern part (fig. 25). Radionuclides reaching the ground water would have a direct flow path about 2,000 feet long, northerly or northwesterly to the Columbia River through the most permeable part of the Ringold Formation and the glaciofluvial deposits (figs. 25 and 26). At least a 450-foot thickness of the Ringold Formation intervenes between the water table and the Yakima Basalt. The blue clay zone in the lowermost unit of the Ringold appears to have been reached by wells 199-K-10 and 199-K-11 at about a depth of 300 feet. It is unlikely that radionuclides from the burial ground would enter the basalt before reaching the river.

Radiological monitoring of ground water was done at wells 199-K-11 and 199-K-20. Neither of these wells is placed so as to intercept radionuclides that may move from the burial ground through the ground-water body. Well 199-K-5, which is within the burial ground, was drilled for subsurface information and its casing was removed. This well was never used for monitoring. Unless this well was refilled with care to prevent circulation through it, it may be an avenue of downward movement of radionuclides from the buried wastes.

The radionuclides in the ground water at the 100 K Area apparently were from local sources such as the effluent trench near well 199-K-20. This well was sampled 13 times for Beta activity from November 1956 to October 1959 and showed a general rise to about 10^4 pCi/ℓ. Another series of Beta activity determinations for the years 1968-72 showed levels of about 10^6 pCi/ℓ which declined throughout 1970, after waste discharges ceased, to about 10^2 pCi/ℓ. Beta activity at well 199-K-11 was low, about 10^2 pCi/ℓ during the period 1967-69 but the well was not otherwise sampled for Beta activity. Tritium apparently was released to the ground locally within the 100 K Area. Tritium determinations for the two monitoring wells are few and were made mainly during 1971 and 1972. These tritium data, though inconclusive, suggest that some tritium-bearing ground water moved southward when waste water was discharged to the ground, then moved northward toward the Columbia River as normal gradients were restored. A large body of nitrate contaminated ground water is south and southeast of the 100 K Area (fig. 10) and may move northward through the area to the Columbia River. The possibility that wastes originating outside the 100 K Area may move into the area should be considered if monitoring of the burial ground is undertaken.

100 N Area

The 100 N Area is located at Hanford coordinates N85000 and W61000. Surveying within the area based on a local 100 N grid which is shown on figures 27 and 28 along with the Hanford grid. The only radioactive solid wastes stored in the 100 N Area are used fuel element spacers, which are stored in a concrete subsurface structure containing three silos northwest of the 105-reactor building. The spacers may be retrieved through hatches in the tops of the silos. There is no likelihood of radioactivity from the spacers entering the soil materials as long as the storage structure is intact.

The surficial materials in the 100 N Area are principally sand and coarse gravel of the glaciofluvial deposits. These are underlain at an indefinite depth by the middle conglomerate unit of the Ringold Formation. The upper surface of the Ringold may range from about an altitude of 350 feet near the Columbia River to about 400 feet in the eastern part of the 100 N Area (figs. 29 and 30). At well 699-86-60, where the top of the Ringold is at an altitude of about 400 feet, the top of the blue clay unit is at an altitude of about 360 feet.

A large ground-water mound has been built up to an altitude of more than 400 feet, more than 20 feet above normal river stage, where waste water is discharged to the ground in the northeastern part of the area. Ground water has moved in all directions from this mound. The eastward moving ground water probably has carried contaminants into the 100 H and 100 F Areas. Radionuclides entering the ground-water body from the spacer storage will move toward the Columbia River under the influence of the high artificial ground-water gradient from this mound. If waste-water discharge were stopped and the mound decayed completely, movement of ground water beneath the spacer storage facility would still be toward the river but at a lower velocity. However, at times of high stage of the Columbia River, there would be a movement of water eastward beneath the spacer storage facility. In fact, during high stages, water might move in the subsurface across the part of the reservation enclosed by the bend of the river and eventually enter the river (after it had returned to normal stage) in the reach that includes the 100 H and 100 F Areas.

Although several completed wells are in and near the area of waste discharge, only test boring data are available on the subsurface materials in the southern two-thirds of the 100 N Area. Samples for radiological monitoring are collected regularly at wells 199-N-3, 199-N-4, and 199-N-10 near the waste discharge. Beta activity, tritium, and nitrate concentrations are available and originate from reactor liquid wastes.

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300 Area

The 300 Area is in the southeastern part of the Hanford Reservation at S 24000 and E 13000 of the Hanford plant coordinate system. Facilities in the 300 Area are referenced to the Richland coordinate system. Both systems of coordinates are shown in figures 31 and 32.

The burial grounds in or near the 300 Area are designated no. 1, 2, 3, 4, 5, 7, 8, and 300 West. Of these burial grounds, only no. 7 is still receiving solid wastes. Burial ground no. 1 is east of the 333 building at plant coordinates S 24000 and E 13400 and is marked by monuments. Part of its surface is paved with asphalt and the remainder is graded smooth. Two small steel buildings are on it.

Burial ground nos. 2 and 3 are side by side a short distance north of burial ground no. 1 and are marked by monuments. Surficial materials are sand and gravel. A few minor depressions occur in the surface. Surface drainage is to the north.

Burial ground no. 4 is north of the 300 Area and is marked by monuments. Surface materials are sand and gravel. It is in a broad shallow swale that drains eastward to the Columbia River. Fill placed in the burial ground has blocked drainage through the swale and created a surface depression centering on the burial ground. The depression may also be partly caused by compaction of buried materials. With the present condition, runoff can collect on the burial ground and seep through it. The burial ground may also be susceptible to erosion by runoff, if the fill is washed out.

Burial ground no. 5 is also located in a swale about 1,000 feet southeast of burial ground no. 4. A burning pit, the use of which was discontinued in 1973, is within the monumented confines of the burial ground. Excavation and backfilling for the burials has considerably modified the natural drainage. The swale has been blocked by fill at the downstream end of the burial ground and an excavation was made on the upstream end. As with burial ground no. 4, burial ground no. 5 may collect runoff that will infiltrate through it, and it may be eroded by surface water.

Burial ground no. 7 is northwest of the main facilities sector of the 300 Area. It is marked by steel posts and a chain. Surficial materials are sand and coarse gravel. Natural topography consists of rolling prairie with 8-10 feet of relief. Operations at the burial ground have considerably modified the surface at places. In January 1973, a trench was open in the northern part of the burial ground in which a variety of solid wastes had been placed. These wastes contained such items as stainless steel and aluminum vessels, a tank truck body, machine equipment, a wooden ladder, and various packaged wastes. Presumably these materials were only slightly contaminated by radioactivity as access to them was controlled only by radiation signs.

The 300 West burial ground is about 1000 feet southwest of burial ground no. 7 (fig. 32) and is marked by monuments. It is a small burial ground about 20 by 140 feet in dimension. The surficial materials are sand

and gravel. The topography of the burial ground and surroundings is gently rolling. The 300 West burial ground contains uranium-bearing solvent in steel drums which were buried in 1955-56.

The water table beneath the 300 Area is affected by waste water discharges to the north and south process ponds. A low ground-water mound has formed beneath the ponds (fig. 31). This mound causes ground water that normally would move beneath the burial grounds, to follow circuitous courses to the Columbia River. The water-level data on the 300 Area are insufficient to allow the flow paths from the burial grounds to be traced. If waste-water discharges were stopped, ground water should flow easterly directly to the river after the mound decayed. All of the burial grounds are close enough to the river, so that ground-water flow beneath them is reversed when the Columbia attains high stage in late spring.

The relationships of the burial grounds to the geologic materials and the water table are shown in the cross sections of figures 33 and 34.

Within the 300 Area, the water table lies at a general altitude of about 342 feet. The more easterly burial grounds are about 20 feet above the water table; the westerly burial grounds are about 40 feet above it. The water table lies in the glaciofluvial deposits, which are underlain by the middle conglomerate unit of the Ringold Formation. Hydraulic data show that the water-bearing materials in the 300 Area have a high transmissivity and the movement of water to and from the Columbia occurs at a high rate (Tillson, Brown, and Raymond, 1969). The surface of the

Yakima Basalt is at an altitude of about 200 feet. There is a saturated section of about 140 feet of Ringold Formation and glaciofluvial deposits above the basalt. The Yakima Basalt probably is involved little, if at all, in the movement to the river of wastes originating in the 300 Area.

Radiological and chemical monitoring data are available for 14 of the wells shown in figures 31 and 32. Tritium was not determined but alpha activity and Cr^{+6} and F^- concentrations, as well as beta activity and nitrate concentrations, were measured in ground-water samples.

Apparently all of the contaminants observed at these wells are locally introduced by liquid waste discharges, principally to the process ponds. The concentrations of contaminants observed at wells decrease in a general way with distance of the well from the process ponds. Radioactivity in the ground water is caused mainly by uranium (Kipp, 1973, p. 23). Beta and alpha activities generally are low. In wells near the ponds, beta activity occasionally reaches levels of 10^4 pCi/ℓ or somewhat higher, but generally is not much higher than 10^2 pCi/ℓ. Nitrate is the principal chemical contaminant having reached concentrations greater than 100 ppm in the ground water near the ponds. Nitrate determinations on wells 399-8-1, 399-8-2, and 399-8-3 indicate that wastes from the process ponds probably have moved beneath even the most distant burial grounds.

300 North Burial Ground

The 300 North burial ground is about 2-1/2 miles north-northwest of the 300 Area at Hanford plant coordinates S 6000 and E 3000 (fig. 35). Its boundaries are delineated by monuments. The burial ground is in an area of undulating topography with 10 to 20 feet of relief between swales and hillocks. There is no plant topographic map for this area. Altitudes are available for wells and the corners of the burial ground (fig. 35). The profile of the topography shown in figure 36 was based on the U.S. Geological Survey topographic map of the Richland quadrangle (contour interval, 20 feet).

Surficial materials are sand and coarse gravel. Surface drainage from this area is eastward to the Columbia. However, the burial ground has been graded with earth-moving machines, is poorly drained, and may be in a closed basin. Seven wells were drilled east and southeast of the burial ground. Five of these wells were found in 1973 to be still in existence. Apparently one of the wells was a production well which supplied water to wash out truck bodies after wastes were delivered to the burial ground. It was reported that this wash water was disposed of in a crib adjacent to the burial ground.

The ground-water level is monitored near the burial ground at well 699-S6-E4C. This record indicates the water table to be at an altitude of about 370 feet. The water table is within the permeable glaciofluvial deposits, as shown in figure 36. The water table is about 45 feet beneath the bottom of the burial ground. The Hanford water-table

9 2 1 2 4 2 1 9 5 9

map (fig. 8) indicates that ground water moves easterly from the burial ground to the river. The map of tritium concentrations in ground water (fig. 9) shows that there is a preferential movement indicated by the most southerly segment of the waste plume extending from the 200 West Area. In general, the direction of ground water should roughly approximate the line of section of figure 36. The length of the flow path from the burial ground to the river is on the order of 2 miles.

Monitoring of ground water at wells 699-2-3, 699-S6-E4C, and 699-S11-E14 indicate that wastes from the 200 West Area have appeared at all three wells. At well 699-2-3 tritium reached a level of $>10^3$ pCi/ℓ in 1969, indicating that contaminants were present. Tritium increased to 2×10^4 pCi/ℓ by October 1972. Nitrate content at this well increased in 1970 to 16 ppm and has been rather erratic in concentration since, but at levels generally of 7.5 to 10 ppm. Beta measurements were discontinued at this well before the arrival of the tritium.

At well 699-S6-E4C piezometers O and P have been sampled. Piezometer O is 148 feet deep and piezometer P is 460 feet deep. The shallow ground water is not monitored at this site. Beta activity has not been determined since 1969. However, tritium and nitrate appear to have been present as contaminants in small concentrations. In the shallower piezometer, nitrate was as high as 6 ppm in 1969. Tritium has fluctuated in recent years from 5×10^2 to 10^3 pCi/ℓ. In the deeper piezometer, tritium fluctuations were similar but nitrate did not rise above a maximum of about 2 ppm.

9 2 1 2 3 2 1 9 7 1

At well 699-S11-E12 nitrate concentrations rose to 6 to 11 ppm during 1971 and 1972, which definitely indicate the arrival of wastes. Beta activity was not monitored. Tritium was reported at low levels during 1971 and 1972, except for one measurement of 7.7×10^4 pCi/ℓ, which probably resulted from a contaminated sample or a poor measurement.

300 WYE Burial Ground

The 300 WYE burial ground is about 7-1/2 miles northwest of the 300 Area and 3-1/2 miles west of the Columbia River (fig. 1). The burial ground is inactive and is marked with monuments. The WPPSS (Washington Public Power Supply System) Hanford No. 2 generating plant is under construction to the east of the burial ground.

The burial ground is on one of the lower river terraces with an altitude of 440 feet and with a topography characterized by areas of rolling prairie and intervening broad, flat meadows. There is no plant topographic map of the burial ground area. The authors have drawn contours of the area, shown in figure 37, on the basis of altitudes obtained by WPPSS in its site investigation for the Hanford No. 2 generating plant. Land surface profiles shown in figures 40 and 41 were drawn on the basis of the topography shown on the U.S. Geological Survey topographic map of the Richland quadrangle. A low medial ridge, 4-5 feet high, trends east-west through the burial ground. Drainage from the burial ground is locally north and south of this ridge and generally eastward to the Columbia River. There are some shallow depressions at the west margin of the burial ground.

Surficial materials at the burial ground are sand and gravel of the glaciofluvial deposits. These extend downward about 45 feet, as shown in figures 38 and 39, to the middle unit of the Ringold Formation. However, the base of the glaciofluvial deposits is not definitely known in this area, and it may really lie at a greater depth of about 40 feet below the bottom of the trenches at the burial ground. There are some tubular-shaped caissons that reportedly received considerable solid radioactive wastes in the burial ground, which extend to greater depths than the trenches.

Ground water moves easterly from the 300 WYE area to the Columbia River. The lobate fronts of the waste plumes from the 200 East Area, shown by tritium and nitrate concentrations of ground water (figs. 9 and 10) indicate that ground water flow is more rapid to the north and south of the 300 WYE burial ground. These differences in the rate of ground-water flow probably result from the different transmissivities of materials in the upper part of the zone of saturation from place to place on the Reservation.

No monitoring wells are near enough to the 300 WYE burial ground to have any utility in determining if contaminants from the solid wastes are reaching the water table. Wells 699-17-5 and 699-9-E2, the closest monitoring wells, are each about a mile from the burial ground. Soil borings by WPPSS, listed on figure 39, were drilled recently. WPPSS reportedly may monitor two of these borings for water levels and radioactivity but probably in connection with liquid waste discharges or for possible leaks from the Hanford No. 2 generating plant. The monitoring record for well 699-17-5 indicates that wastes from the 200 Areas recently (1972) may have reached that well. Occasional nitrate concentrations above background concentrations have been observed at that well since 1967. These may be accounted for as due to contaminated samples or poor laboratory analyses. In 1972, nitrate contents of 5.9, 11, <0.5, and 7.7 ppm were observed in the months of February, May, July, and September, respectively. Three of these determinations are indicative of contamination.

200 Areas

The 200 East and 200 West fuels separations areas are spaced about 3 miles apart in the central part of the Hanford Reservation on a high terrace with an altitude of about 700 feet. The 200 East Area is approximately centered on Hanford coordinates N 42000 and West 52000 and the 200 West Area on Hanford coordinates N 42000 and W 74000.

The solid waste burial grounds and regulated storage sites in the 200 Areas contain most of the radioactive solid wastes from the operations at Hanford. There are 27 solid waste burial sites and 9 regulated equipment storage locations (L. L. Lundgren, Atlantic-Richfield Hanford Co., written communication, January 26, 1971). Many of the burial grounds coalesce into large areas of solid waste burials. The Atlantic-Richfield Hanford Company is presently updating drawings and maps showing the various burial grounds and other solid waste storage. Most of the burial grounds are shown in figures 40 and 41. Wastes generally have been placed

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in trenches in the burial grounds which were backfilled with the excavated soil material. There is also contaminated or radioactive equipment in various storage facilities. The largest such facility consists of two railroad tunnels in which are stored flat cars containing large radioactive equipment items from the Purex plant (the 202-A building in figure 40). Such stored equipment is presently retrievable.

The topography of the 200 Areas is flat or gently sloping. In the 200 East Area the slope of the land and the natural drainage is northeasterly. In the 200 West Area the land slopes and natural drainage are mostly westerly and southwesterly. Both of the 200 Areas are intensively developed and drainage is now controlled along the networks of roads and railroads, the waste-water canals and ponds, and other structures. The 700-foot altitude of the 200 Areas would seem to place them well above any conceivable extreme flood levels of the Columbia River. Unruh (1970, p. 25) states, "....a coincident failure of Grand Coulee Dam and the simultaneous arrival of breech (sic) flows from upper Canadian storage projects.....would produce a flow of only 10 million cfs past Hanford. Even this flow rate would raise the surface waters to an elevation only 560 ft. above sea level...."

The surficial materials in the vicinity of the 200 Areas are mainly sand and gravel of the glaciofluvial deposits. In the 200 West Area the surficial materials are a finer grained facies of the glaciofluvial deposits and consist mainly of sand and silt. The subsurface geology of the 200 Areas has been described by Brown (1959). Figure 42 is a topographic map of the 200 Areas taken from Brown's report and shows lines of geologic cross sections that Brown prepared. Figures 43, 44, 45, 46, and 47 are copies of Brown's cross sections and show the character of the geologic materials at depth in the vicinity of the 200 Areas.

The glaciofluvial deposits are much thicker beneath the 200 East Area than they are beneath the 200 West Area. As a result of waste water discharge, the water table has risen into the glaciofluvial deposits beneath the 200 East Area. The water table has risen considerably higher beneath the 200 West Area, but it is well within the Ringold Formation. Because the glaciofluvial deposits are much more permeable than the Ringold Formation, wastes in the ground-water system move away from the 200 East Area much more rapidly than they do from the 200 West Area. The extent of waste movement and the direction of ground-water flow from the 200 Areas is indicated by the bodies of wastes originating in these areas and moving principally easterly and southeasterly as a large plume and northerly toward the Columbia River (figs. 9 and 10).

Radiologic monitoring of ground water has been intensive in the 200 Areas and immediate vicinity. However, this monitoring has been conducted to provide operating information for liquid waste discharge facilities, consisting of cribs and ponds, and to provide information on the movement of radionuclides from liquid wastes through the ground-water system. The monitoring wells are not located to detect if materials from solid wastes have entered the soil or the ground water beneath the burial grounds.

In recent years, a considerable effort was made at Hanford to develop a predictive computer model of waste transport through the soil and ground-water system. Cearlock (1971) describes the features of this computer model system. De Mier (1972) described the use of the model relative to ground-water flow and indicates that the predictive capability of the model is poor, except for the region of the tritium plume extending southeast of the 200 East Area and shown on figure 9. The modeling of waste movement through the soil at Hanford is still in the development stage. Further laboratory and theoretical studies are necessary to determine the intereactions of wastes and soil materials and to develop suitable mathematical relationships (Battelle Pacific Northwest Laboratory, 1972, p. 2).

213 Area

The 213 Area is located on the south flank of Gable Mountain at Hanford coordinates N 54000 and W 35000 (fig. 1). It includes a concrete structure containing two vaults formerly used for storing the plutonium product of the Hanford Works and two small burial pits in the yard south of the vault structure. These pits are reported to be about 4 feet deep and to be covered with rough concrete slabs about 8 feet square. They received both solid wastes such as plutonium-bearing wipe rags and wash water used for decontamination. The wash water may have contained particulate plutonium.

The yard where the pits are located has a gently sloping surface. However, runoff can reach the area from a steep slope north of the facility.

In light of the shallowness of the pits, erosion by surface water or wind may in time release the wastes. The water table is probably on the order of 150 feet or more below the land surface. It may lie either within the unconsolidated deposits or the Yakima Basalt. The concrete slab covers probably have prevented water from infiltrating the ground. The wash water presumably could have carried either dissolved or particulate plutonium into the ground beneath the pits.

Hydrologic factors related to long-term waste storage at burial grounds

The burial grounds in the 100 Areas and the 300 Area have in common the following features: (1) nearness to the Columbia River, (2) unsaturated materials above the water table are mainly coarse-grained glaciofluvial materials, (3) the uppermost part of the saturated zone is mainly in coarse-grained glaciofluvial deposits and the middle conglomerate unit of the Ringold Formation, (4) location on low river terraces that could be flooded and eroded away without the protection provided by upstream dams on the Columbia River or they could be flooded in the event of a rupture of a dam. In the light of the hydrologic setting of these burial grounds in the areas near the river, it can be concluded that they are not suitable for long-term storage of radioactive solid wastes. Radionuclides could conceivably be leached from the wastes by infiltrating water and reach the water table, from which they could reach the Columbia River within several days to several months. Despite the dry climate at Hanford, infiltration and ground-water recharge could occur in amounts of significance to radionuclide transport in the 100 Areas and 300 Area burial grounds. The precipitation is seasonally distributed with about one-half of the average annual precipitation occurring in the winter months when evapotranspiration is negligible and conditions for infiltration are most favorable. These burial grounds are underlain by very permeable deposits, and the water table is relatively close to the surface. The possibility of water infiltrating through the burial grounds and reaching the water table is enhanced if the burial grounds have surface depressions in which water can collect, as some of them do.

The 100 Areas and 300 Area burial grounds would be flooded in the event of the "probable maximum flood" predicted by the U.S. Army Corps of Engineers (1969). However, such a flood would cause much more serious results by inundating reactor and laboratory buildings. The possible flooding of these burial grounds is not as important a factor in their evaluation as is the possibility of the release of radionuclides through the soil water and ground-water systems, which could be a continuous process.

The 300 North and 300 WYE burial grounds are on relatively low river terraces but are at a considerable distance from the Columbia River. Except for their greater distance from the river, they have all the undesirable features of the 100 Areas and other 300 Area burial grounds.

The 200 Areas burial grounds are the most favorably situated for long-term storage of any of the burial grounds in the Hanford Reservation. They lie on a high terrace underlain at depth by fine-grained materials.

The depth to the water table is on the order of 200 to 300 feet. These depths would be greater if waste-water discharge to the ground were stopped and natural ground-water conditions were restored. The great depth of the water table and the fine-grained sediments at depth make it much less likely than in the 100 Areas that infiltrating water would actually reach the water table under present climatic conditions. The fine-grained geologic materials at shallow depth beneath the 200 Areas have been shown to sorb large proportions, but not all, of the radionuclides that have been discharged to the ground in liquid wastes (Brown, 1967). These liquid wastes, however, have been treated to raise their pH to alkaline, which facilitates sorption in the soil. However, in the event of water infiltrating the burial grounds, the resultant chemical character of water-waste mixtures could be expected to be closer to natural conditions. Conceivably, large concentrations of radionuclides could be built up in a particular zone of sediments below a burial ground through sorption. This tendency for radionuclides to be concentrated in particular soil layers has been observed with regard to liquid waste disposal at Hanford (Brown, 1967, 1971). Under some circumstances such a concentration of radionuclides may be particularly hazardous should the materials be breached by erosion or should the burial ground be dug up for removal of wastes. The suitability of the 200 Area burial grounds for long-term storage cannot be evaluated with the data available. The important deficits pertain to the effects of the movement of soil water, as was discussed previously in relation to sorption and infiltration, and to the transport of radionuclides by soil water.

Conclusions and Recommendations

The following actions should be undertaken to assure that the release of radionuclides from the burial grounds will not occur.

100 Areas.--Solid waste burials in the 100 Areas are poorly inventoried for the years prior to 1969. However, file data indicate that most radioactive solid wastes in the 100 Area burial grounds are irradiated reactor components, pipes, and various metal equipment items. Most of the radioactivity in these burial grounds is believed to be in these metallic wastes and is due to cobalt-60 and other activation products. It was estimated by Corbit (1969, p. 61) that the bulk of these radioactive wastes would decay to nonradioactive states by the year 2050 though a small amount would still be considered radioactive through the year 2110. Wastes of this type would release radioactivity slowly even if subjected to continuous percolation of water through them, because the metals would have to corrode in order to release any significant amounts of soluble ions of radionuclides. Because these wastes are relatively insoluble and the radiation is due to fairly short-lived radioisotopes, such wastes probably are not serious environmental hazards. However, a review should be made of the records of disposals to identify those burial grounds or the parts of burial grounds where relatively large quantities of cobalt-60 bearing metallic wastes or other very hazardous wastes are located. At a few sites, mainly older burials, containing hazardous materials, samples should be taken of the soil below the wastes and analyzed to determine if radionuclides are migrating downward to the water table. Wells also should be constructed adjacent

to selected burial sites so as to intercept water moving beneath them in the uppermost part of the saturated zone. They should be sampled regularly and the water analyzed for chemical and isotopic constituents indicative of the waste constituents in the burial grounds. If movement of radionuclides from these burial grounds is detected, a study should be made of the advisability of removing the wastes.

300 Area.--The burial grounds in the immediate vicinity of the 300 Area are reported to contain little radioactivity. None is reported to contain plutonium except burial ground no. 1. If plutonium is present there in other than trace quantities, then removal of the plutonium-bearing wastes should be considered.

300 North and 300 WYE Burial Grounds.--Both of these burial grounds contain fission products and plutonium, apparently in large quantities. Neither can be depended upon to retain these radionuclides through long periods of several hundred to several thousand years, the time required to reduce the activity to innocuous levels. It is recommended that the desirability of removing the plutonium and fission products from these burial grounds be considered.

200 Area Burial Grounds.--The numerous burial grounds in the 200 Areas contain large amounts of plutonium, fission products, and radioactivity and are great potential environmental hazards. It is also pointed out that the high-level liquid wastes stored in the 200 Areas and now being reprocessed to salt cakes, and radionuclides in the soil beneath abandoned cribs and ditches also are a great potential hazard. It is clear that presently there is no means to predict the potential

for movement of radionuclides from the solid waste burial grounds, particularly over the many thousands of years that containment of plutonium would be necessary. The waste management plan for Hanford (Karagianes, 1973, p. 119) calls for environmental studies to determine the safety of long-term storage of the residual salt-cake from high level liquid wastes. Information developed through these studies on water and radionuclide movement through the soils beneath the 200 Areas may have a direct bearing on determining the suitability of the 200 Area burial grounds for long-term storage. In fact, these environmental studies should be designed so as to also provide conclusions directly pertinent to the burial grounds.

<u>213 Area</u>.--The two small burials of plutonium-bearing waste in the 213 Area should be considered for removal as their location and the shallowness of the burials do not assure long-term containment.

<u>General</u>.--Where necessary, the surface characteristics of the burial grounds should be modified to prevent or reduce (1) erosion by local runoff or wind and (2) collection of runoff and precipitation in depressions or swales that will add to the infiltration of moisture.

<u>Temporary storage facilities for relocated solid radioactive wastes</u>.--Solid radioactive wastes containing plutonium and other fission products, removed from burial grounds, according to the recommendations of this report, must be stored so as not to cause environmental hazards. Temporary storage for these relocated wastes should be provided in either or both of the 200 Areas. These areas already contain extensive waste management

facilities, personnel security measures are stringent in both areas, and, from a hydrologic standpoint, they are least objectionable for solid radioactive waste storage of any of the facilities areas.

The relocated wastes should be placed in facilities that will prevent any possible release and transport of radionuclides and from which they can be recovered subsequently. Ease of recovery is desirable should later studies lead to the requirement that solid wastes containing transuranium elements and fission products be removed from the 200 Areas and placed elsewhere in a permanent repository. The facilities also should be designed so that they can be stabilized with relative ease if it is later proved that the wastes may be retained with safety in the 200 Areas.

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REFERENCE 16

<u>Waste Management Operations</u>; ERDA 1538

- 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.