1242556

RHO-CD-798

-62

[0072752H]

Current Status Of 200 Area Ponds

November 1979

Prepared for the United States
Department of Energy
Under Contract EY-77-C-06-1030

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

93

RHO-CD-798

CURRENT STATUS OF THE 200 AREA PONDS

by

C. C. Meinhardt
J. C. Frostenson

November 1979

Prepared for the United States
Department of Energy
Under Contract DE-AC06-77RL01030

Rockwell International
Rockwell Hanford Operations
Richland, Washington 99352

Document Number RHO-CD-798

Issue Approval:

Functional Director — Date

Issuing Manager H. E. McGuire
Manager, Low-Level Waste Unit — Date 12/20/79

Concurring Approval L. E. Kusler
Project Engineering — Date 12/20/79

Concurring Approval — Date

Program Office Representative W. F. Heine
Manager, Low-Level Waste Program — Date 12/20/79

Rockwell International

Rockwell Hanford Operations
Energy Systems Group

A-6000-084 (R-7-79)

CONTENTS

TABLES:

FIGURES:

1.0 INTRODUCTION

Over the past 35 years of operation on the Hanford site, large volumes of low-level liquid effluents have been discharged to a number of infiltration waste ponds. As a result of the routine discharge of low-level effluents and several isolated incidents involving considerably greater nonroutine discharges, these waste ponds have accumulated radionuclide inventories, including transuranics, fission products, and activation products. These ponds and their associated ditches have also developed aquatic/riparian ecosystems ranging from fairly simple to relatively complex. These ecosystems harbor a variety of plant and animal life including mammals and resident and migratory waterfowl. A number of ecological studies have been performed over the past 10 years to characterize the pond ecosystems, evaluate ecosystem interactions with nuclide inventories, and assess specific biological transport pathways to man.

2.0 OBJECTIVE AND SCOPE

The objective of the Rockwell Pond Management Study is to develop a plan to improve pond management and reduce the attractiveness of 200 Area ponds to wildlife, especially waterfowl. This is consistent with the current Rockwell Hanford Operations (Rockwell) policy of reducing biological transport to as low as technically and economically practicable (ALATEP).

The Pond Management Study is presented in two reports:

1. Current Status of the 200 Area Ponds (RHO-CD-798)
2. Alternatives for 200 Areas Pond Management (RHO-CD-799)

This document, (1) Current Status of the 200 Area Ponds, reviews current conditions and existing pond management practices, based on the available literature, to establish the baseline necessary to develop and evaluate improved pond management practices.

It provides the site specific basis for developing and evaluating the improved pond management practices referred to in the second report of the study, Alternatives for 200 Areas Pond Management. This report summarizes the available information pertaining to potential biological transport pathways. Current pond management practices which are directed towards monitoring pond operation and preventing unusual discharges are also addressed.

The facilities addressed within the scope of this study include all active open-air, low-level, liquid effluent retention, transfer and disposal facilities. Specifically, this refers to ditches, ponds and retention basins used to transfer and dispose of low-level liquid effluents. Retired facilities (dry, stabilized ponds and ditches) and subsurface disposal facilities (cribs, french drains) are not addressed by this study.

3.0 SUMMARY

The Hanford 200 Area pond and ditch systems have developed ecosystems ranging from fairly simple to relatively complex over their 35 year period of operation. Routine low-level waste discharges and several abnormal occurrences have resulted in radionuclide inventory buildup within the pond and ditch systems. Wildlife utilization of these ecosystems has resulted in onsite transport of radioactivity away from the established radiation areas, and a number of ecological studies have shown that the potential for offsite transport does exist. The calculated dose-to-man associated with this potential offsite transport has been shown to be well within existing regulations and standards. A comparison of doses attributable to Hanford with the Department of Energy Manual Chapter limits and related (but not applicable) Environmental Protection Agency standards is given in Table 3-1.

The concept of maintaining doses as low as technically and economically practicable (ALATEP) calls for periodic reevaluation of methods to further reduce real or potential doses attributed to Hanford environmental discharges. Rockwell Hanford Operations (Rockwell) is evaluating improved pond management alternatives as a method of further reduction of actual and potential radionuclide transport.

This document is an extensive review of the available literature and current operating practices. It encompasses active surface effluent transfer and disposal systems, pond descriptions, radionuclide transport from pond systems, and current pond management practices. The 200 Area effluent transfer and disposal systems are described in Tables 4-1 and 4-2. Nature and origin of effluents are listed along with routes to final disposal sites.

Pond descriptions include the physical, chemical, radiological, and biological condition of each pond and ditch. The data were collected from a number of ecological studies conducted during the last 10 years and from routine environmental surveillance. Data is summarized in Appendix A and reviews of relevant studies are contained in Appendix B. Pond water concentrations for 1978 are summarized in Table 3-2 and compared with Department of Energy Manual Chapter 0524 Table II concentration guides and (for reference only) with the Environmental Protection Agency drinking water standards.

Of the various Hanford 200 Area Pond systems, U-Pond and the associated Z-ditches have received the greatest quantities of transuranic waste (plutonium, americium). U-Pond is also the most nutrient rich and biologically productive of the ponds. Onsite transport of radioactivity by small mammals and birds is the primary concern in the U-Pond system.

Gable Mountain Pond has received the greatest quantities of fission product waste of all Hanford ponds. It is a biologically productive system with aquatic emergent vegetation more developed than other ponds. Due to its remote location and large size (71 acres), the potential for offsite waterfowl transport is the main concern at Gable Mountain Pond.

B-Pond has received substantial amounts of fission product waste. It is the least biologically productive of the ponds. Although treated with aquatic herbicides in 1971 and 1972, limited aquatic vegetation has returned in the last several years. A perimeter road and steep riprap bank on the east side have left the bank essentially free of riparian vegetation growth.

All currently active ditches have well developed and uncontrolled growth similar to that of ponds. The ditches provide available and attractive habitat for small mammals, birds, and other wildlife.

Current pond management practices include water level control to minimize exposure of contaminated sediments. Surveillance of pond and ditch systems includes radiological monitoring of effluents and mud, vegetation, and wildlife sampling (see Table 7-1).

TABLE 3-1. Whole Body Dose Comparison.

Source	Whole Body Dose (mrem)
DOE Manual Chapter 0524	
Maximum Individual Dose	500
Average Population Dose	170
EPA Nuclear Power Operations (41 CFR 190, Hanford Defense facilities excluded)	25
EPA Drinking Water (41 CFR 141)	4
Estimated first year dose to an individual from consumption of single average coot from Gable Mountain Pond(2)	1.9
Natural Background Radiation(15)	100

TABLE 3-2. Pond Water Radioactivity Comparison (pCi/ℓ).

Source	Total Alpha		Total Beta	
	Annual Average	Maximum	Annual Average	Maximum
U-Pond[a]	60	800	100	2,400
B-Pond[a]	40	300	100	1,000
Gable Mountain Pond[a]	40	200	100	600
West Pond[a]	100	400	500	1,200
Richland Drinking Water(15)	0.7	2.3	5.2	7.8
DOE MC 0524 Table II	5000*	(none)	300**	(none)
EPA Drinking Water (41 CFR 141)	(none)	15	(none)	8

*Interpreted as Pu-239

**Interpreted as Sr-90

[a]Information from 1978 Environmental Protection Annual Report (in preparation).

4.0 EFFLUENTS AND ASSOCIATED TRANSFER/DISPOSAL SYSTEMS IN 200 AREAS

Tables 4-1 and 4-2 summarize all current liquid effluents discharged to pond systems within the 200 East and West Areas. These tables describe the nature and origin of the effluents and the various discharge routes taken to reach the final disposal site, either a pond or a holding/leaching ditch.

Some of the effluents are collected in a retention basin for sampling before discharge to the ditches. Thus specific types of retention are stated when applicable. Two retention basins, 207-U and 207-T, are not in operation at this time. Their discharge water flows through the basin en route to the ditch, without monitoring prior to release. Figure 4-1 shows pipelines and diversion capabilities for effluents discharged to Gable Mountain and B-Ponds.

Another means of preventing the discharge of liquid effluents having above normal levels of contamination is to divert the effluent from discharge to an open ditch or pond to an alternate disposal site (i.e., crib or basin) by means of monitoring instrumentation and automatic valving. Such diversion capability exists for Purex process cooling water. During alarm conditions, this effluent is diverted to the 216-A-42 holding basin. Further investigation of diversion retention capabilities within process facilities is being addressed by the Rockwell Environmental Protection Group.

TABLE 4-1. Liquid Effluent Transfer Systems for Ponds and Ditches - 200 East Area.

Building	Effluents	Volume, ℓ**	Total Beta, µCi/mℓ**	Pu, µCi/mℓ**	Retention	Discharge Route	Pond
242-A Evaporator	Steam Condensate	.475E+08	<.199E-05	<.249E-07	Steam Condensate Receiver Tank then 207A Retention Basin	*Piped from basin to main pipeline for Gable Mt.	216-A-25 Gable Mt.
242-A Evaporator	Cooling Water	.381E+10	<.111E-07	<.473E-08	Cooling Water Receiver Tank	*Piped to main pipeline for Gable Mt. Pond.	216-A-25 Gable Mt.
284-E Powerhouse 283-E Water Treatment Plant	Cooling Water Flushwater Boiler Blowdown All Wastes	~3.65E+07	NDA	NDA	NR	*Piped to ditch then piped to main pipeline for Gable Mt. Pond.	216-A-25 Gable Mt.
241-A-401 Bldg. A-Tank Farms	Cooling Water from Surface Condenser	NDA	NDA	NDA	NR	*Piped to main pipeline for Gable Mt. Pond.	216-A-25 Gable Mt.
244-AR Vault	Cooling Water	.189E+09	~.325E-05	<.403E-08	NR	*Piped and ties in with last section of pipe from the 284-E Powerhouse which ties into the main pipeline for Gable Mt.	216-A-25
202-A Building Purex	Process Cooling Water	.560E+10	<.167E-07	<.255E-08	NR	*Piped to main pipeline for Gable Mt. Pond. (Diversion capability to 216-A-42 holding trench.)	215-A-25 Gable Mt.
202-A Building Purex	Chem Sewer Wastes	.518E+09	<.173E-07	<.665E-08	NR	Piped to 216-A-29 ditch which extends into the 216-B-3-3 ditch, extending into pond.	216-B-3 B-Pond
221-B Building B-Plant	Process Equip. Jacket Cooling Water All Cooling Water (except condensate cooling water which discharges into B-55 Crib)	.385E+10	<.957E-07	<.133E-07	207-B Retention Basin	*Piped from basin to 216-B-2-3 ditch, piped from ditch to a diversion box, discharging into the 216-B-3-3 ditch, extending into pond.	216-B-3 B-Pond
221 B, B-Plant	Chem Sewer Wastes	.314E+09	.690E-07	<.512E-08	NR	Piped into the 216-B-63 ditch. (This ditch does not extend into pond, it is used as a leaching ditch only).	N.A.
Waste Encapsulation Storage Facility	Cooling Water	NDA	NDA	NDA	NR	*Piped to 216-B-2-3 ditch, piped from ditch to diversion box, which discharges into 216-B-3-3 ditch extending into pond.	216-B-3 B-Pond
C-Plant (Semiworks)	Air Conditioning Water, Vent Drains from 209E Lab (non-contaminated waste)	NDA	NDA	NDA	NR	Piped to pond.	216-C-9

NDA - No data available
NR - No retention
*All these effluents pass through the diversion box which enables flow to be diverted to Gable Mt. or B-Pond for level maintenance.
**Volume - 1978 yearly total; Total Beta and Pu - 1978 yearly average concentration (RHO-CD-78-34-4Q).

TABLE 4-2. Liquid Effluent Transfer Systems for Ponds and Ditches - 200 West Area.

Building	Effluents	Volume, L**	Total Beta, µCi/mL**	Pu, µCi/mL**	Retention	Discharge Route	Pond
221-U U Plant	Chem Sewer Wastes	NDA	NDA	NDA	NR	Piped to the 216-U-14 ditch which extends to pond.	216-U-10 U-Pond
224-U and 271-U Bldgs. U-Plant	Cooling Water	NDA	NDA	NDA	207-U Retention Basin (not in operation)	207-U empties into the 216-U-14 ditch, extending to pond.	216-U-10 U-Pond
284-W Powerhouse	Cooling Water Flush Boiler Blowdown	.681E+08	.195E-05	-.133E-06	NR	All facilities pipe their wastes, tieing into one pipeline which extends into the 216-U-14 ditch, extending into the pond.	216-U-10 U-Pond
272-W Mask Cleaning Station	All Wastes						
2724W Laundry Facility	All Wastes						
283-W Water Treatment Plant	All Wastes (Laundry is the only contaminated effluent)						
231-Z Bldg Z Plant	Process Cooling Water Steam Condensate Vacuum Pump Seal Water (from 291-Z)	.125E+09	.355E-06	.342E-06	NR	Piped to the 216-Z-19 ditch which extends to the pond.	216-U-10 U Pond
234-5Z, Z-Plant	Cooling Water (Battelle Lab) Cooling Water, Steam Condensate	.130E+09	.115E-06	.110E-07	NR	Piped to 216-Z-19 ditch which extends to the pond.	216-U-10 U-Pond
242-S, Evap. Bldg.	Cooling Water	.405E+08	.936E-08	-.472E-08	Cooling Water Receiver Tank	Piped to 216-U-14 ditch extending to pond.	216-U-10 U-Pond
	Steam Condensate	.420E+08	.935E-07	-.101E-07	Steam Condensate Receiver Tank		
241-SX, Tank Farm	Steam Condensate from sludge cooler	NDA	NDA	NDA	NR	Piped to 216-U-10 Pond via short unnamed ditch	216-U-10[2B] U-Pond
222-S Building	Ventilation Cooling Water Misc. Wastes from 222 Lab Hoods and Sinks	.609E+08	.813E-07	-.749E-08	207-SL Retention Basin	Piped from basin into pond.	216-S-19 S-19 Pond
202-S Building	Chem Sewer Wastes; Overflow from High Water Tower	.199E+09	.152E-07	-.620E-08	NR	All wastes flow into one pipe which extends into S-10 ditch. (Flow too minimal to reach pond.)	216-S-10 Pond is dry
221-T Building	Non-radioactive Waste Water from Air Conditioning Filter Units and Floor Drains	NDA	NDA	NDA	207-T Retention Basin (not in operation)	Piped from basin to 216-T-4-2 ditch. (Flow too minimal to reach pond.)	216-T-4-2 Pond is dry
221-T Building	Condensate from Steam Heated Radiators, Sodium Hydroxide Wash Water Waste Solution from Sodium-Air Water-Reaction Emergency Air Cleaning Development (HEDL) (All considered noncontaminated)	NDA	NDA	NDA	NR	Piped to 216-T-1 ditch. (Ditch does not extend into pond, using as a leaching ditch only.)	NA
242-T Evaporator	Steam Condensate, Condenser Cooling Water	NDA	NDA	NDA	207-T Retention Basin (not in operation)	Piped from basin to 216-T-4-2 ditch. (Flow too minimal to reach pond.)	216-T-4-2 Pond is dry

NDA - No data available
NR - No retention
*All these effluents pass through the diversion box which enables flow to be diverted to Gable ML or B-Pond for level maintenance.
**Volume - 1978 yearly total, Total Beta and Pu - 1978 yearly average concentration, (RHO-CD-78-34 49).

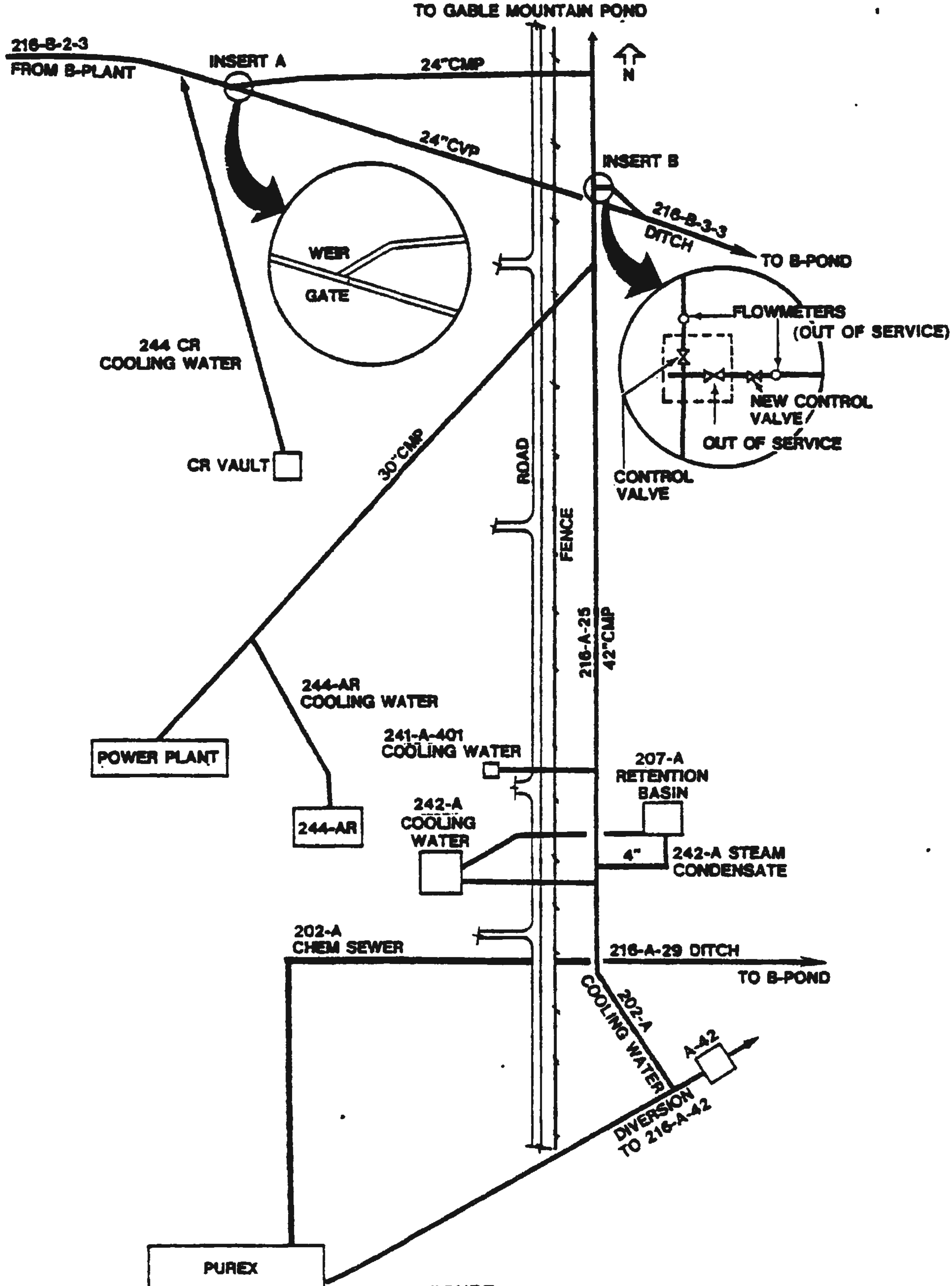


FIGURE 4-1

EFFLUENT PIPELINES AND TRANSFER CAPABILITIES FOR GABLE MOUNTAIN POND AND B-POND

5.0 DESCRIPTION OF PONDS

Each of the ponds and ditches is described in terms of physical, chemical, radiological, and biological conditions. The data presented here were collected from a number of studies conducted during the past 10 years and therefore may not represent the exact conditions at this time. However, the general conditions and trends described should be considered reasonably accurate reflections of current conditions. All data tables referred to in this section are contained in Appendix A. Figure 5-1 illustrates the area discussed in this status report and the locations of surface waters in the Hanford 200 Areas.

5.1 U-POND, 216-U-14 DITCH, AND 216-Z-19 DITCH (FIGURE 5-2 AND APPENDIX C)

U-pond was constructed in 1944 to receive low-level liquid effluents from plutonium processing facilities. It later served a uranium recovery plant, plutonium reclamation facility and other supportive laboratories in the 200 West Area. Since 1974, U-Pond's major supply of water has been from the 242-S evaporator via the U-14 ditch. Contaminated laundry effluent and other noncontaminated effluents are also discharged to the U-14 ditch.

U-Pond has a surface area of only 14 acres and a mean water retention time of 37 hours.[5] Other physical characteristics of the pond and ditches are listed in Tables A-1 and A-2. Chemical characteristics are listed in Tables A-3 and A-4. The only unusual chemical characteristic is a relatively high phosphate content of 123 μg/ℓ PO_4-P, which is probably related to the laundry discharge.

U-Pond has the most vigorous growth of shoreline (riparian) vegetation of all the Hanford ponds. Algal and macrophyte growths are the most diverse among Hanford aquatic systems. Submerged and emergent macrophytes such as pondweed, duckweed, cattail, and bulrush heavily vegetate the shallows leaving little open shoreline. Willow and cottonwood trees up to 30 feet high and dense underbrush provide a lush vegetative cover. The relatively abundant and diverse algal and macrophyte populations support a diverse and moderately productive invertabrate population.[5]

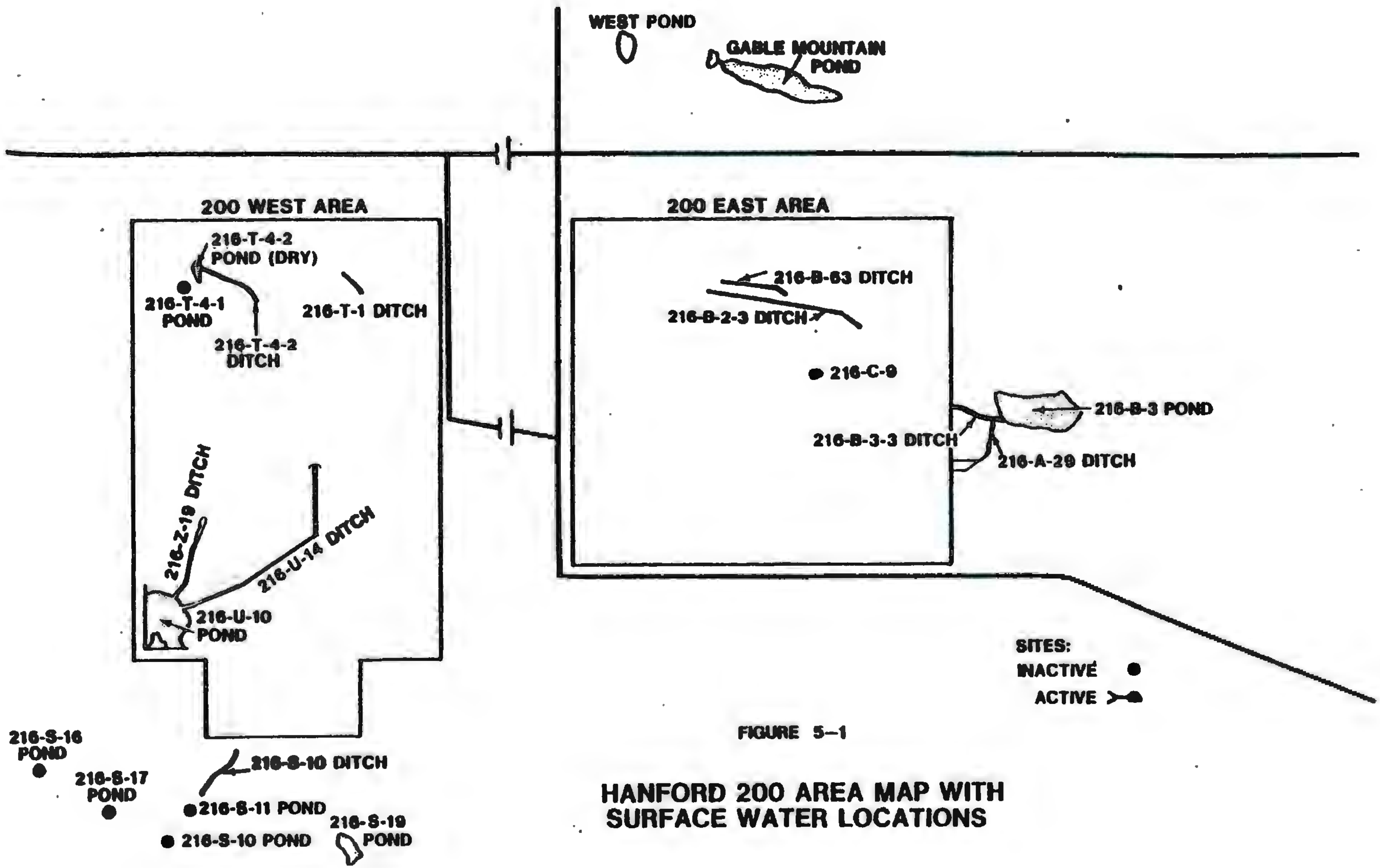


FIGURE 5–1

HANFORD 200 AREA MAP WITH SURFACE WATER LOCATIONS

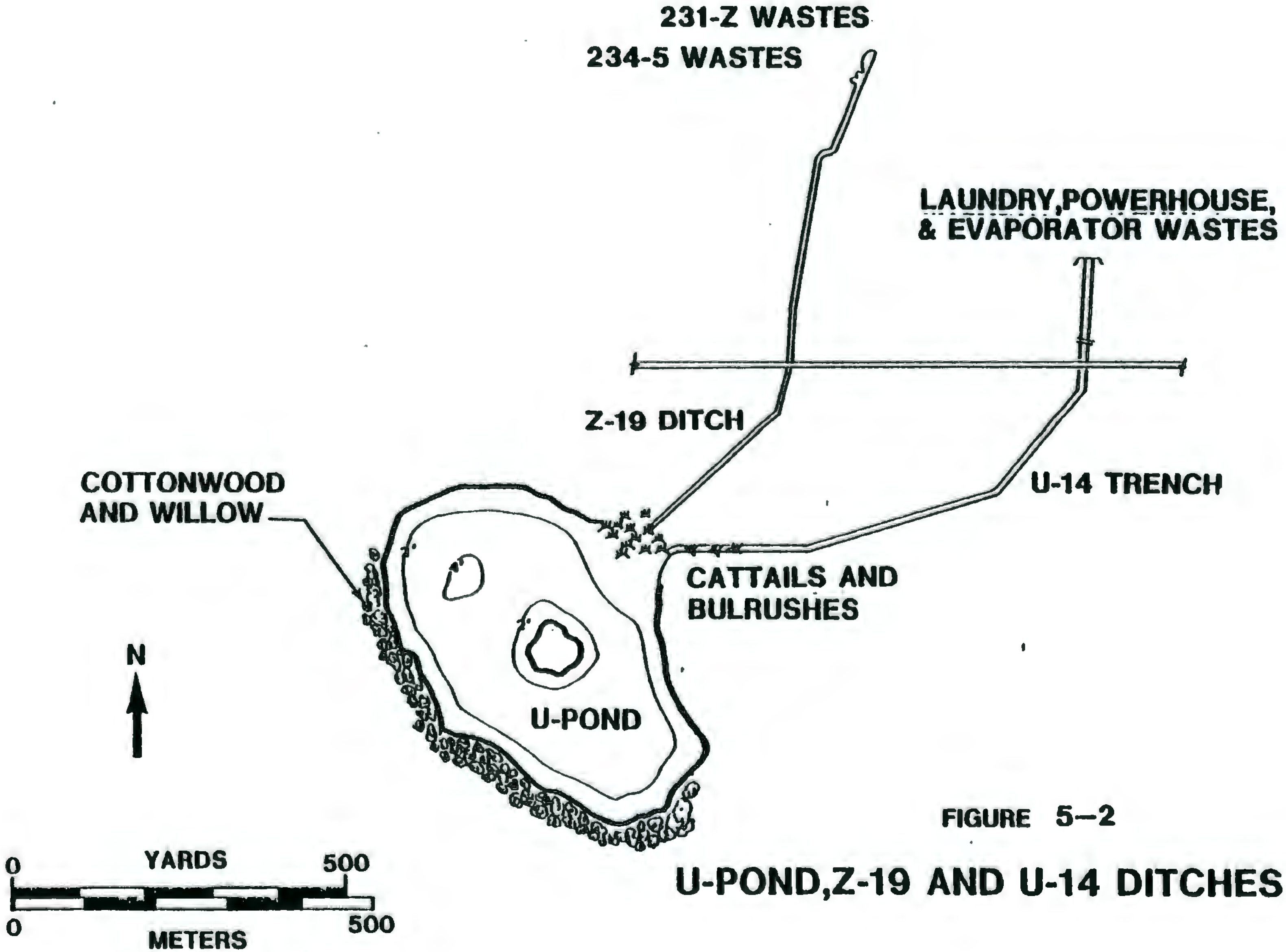


FIGURE 5–2

U-POND,Z-19 AND U-14 DITCHES

Mammals observed in the U-Pond area include several species common to the Hanford site. Mice in the U-Pond area have been studied in some detail and been found to include four species: Great Basin pocket mouse, deer mouse, house mouse, and western harvest mouse.(13) The house mouse and deer mouse were found to prefer the dense vegetation along pond margins which is more contaminated than the sparse vegetation of the surrounding environs. Medium and large mammals such as badger, raccoon, porcupine, muskrat, deer and coyote have been observed but their access is somewhat limited by the 200 West Area fence. U-Pond is also known to have a large population of goldfish.

Avifauna (birds) observed in the U-Pond also include most of those species known to the Hanford site.

Dabbling ducks are the most abundant waterfowl on U-Pond with an observed population similar to the much larger B-Pond, but much lower than Gable Mountain Pond.(11) Diving ducks were observed at a frequency considerably lower than at either Gable Mountain Pond or B-Pond while mergansers, Canadian geese, and whistling swans were almost never sighted. The American coot was also observed at a frequency considerably lower than at Gable Mountain Pond or B-Pond. Observed waterfowl populations on all ponds for dabbling ducks, diving ducks and coots are reported as weekly totals in Figures A-12, A-13, and A-14, respectively. The total counts for the same period of observation are given in Table A-15.(19) Perching birds and other small birds were observed in greater numbers at U-Pond than at other Hanford ponds. This is probably a result of its well developed tree-shrub community.(10)

The radiological characteristics of the U-Pond system are similar to the other Hanford ponds with respect to fission products while the transuranic content is relatively high. Discharges to U-Pond and associated ditches are shown in Table A-5. The majority of this contamination is believed to be trapped in the ditches and not in the pond. This is illustrated by comparing the concentrations of Am-241, Pu-239, and Pu-240 in pond sediments (see Table A-7). The radionuclide levels in Z-19 ditch sediments are two orders of magnitude above those found in U-Pond. Preliminary results from work in progress by Rockwell Research Department indicates that U-Pond may contain as little as 200 grams of plutonium with the majority of the 8000 grams discharged distributed between the active 216-Z-19 ditch and the inactive (and backfilled) 216-Z-1 and Z-11 ditches. Tables A-6 and A-9 list activity in current discharges and pond water samples.

Uptake of transuranics by vegetation at U-Pond and associated ditches has been studied to a limited extent. Table A-10 shows the concentration of Am-241, Pu-238, and Pu-239, 240 for a variety of aquatic plants. In addition, Table A-8 lists data for other radioisotopes. A more comprehensive version of Table A-8 is presented in Table A-11 for U-14 and Z-19 ditches.

U-Pond was generally undisturbed until 1972 when a single application of herbicides was applied.(11) The herbicides were somewhat effective for a short period of time, however, no further applications were made and vegetation growth rapidly returned.

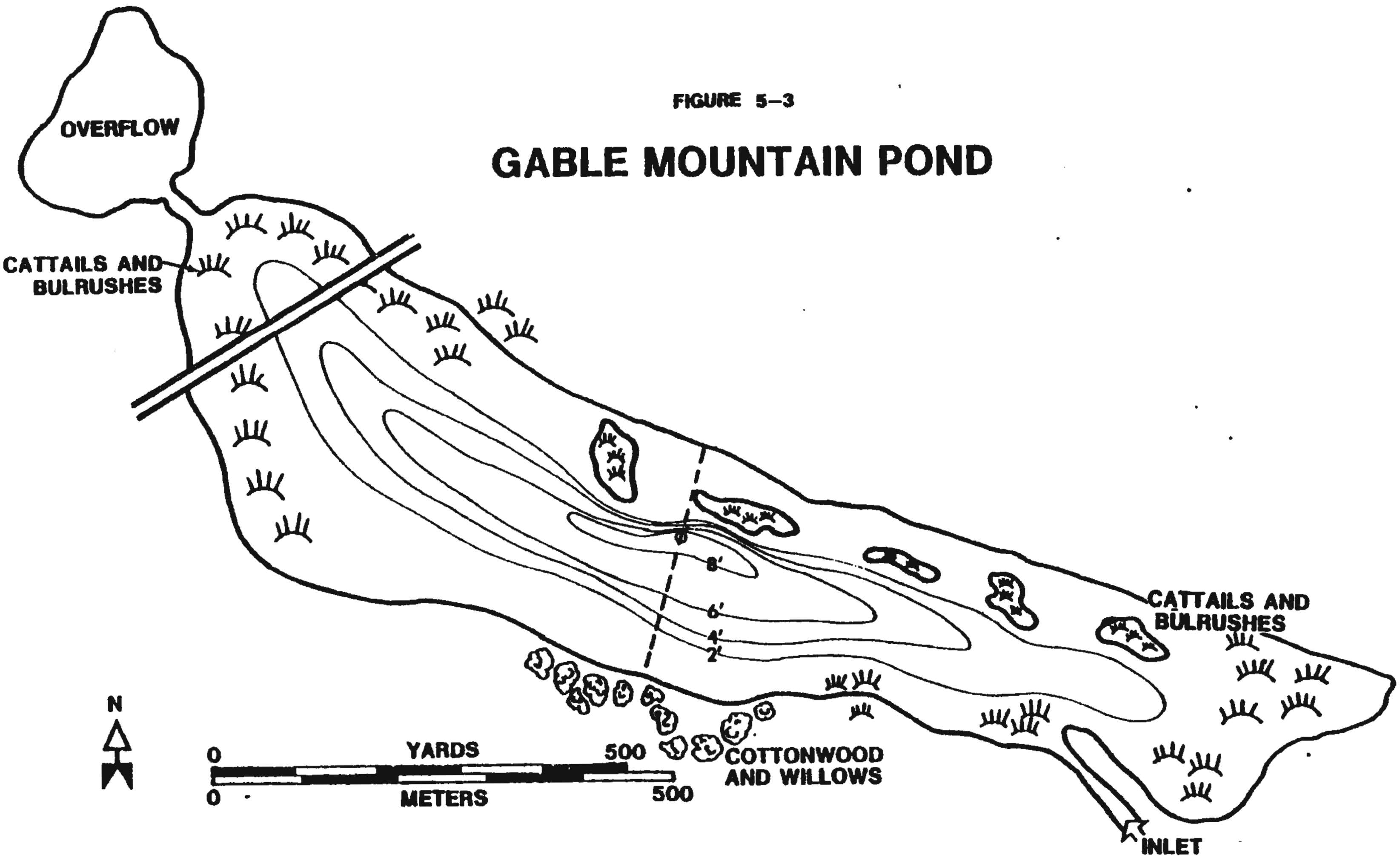
5.2 GABLE MOUNTAIN POND (FIGURE 5.3 AND APPENDIX C)

Gable Mountain Pond was constructed in December of 1957 to receive cooling water from Purex Plant. It has a surface area of 71 acres making it the largest of the Hanford ponds. Gable Mountain Pond also has the longest mean water retention time at 504 hours.(5) Tables A-1 and A-3 show the physical and chemical characteristics of the pond.

A large variety of plant and animal life has been observed inhabiting the Gable Mountain Pond area creating a diverse, biologically productive ecosystem.(5) The pond edge, having little open bank or shoreline, is heavily vegetated with peach leaf, sandbar willow, wild millet, horsetail, sedges, and other terrestrial vegetation. Algae are abundant and similar to U-Pond and B-Pond. However, the lush growth of submerged and emergent vegetation such as pondweed, cattail, and bulrush in the pond shallows exceeds that of any other Hanford ponds. Insects and other invertebrates are also abundant and similar to other Hanford ponds.

FIGURE 5–3

GABLE MOUNTAIN POND



Little information is currently available concerning densities of small or large mammals in the Gable Mountain Pond area. However, mice, rabbits, deer, coyotes, badgers, porcupine and raccoon have been observed. A large population of goldfish is known to inhabit Gable Mountain Pond.

A wide variety of avifauna has been observed utilizing Gable Mountain Pond.[11] Due to its relatively large size, abundant vegetation and isolation, Gable Mountain Pond is with few exceptions the most intensely used Hanford pond by both migrant and resident waterfowl. The American coot is the most abundant waterfowl observed at all Hanford ponds with over 90% of these observations made at Gable Mountain Pond. The American coot is also the most abundant breeding waterfowl population on Hanford ponds with a hatch estimated of up to 200 young per year, essentially all on Gable Mountain Pond. Over 50% of the dabbling and diving ducks are observed on Gable Mountain Pond. Other waterfowl include mergansers (over 90% Gable Mountain), Canadian geese (80% Gable Mountain), and whistling swans (100% Gable Mountain). Waterfowl observations for specific species are reported in Table A-15. The abundance and variety of birds other than waterfowl observed at Gable Mountain Pond are second only to that of U-Pond.[10]

Gable Mountain Pond has been used for the release of low-level liquid effluents since its inception in 1957. In addition to regular releases, a single unplanned release in June of 1964 contributed an estimated 100,000 Ci of short and long lived mixed fission products to the B and Gable Mountain Ponds. The pond water activity level reached 48,000 pCi/cc on June 16, 1964, and vegetation samples as high as 45,400 pCi/g for Sr-89, 22,400 pCi/g for Sr-90, and 3100 pCi/g for Cs-137 were collected. Immediately following this incident, a task force was formed to recommend actions to reduce potential transport from the ponds.[17] The following actions were taken: The short inlet ditch to Gable Mountain Pond and the B-3-1 ditch to B pond were filled and replaced by new ditches. Copper sulfate was added to both ponds to kill algae. Diatomaceous earth was added in an attempt to raise the water level; however, this was only partially completed and appeared to have little effect. The water level was raised by pushing perimeter soil into the pond an average of 20 feet around its circumference creating a new dike.

Total decayed radionuclide inventories for Gable Mountain Pond are listed in Table A-5. Discharges for 1978 are in Table A-9 while total alpha and beta values for pond water are in Table A-6. Results from the analysis of sediment samples are given in Table A-7. Aquatic vegetation radionuclide data are given in Table A-8.

5.3 WEST POND (WEST LAKE OR HONEYHILL POND, FIGURE 5-4 AND APPENDIX C)

West Pond was a seasonal pond in a shallow basin in 200 North Area prior to construction of Gable Mountain Pond. After Gable Mountain Pond was constructed and began receiving effluent, West Pond enlarged and became a "permanent" pond as a result of a raised water table due to Gable Mountain Pond.[25] West Pond has never received direct discharges of contaminated effluent. The source of the existing activity is currently unknown, however, it may be the result of evaporative concentrations of fallout and/or subsurface, migratory transport from Gable Mountain Pond.[5, 25] The pond is unusually high in alkaline and phosphate levels and also shows an elevated pH (Table A-3). This is attributed to the disposal of sanitary sewage sludge from the early Hanford construction camp in the basin where West Pond later appeared.

West Pond has an assortment of algae similar to that of other Hanford ponds. There is no evidence of submerged macrophytes. The pond perimeter is composed primarily of salt encrusted mud flats with emergent macrophytes limited to small scattered patches of cattails and bulrushes.

The unusual properties of this pond also limit its use by animals. Only nine species of birds other than waterfowl were observed at West Pond, while U-Pond supports 55 species.[10] The stagnant water provides an excellent breeding ground for mosquitos and other insects.[5] Although little data are available on waterfowl and mammal use of the pond, the use is low presumably because of the salty water, lack of vegetation, and close proximity of the more attractive Gable Mountain Pond ecosystem.

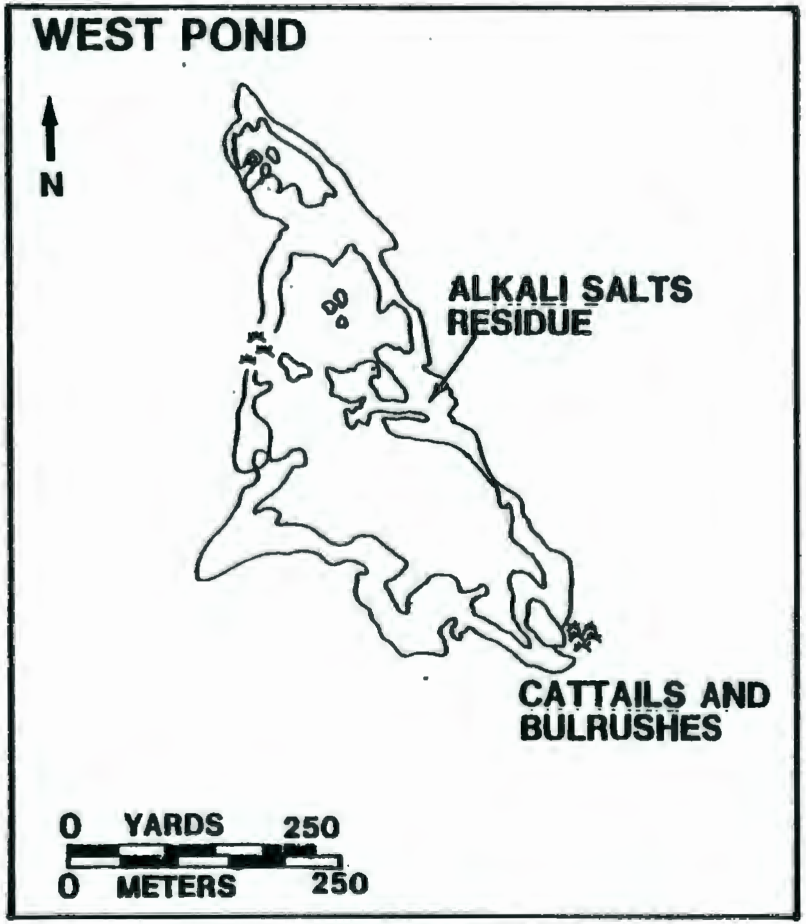

WEST POND
N
ALKALI SALTS RESIDUE
CATTAILS AND BULRUSHES
0 YARDS 250
0 METERS 250

FIGURE 5–4

Since West Pond does not receive direct liquid effluent discharges from processing facilities, only limited radiological data are available. Table A-6 gives the total alpha and beta concentrations for the ponds. Although the beta concentration decreased in 1978, the 1977 value exceeds the Department of Energy Manual Chapter 0524 Table II concentration guide if interpreted as Sr-90. Radiological data from sediment samples are given in Table A-7, while aquatic vegetation data are given in Table A-8. Neither sediment nor vegetation samples revealed any unusual levels of activity.

5.4 B-Pond, 216-A-29, 216-B-2-3, AND 216-B-3-3 DITCHES (FIGURE 5-4 AND APPENDIX C)

B-Pond was constructed in 1945 to receive liquid effluent from the 200 East Area processing facilities via B-2 and B-3 ditches. B-Pond also receives cooling water and chemical wastes from Purex via A-29 ditch.

Physical characteristics of the pond and ditches are given in Tables A-1 and A-2 while the chemical features, including a relatively high NO_3-NO_2-N concentration of 3.65 mg/ℓ, are listed in Tables A-3 and A-4.

B-Pond supports the least diverse and biologically productive ecosystem of the Hanford ponds. Algae are abundant and similar to other Hanford ponds, however, submerged and emergent macrophytes are sparse and present only in isolated clusters scattered around the pond. Riparian vegetation is almost non-existent, primarily as a result of a well maintained road around the pond and a steep banked, well stabilized dike on the east end. In 1971 major construction work was performed on B-Pond to raise and slope the east bank. At that time and again in 1972, herbicides were sprayed along the shoreline. This herbicide treatment reduced both the quantity and variety of vegetation.

Insects and other invertebrates are abundant and similar to other Hanford ponds.

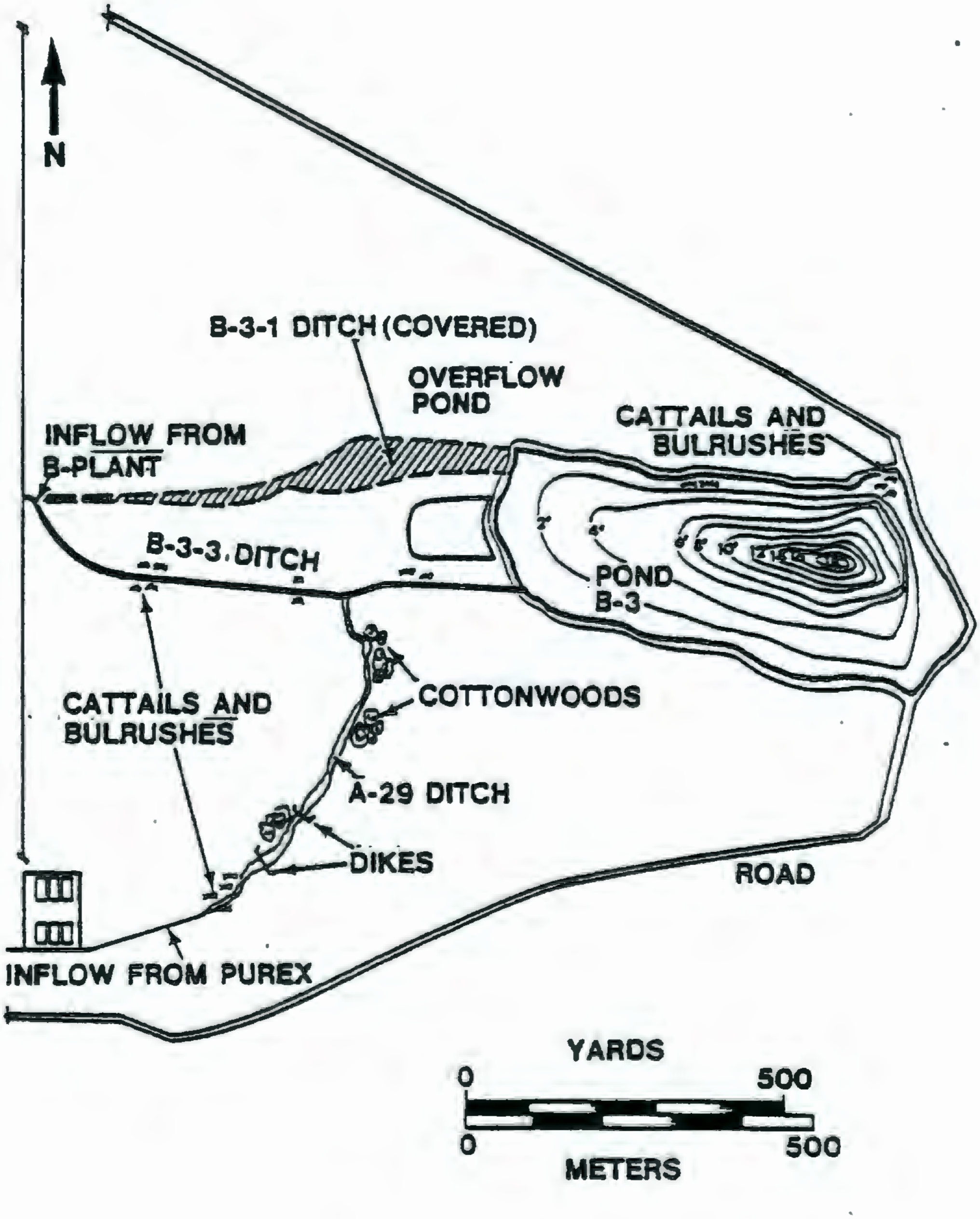


FIGURE 5—5

B-POND, B-3-3 AND A-29 DITCHES

Although no detailed studies of mammal populations at B-Pond have been undertaken, a number of species have been observed at the pond. Small mammals include the Great Basin pocket mouse, house mouse, and deer mouse. Medium and large mammals include badger, deer, rabbit, porcupine, and coyote.

The bird population at B-Pond shows the lowest diversity of all the ponds receiving wastes. Only 18 species of non-waterfowl birds were observed, while U-Pond, in contrast, with its well developed tree shrub vegetation supports 55 species.(10) This relatively low usage is attributed to a lack of vegetation which is needed to provide food and cover from predators.

Waterfowl, unlike other birds, make frequent use of B-Pond. As a percent distribution of sightings from all ponds, B-Pond had 23% of dabbling ducks sighted, 36% of diving ducks, 21% of Canadian geese, and 7% of American coots.(11) Specific observations are listed in Table A-15. The majority of these birds use the pond as a resting point during their migration. The pond is attractive to certain species, particularly diving ducks, due to its large size and open surface. The lack of emergent vegetation, however, combines with the traffic of the 200 East Area to make the pond unattractive for breeding waterfowl.

B-Pond has received a combination of fission products and transuranics in effluent discharges with the total discharges listed in Table A-5. On two occasions it has received radioactivity from unplanned releases.(17) In excess of 10,000 Ci of short and long-lived mixed fission products were released on June 12, 1964, to B and Gable Mountain Ponds. B-Pond had readings of 2 R/hr in the ditch bank 8 feet from the inlet and 150 mR/hr along the pond road. When it was found that most of the radioactivity was trapped in the ditches, 216-B-2-1 and 216-B-3-1 were covered and replaced by the 216-B-2-2 and 216-B-3-2 ditches.

On March 22, 1970 a second major release to B-Pond occurred. A discharge of 1,000 Ci of Sr-90 entered 216-B-2-2 and 216-B-3-2 ditches. By March 24 the beta activity in the pond water had increased to

1.7×10^{-3} Ci/ml with 1.5×10^{-2} Ci/ml in the ditch water. Again, these ditches were covered and new ditches, 216-B-2-3 and 216-B-3-3, constructed and remain in current use.

Annual average and maximum beta and alpha concentrations in the pond for 1978 are contained in Table A-6. Concentrations in sediment samples are found in Table A-7 while aquatic vegetation concentrations are given in Table A-8. Average concentrations of radioisotopes in discharges to B-Pond during 1978 are shown in Table A-9.

The 216-B-63 leaching ditch was created in March of 1970 to receive chemical sewer wastes from B-Plant. The available physical data are included in Table A-2. No chemical data are available.

Radiological discharges to the ditch have been relatively low with a total beta discharge of 8.7 Ci. Approximately 7.6 kg of U has been discharged as well as other radionuclides as outlined in Table A-5. Radionuclide discharges for 1978 are found in Table A-9. Sediment samples results are shown in Table A-7 while vegetation sample data are listed in Table A-8.

5.5 T-SYSTEM

The T-System includes 216-T-4-1 and T-4-2 ponds and 216-T-1, T-4-1, and T-4-2 ditches. Only 216-T-1 and T-4-2 ditches still receive effluents.

216-T-1 ditch first received effluents from T-Plant in November 1944. Currently the ditch receives nonradioactive liquid condensate from 221-T and sodium hydroxide waste water from the Sodium-Air-Water Reaction Emergency Air Cleaning Development (HEDL). Total discharge estimates of radioactive materials are found in Table A-5. Known physical characteristics are found in Table A-2. No sampling program currently exists for the ditch.

The 216-T-4 pond and ditch system was created in November 1944 to receive effluents from T-Plant. The original pond and ditch (216-T-4-1) accumulated relatively large quantities of fission products and transuranics from T-Plant operations. The creation of 216-T-4-2 pond and ditch in May 1972 eliminated the need for the original pond and ditch. The new ditch utilized the first 15 meters of 216-T-4-1 ditch. In February 1973 the top 15-23 centimeters of soil was scraped off the top of 216-T-4-1 pond and buried in a trench. Siberian wheat grass was planted in April 1973 to improve soil stability in the former pond bottom.[17]

Readings in the ditch other than in the first 15 meters indicate no detectable radiation. Sampling results from the first 15 meters are shown in Tables A-6, A-7, and A-8.

5.6 S-SYSTEM

The S-System includes 216-S-10 ditch and pond, 216-S-11 pond, 216-S-15 pond, 216-S-16 pond and ditch, 216-S-17 pond, and 216-S-19 pond. Only 216-S-10 ditch and 216-S-19 pond are still receiving effluents.

On March 15, 1954, 216-S-17 pond was removed from service and backfilled with 3 to 4 feet of sterile coarse black sand. This action was taken as the result of unplanned releases and radionuclide buildup in pond sediments. In the early 1970's when contaminated weeds were observed in the area, the site was seeded with Siberian wheatgrass to compete with the Russian thistle.[17]

In October of 1952, 216-S-15 pond was taken out of operation and filled with 2 feet of clean soil. These actions were taken after an estimated 1 Ci of fission products had accumulated in the pond.[17]

Removal of the 216-S-16 pond and ditch system from active service began in May 1969. This work was prompted by several releases over the years including 3.7×10^2 g of Pu. Pond 2 of the system was covered with 6 to 12 inches of gravel while ponds 1 and 3 and the ditch were covered with dikes from between the ponds. Later revegetation proved only partially successful.[17]

The 216-S-10 pond and ditch system was created in February of 1954. The system was designed to handle chemical sewer, air conditioning and drain waste from 202-S and the high water tower overflow. The ditch is 2,250 ft long by 6 ft wide while the pond has a surface area of 5 acres. In May 1954 two 216-S-11 ponds were added to give additional leaching area. By August of 1965 both of the 216-S-11 ponds and the 216-S-10 pond were dry.[17] The estimated decayed inventory of the 216-S-10 pond ditch is listed in Table A-5. A dirt overfill has been placed on the south 216-S-11 pond and is currently being used as a root penetration study site. The remaining S-10 ditch still receives 202-S effluents. Physical characteristics are listed in Table A-2. Total discharges and current effluents are listed in Tables A-5 and A-9.

216-S-19 pond is also an open-air effluent disposal site in the 216-S system. It was placed into service in February of 1952. The pond receives effluent from 222-S laboratory (Table A-9). This is one of the smallest ponds at Hanford with a surface area of 3.5 acres and a smaller actual wetted area (Table A-1). Currently, 216-S-19, known as S-Pond, is almost dry with a small area of aquatic/riparian vegetation. Deer have recently been sighted using the pond and other mammals may also frequent the area. Tables A-6, A-7, and A-8 list water, sediment, and vegetation samples.

5.7 C-POND

The 216-C-9 pond was constructed in the excavation pit for the never-constructed C-Plant Canyon Building. It began service in 1953 receiving miscellaneous waste water from the Semi-Works facilities. In 1960 steam condensate and drainage from the 290-E critical mass lab was added. Since the shutdown of semi-works operations the pond has decreased to its present size of a small marsh in the bottom of the excavation with no observed standing water. Vegetation similar to that found at other ponds and ditches is present at the site. No extensive studies or samples have been taken in recent years. A 1978 radiation survey of the marsh perimeter did not find any significant contamination. Decayed radionuclide inventory is given in Table A-5.

6.0 RADIONUCLIDE TRANSPORT FROM POND SYSTEMS

6.1 TYPICAL POND ECOLOGY

Each of the Hanford ponds supports a somewhat different aquatic/riparian ecosystem. These differences are the result of pond age, past management practices and effluent characteristics unique to each pond. Radiological characteristics appear to have little impact on the ecological development of the ponds. Given sufficient time and left undisturbed, the ponds would probably develop similar ecosystems.[5]

By examining the "typical" ecosystem for a Hanford pond, the various pathways that could result in the transport of radionuclides can be illustrated.[23] The transport pathway of most concern for a particular pond can then be identified by examining the characteristics of that pond. Evaluation of potential transport pathways from ponds, therefore, requires knowledge of the following:

1. General conditions or characteristics common to all ponds that establish transport pathways
2. The characteristics and conditions of a specific pond that determines the extent and magnitude of transport through various pathways from that pond.

The ecosystem of Hanford waste ponds, as with any aquatic system, is based on the primary producers including algae and macrophytes. Algae and nonrooting macrophytes utilize the nutrients available in the pond water. Rooting macrophytes also utilize the nutrients available in pond sediments supplied by the decomposition of organic matter on the pond bottom. This conversion of available pond nutrients into utilizable organic matter provides the basis upon which a complex pond ecosystem can develop.

Primary consumers include those species that feed primarily on algae, aquatic macrophytes, and the organic matter on the pond bottom. The bulk of the organic matter is composed of dead algae and aquatic macrophytes. The nonpredaceous invertebrates feed wholly on aquatic vegetation and bottom organic matter. Goldfish, while feeding primarily on aquatic matter, also consume nonpredaceous invertebrates.[3] Waterfowl observed on the ponds also feed primarily on aquatic vegetation to obtain 70 to 90% of their diet.[10] The only exceptions of this are several of the diving duck species whose diets include significantly greater quantities of insects and crustaceans. Muskrats are the only mammal species known to consume significant quantities of aquatic vegetation.

Secondary and tertiary consumers within the pond ecosystem include heron, mergansers, coyote, waterfowl, adult predaceous insects, predatory birds and most other types of birds. Herons and mergansers will feed on goldfish in the ponds,[10] and coyotes will feed on dead goldfish, if available.[20] Adult predaceous insects and dragonfly larvae feed upon other invertebrates at the pond. These in turn are fed upon by some species of waterfowl, shorebirds, and many other types of birds.[10] Small and medium-sized mammals feed on vegetation, seeds, and invertebrates in the riparian areas surrounding the pond.[20] Predatory birds can be expected to feed occasionally on small mammals and birds in the pond areas.[10] The cycle is completed with the accumulation and decomposition of feces, plant materials, and insect and animal carcasses on the pond bottom.

6.2 POND TRANSPORT PATHWAYS

Pond inventory and transport conditions can most easily be illustrated by separating the ecosystem into two categories, the aquatic system and the contacting terrestrial system. The aquatic system can be divided into five major compartments:

1. Sediments (submerged)
2. Water
3. Aquatic vegetation
4. Invertebrates
5. Fish

The contacting terrestial system can be divided into six major compartments:

1. Shoreline (exposed) sediments
2. Riparian vegetation (shoreline and bank)
3. Waterfowl
4. Birds other than waterfowl
5. Mammals and other terrestrial animals
6. Atmosphere (airborne particulates).

The sediment (submerged and exposed), vegetation (aquatic and riparian), and fish compartments are not transient by nature, and, therefore, cannot generally release activity without assistance from one of the other compartments. For example, shoreline sediments can be resuspend as airborne particulates or may be carried in the fur of small mammals. Therefore, the compartments available as transport pathways shown schematically in Figure 6-1 including the following:

1. Water
2. Invertebrates
3. Atmosphere (airborne particulates)
4. Waterfowl
5. Birds other than waterfowl
6. Mammals and other terrestrial animals

Water

Water can provide a pathway for the release and transport of nuclides from a pond system in several ways. First of all, the discharge of contaminated effluents to an unlined ditch/pond system results in the dispersion of those nuclides throughout the system. This occurs as the effluent infiltrates the pond or ditch sediment. In the sediment, suspended and dissolved nuclides are removed and accumulate. With continued use (assuming a constant discharge rate for nuclides), the total activity for a given nuclide in the ditch or pond sediment will increase to an equilibrium level when decay equals discharge. The equilibrium will vary for each nuclide as those having longer half-lives will have higher equilibrium values and take

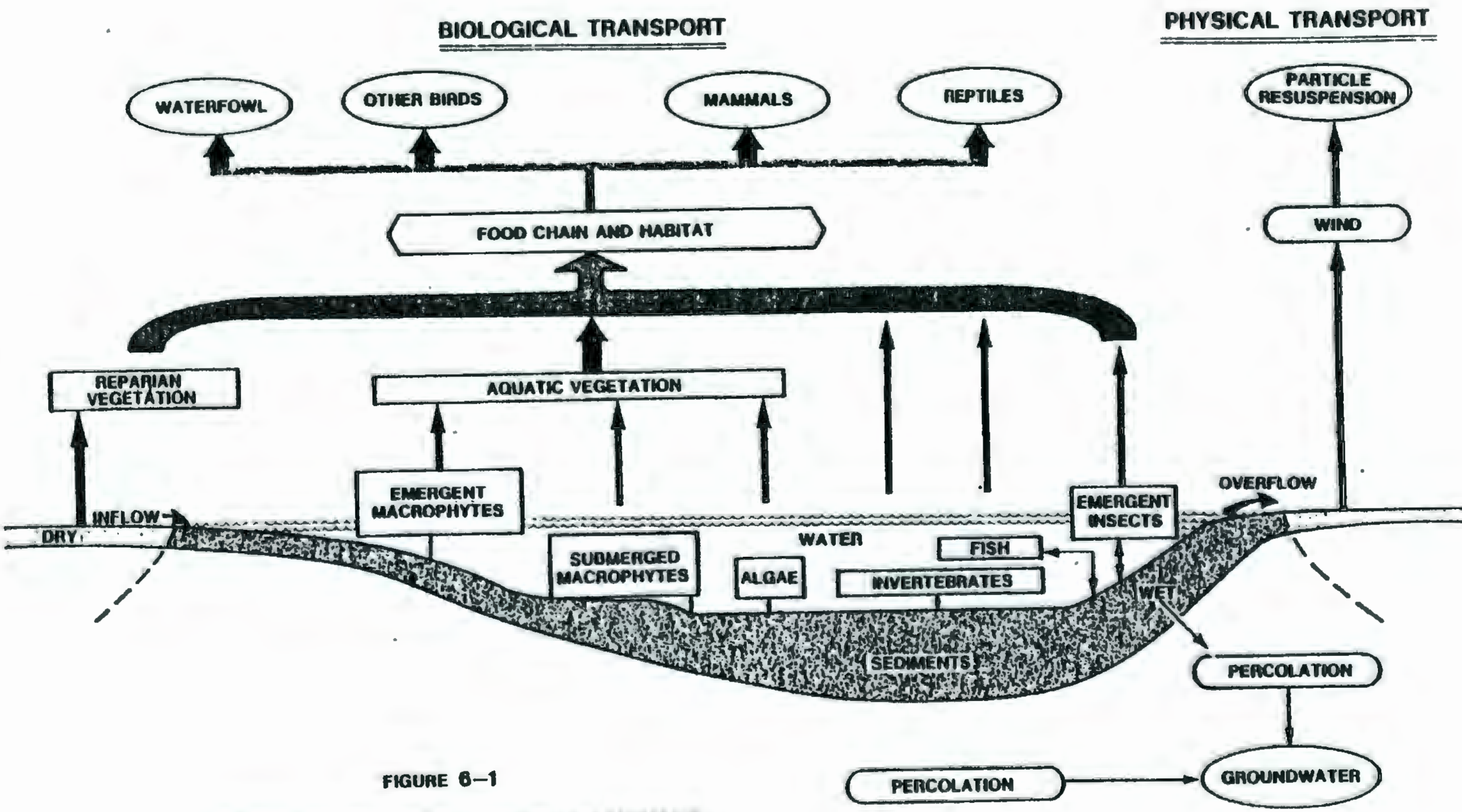


FIGURE 6–1

SURFACE WATER TRANSPORT PATHWAYS

longer to reach them. With continued use, nuclides will migrate downwards with percolating moisture. Equilibrium will again be reached when downward migration equals decay. The downward migration will be a function of the total nuclide inventory, the nuclide forms, the nuclide interaction with sediments, and the quantity of percolating moisture present. While it must be recognized that this is a potentially significant transport mechanism, current data indicate that significant offsite groundwater transport will not result from current waste pond disposal practices.[4] Therefore, the alternatives presented in this study do not address this transport pathway.

The flow of surface water beyond the confines of existing pond boundaries could result in an increase in the size of the current radiation zone. There are three possible ways this could happen: (1) increased effluent rate, (2) decreased infiltration rate, and (3) failure of a dike or berm. The result could be contaminant resuspension and biological uptake.

Atmosphere (Airborne Particulates)

In a properly operated pond system, the resuspension of discharged contaminants is very limited. However, several types of system failure can result in potential contaminant resuspension and transport. The flow of surface water beyond the confines of the pond system can contaminate adjoining surface areas which are then susceptible to resuspension. Another system failure involves a drop in the water level exposing contaminated sediments which are then susceptible to resuspension. This could result from a decreased effluent discharge rate. Construction activities within established pond radiation zones could contribute to resuspension if adequate dust control measures are not implemented.

Routine Pacific Northwest Laboratory (PNL) ambient air surveillance in the vicinity of the Hanford site has consistently shown that, in recent years, site operations have been an indistinguishable impact on offsite airborne radioactivity concentrations.[14,15] Rockwell 200 Area ambient air surveillance has shown local annual average concentrations ten to one hundred times the regional environmental concentration determined by PNL. Though elevated, the 200 Area ambient air concentrations are less than the Department of Energy Concentration Guides (DOE Table II) for continuous occupancy .

Onsite resuspension attributable to ponds and ditches within the 200 Areas has not been extensively studied. The 216-Z-19 ditch is the only surface liquid disposal site with a permanent ambient air sampler associated with it.(27) Elevated levels of gross alpha activity above the DOE Table II Concentration Guide for Pu-239 in air were observed in 1977. Specific nuclide results are not available for 1977, however in 1978 the data indicates all observed nuclides (including Pu-239) were below Table II. Only limited data related to resuspension at other ponds and ditches is available.(26)

Invertebrates

Invertebrates, especially emergent insects, are a mobile life form highly dependent on the pond system for sustenance and must be considered as a potential transport pathway for discharged nuclides. Invertebrates accumulate activity by consuming primary producers, such as algae and periphyton, of which are known concentrators of radionuclides.(3) Invertebrates are also important as an integral link in the food chain transport to mammals, waterfowl, and other birds.(21)

Waterfowl

Waterfowl include diving and dabbling ducks, the American coot, and to a less extent grebes, mergansers, geese, swan, crane and rail. Waterfowl are potentially the most important pathway for the transport of nuclides. This is due to their high mobility and heavy dependence on aquatic ecosystems. Waterfowl feed on practically all lower forms of organic material in the aquatic ecosystem including the organic floc on the pond bottom, primary producers, aquatic and riparian macrophytes and invertebrates. This results in various levels of nuclide accumulation depending on the particular species, whether they are migrant or resident, and their particular feeding preference.

Birds Other Than Waterfowl

Many species of birds other than waterfowl routinely utilize the pond ecosystems for food, habitat, nesting materials and water, and therefore must be considered as potential transport pathways.[10] Of particular interest are swallows and other birds known to nest in occupied buildings and structures. Herons and other birds that nest in the area and feed on goldfish, and raptors that prey on other birds and small mammals utilizing the pond ecosystems are also of interest.

Mammals and Other Terrestrial Animals

A number of species of mammals and other terrestrial animals also routinely utilize the pond ecosystems and are therefore of interest as transport pathways. Mammals use the pond ecosystems as a source of food, water, and habitat. Species observed at Hanford ponds include mice, jackrabbits, badgers, porcupines, muskrats, deer, coyotes and raccoon.[20] Mice and rabbits are of concern because they are known to frequent areas occupied by site personnel and may spread contamination. The larger mammals tend to be more transient by nature and therefore can range over larger areas.

6.3 SITE SPECIFIC BIOLOGICAL TRANSPORT ASSESSMENT

Over the past 10 years, considerable effort has been devoted to the study of the 200 Area waste pond ecosystems. The emphasis of these studies has centered on the interactions of pond ecosystems with radionuclide contaminants and the resulting levels of biological transport. A review of these studies is included in Appendix B of this report. This work has resulted in a much broader understanding of the mechanisms, extent and magnitude of biological transport, as well as providing a valuable data base for future work.

Specific pond ecosystems have been studied and characterized. Nuclide uptake characteristics have been observed for many of the wildlife species utilizing these systems. Game birds (coot, ducks, geese, and pheasant) are collected on the Hanford site, including

100 Areas, and along the Hanford reach of the Columbia River as part of the routine Environmental Surveillance Program for the Hanford environs in general.[12] These game birds are analyzed for radionuclide concentrations and the resulting dose-to-man from ingestion calculated. Table 6-1 details the results of this program for the period 1971-1975.

More recent data from this Environmental Surveillance Program, illustrated in Figure 6-2, compare ducks collected on Hanford ponds with Columbia River ducks.[14]

A recent coot study[2] calculates a possible 1.9 mrem one-year dose (or 2.1 mrem 50 year dose commitment) from the consumption of one Gable Mountain Pond coot having the observed average body burden of 0.3 μCi for all edible tissues. Additional discussion of coots is provided in Section 6.3.2, "Gable Mountain Pond", of this report.

Uptake of radioactivity by mice has also been documented in the vicinity of Hanford ponds.[14] This data is summarized in Table 6-2. This uptake represents a pathway for contamination spread beyond the established radiation zones by fecal droppings and decomposing carcasses.

The following discussion summarizes specific pond data on biological transport. Each of the major ponds will be addressed with general considerations given for all open ditches.

6.3.1 U-Pond

6.3.1.1 Biological Transport Factors

1. U-Pond has received considerably greater quantities of transuranic waste (Pu, Am) than other 200 Area ponds. This is important due to the long half-life of these elements. U-Pond has also received fission product waste similar that of other ponds.

2. U-Pond is the most nutrient rich and biologically productive of the 200 Area ponds. This is important due to the wide variety of biological transport pathways available in a biologically productive system.

TABLE 6-1. Radionuclide Concentrations and 50-Year Dose Commitments for Ingestion of Game Birds Samples 1971-1975.(12)

Game Bird	Nuclide	Conc. (pCi/g)	Dry Wt. (g)	50 Year Dose Comm.		Attributed to Hanford
				Total Body (mrem)	Bone (mrem)	
Pheasant	Cs-137	5.6	500	0.2	--	Yes
	Sr-90	0.08	500	0.1	0.3	Yes
Geese	Zr-65	1.3	5000	0.05	--	Yes
	Cs-137	1.0	5000	0.3	0	No
Ducks	Co-60	1.8	500	0.004	--	Yes
	Zr-65	15.0	500	0.05	--	Yes
	Sr-90	0.3	500	0.3	1.1	Yes
	Cs-137	130.0	500	4.4	--	Yes
Coots	Sr-90	0.1	500	0.09	0.4	Yes
	Cs-137	210.0	500	6.4	8.0	Yes

Nuclide Concentrations and Dose Commitments for ingested game birds (BNWL-2089, J. J. Fix, P. J. Blumer, 1977)

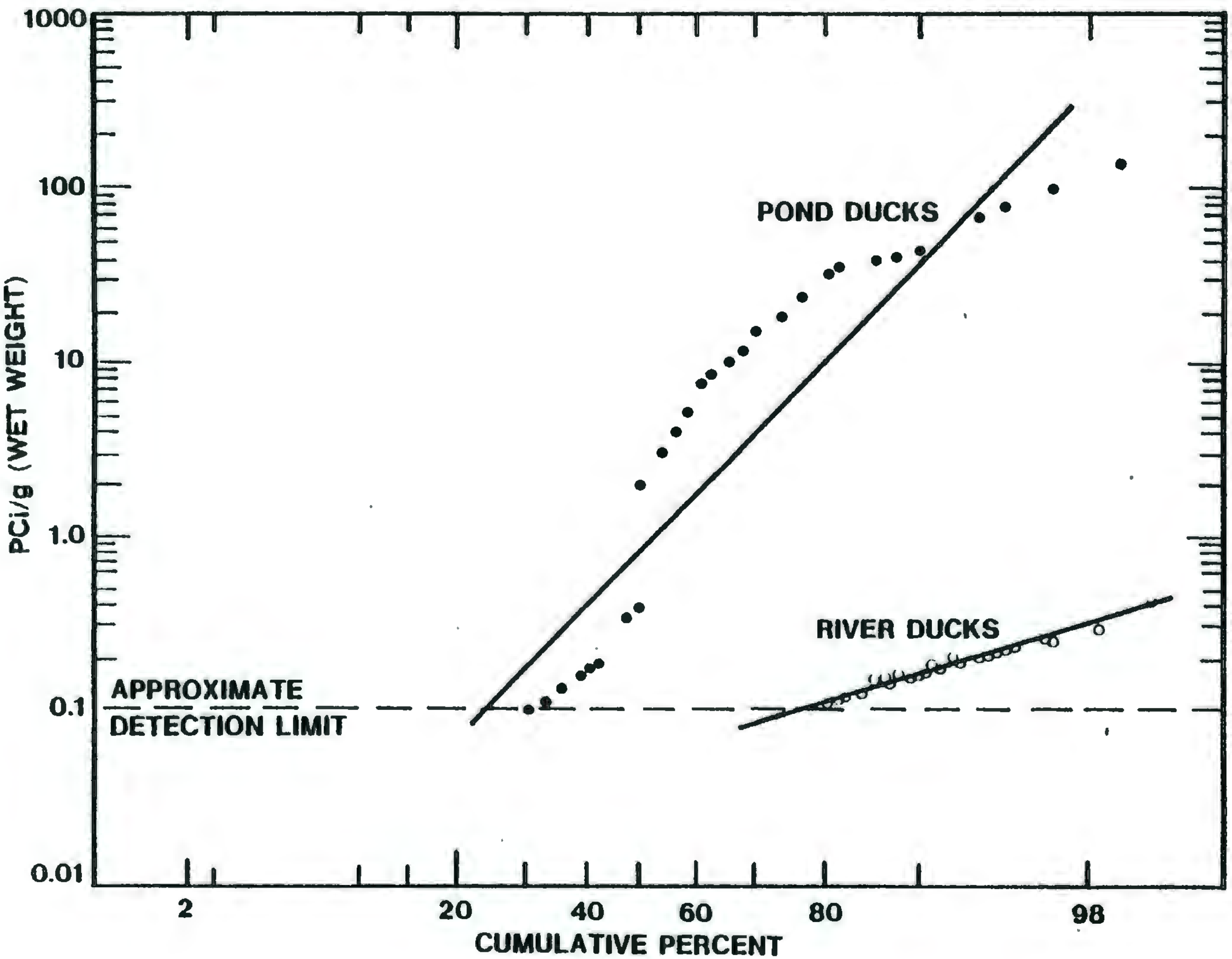


FIGURE 6–2
Cs-137 CONCENTRATIONS IN DUCKS COLLECTED FROM HANFORD PONDS AND THE COLUMBIA RIVER

TABLE 6-2. Radionuclide Concentrations in Mice During 1977.[14]

Locations	Species[a]	Date	Concentration, pCi/g[b]					
			Co-60	Sr-90	Cs-134	Cs-137	U	Total Pu
Gable Pond	Mus M	3/11	*	0.47	*	*		
B-Pond	PM	3/11	*	6.6	*	*		
West Lake	PM	3/18	*	0.10	*	*	0.03	
T-Pond	PM	3/25	0.48	1.5	*	31		
U-Pond	PM	7/08	*	1.1	*	26	*	0.29
T-Pond	PM	7/08	*	8.2	*	27	*	
B-Pond	PM	10.14	*	1.6	*	0.80		
Detection Limit:[c]			0.6	0.005	0.7	0.7	0.02	0.001

*Less than detection limit.

[a]PM - <u>Peromyscus maniculatus</u> (Deer Mouse)
PP - <u>Perognothus parvus</u> (Great Basin Pocket Mouse)
Mus M - <u>Mus musculus</u> (House Mouse)

[b]A blank indicates that no analysis was made.

[c]The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

3. U-Pond is located within the 200 West controlled access area. This location places U-Pond in closer proximity to occupied processing, laboratory, and administrative areas than other ponds. This closer proximity to occupied areas adds additional importance to the consideration of onsite transport resulting from small mammals and birds.

4. U-Pond is a medium-sized 200 Area pond (14 acres) that is considerably smaller than Gable Mountain Pond or B-Pond. Pond size can influence wildlife populations in that a larger pond of similar ecological development can support more wildlife.

6.3.1.2 Transport Characterization

1. A series of studies conducted by Emery et al.,[8] estimated inventories and transport rates for plutonium in the ecological compartments of U-Pond. A summary of these data are presented graphically in Figure 6-3.

   a. U-Pond has received approximately 1 Ci of plutonium, greater than 99% is retained in the pond sediments.

   b. Ninety-five percent of the plutonium associated with the pond biota is contained in the plant life. Diatoms and pondweed account for 99% of the plant inventory.

   c. Emergent insects are the most significant biological export route in terms of the total plutonium leaving the pond as shown in Figure 6-3.

   d. The estimated mean annual transport of plutonium for waterfowl and other birds is 500 nCi, and 100 nCi, respectively, and the maximum for mammals is 30 nCi.

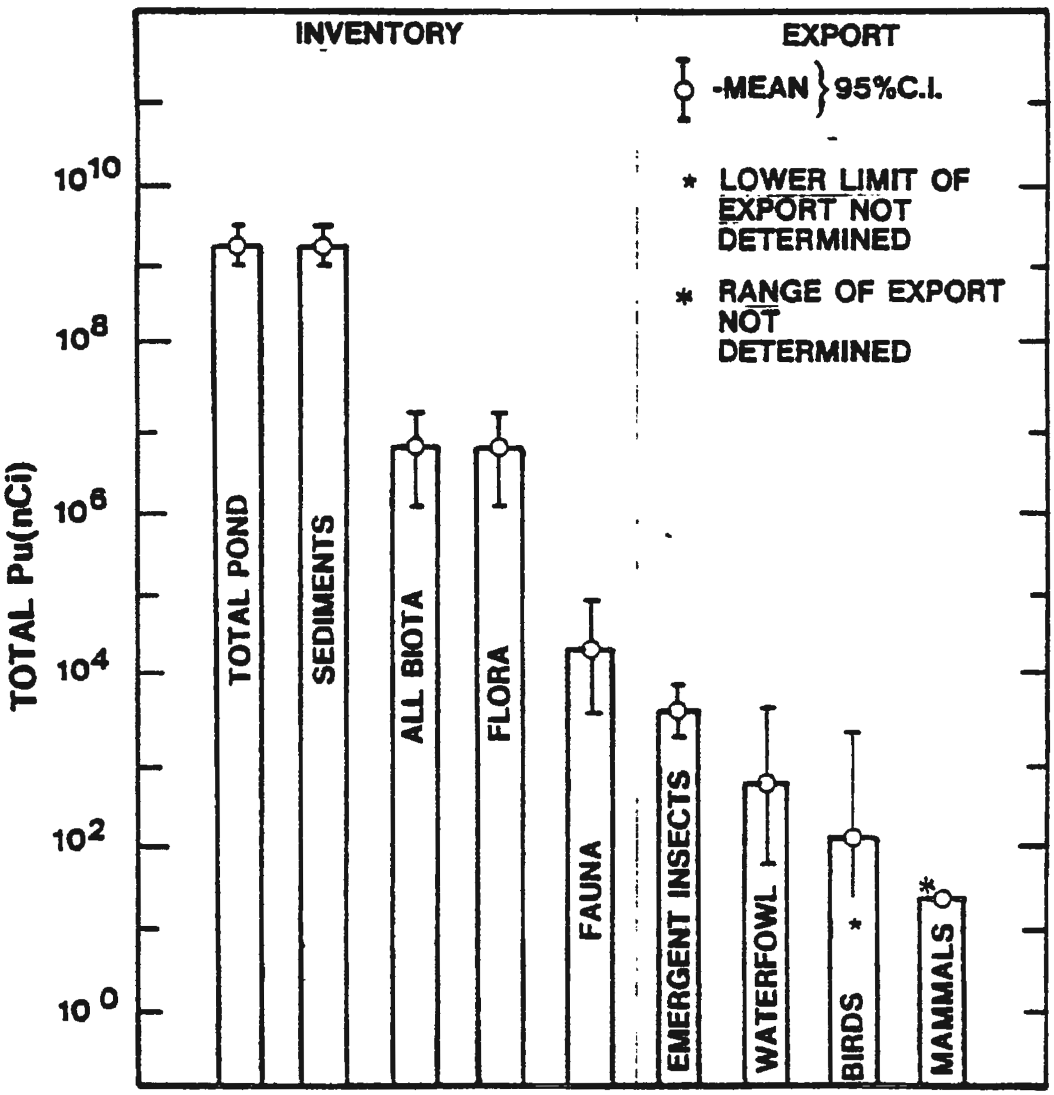


FIGURE 6–3

ESTIMATED U POND Pu INVENTORY AND EXPORT BY ECOLOGICAL COMPARTMENT

2. Waterfowl use of 200 Area ponds and resulting levels of Cs-137 accumulation were investigated and reported by Price and Fitzner.[11] That report found that Cs-137 concentrations in muscle tissue seems to be related to pond size, human disturbance, biological habitat, and sediment concentration. The following results support this indication.

   a. U-Pond, with a relatively small size and high degree of human disturbance, had a lower waterfowl utilization.

   b. U-Pond has abundant vegetation and relatively high concentrations of Cs-137 in vegetation and sediments. Waterfowl sampled at U-Pond showed correspondingly high Cs-137 concentrations (Figure 6-4).

3. Gano[13] investigated mice inhabiting the U-Pond ecosystem. This study was designed to identify the different species within the small mammal community, the radiation exposures received, and the level and type of nuclides accumulated. The most significant results were:

   a. Four species of mice inhabit the U-Pond area: deer mouse, Great Basin pocket mouse, house mouse, and the western harvest mouse. All species were found to accumulate elevated levels of nuclides.

   b. Pocket mice prefer the noncontaminated sagebrush-cheatgrass habitat adjacent to the ditches, thus reducing the biological transport potential for this species.

   c. House mice, deer mice, and harvest mice prefer the denser vegetation of the riparian areas around the pond which are more contaminated than outlying areas and, therefore, accumulate greater quantities of radionuclides.

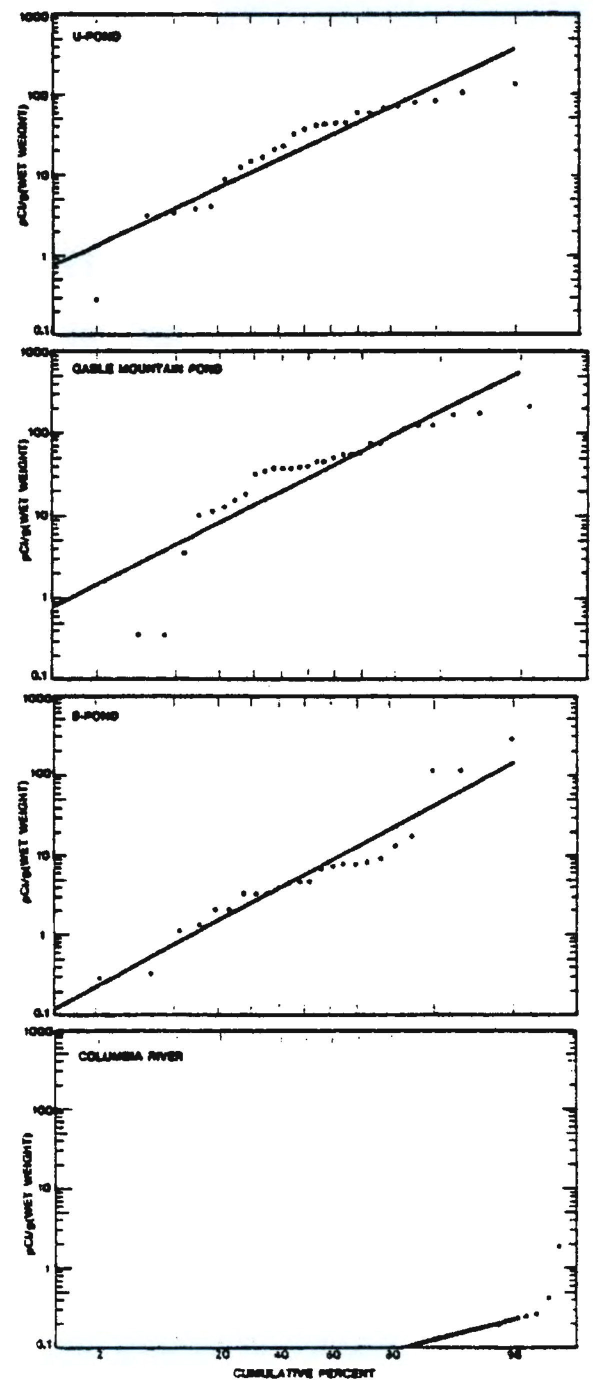


FIGURE 6-4
CESIUM-137 CONCENTRATION IN ALL DUCKS,1971-1977 (11)

d. House mice captured near the 216-Z-19 ditch in the vicinity of U-Pond showed the highest levels of activity with one gastrointestinal (GI) tract sampling having 1600 pCi Cs-137/gm dry weight. Fur-skin, liver, kidney, lung, and bone-muscle samples for all species ranged from nondetectable to hundreds of pCi Cs-137/gm dry weight. At the Rattlesnake Springs control transect composite samples for deer mice ranged from nondetectable to 1.3 pCi Cs/g dry weight.

6.3.2 Gable Mountain Pond

6.3.2.1 Biological Transport Factors. Several important factors influencing biological transport at Gable Mountain pond are:

1. Gable Mountain Pond has received the greatest quantities of fission product waste of all the Hanford ponds. This pond has also received substantial quantities of plutonium and other transuranic waste.
2. Gable Mountain Pond is a biologically productive system. Aquatic emergent vegetation is more developed than other ponds. Riparian vegetation is similar though less developed than U-Pond.
3. Gable Mountain Pond is located in a relatively remote area of the Hanford site, a considerable distance from any substantial human activities. This situation is essentially opposite that of U-Pond in that the lack of human activity in the area may permit a higher rate of wildlife utilization, especially waterfowl. Therefore, offsite biological transport is given added significance at Gable Mountain Pond especially for the waterfowl pathway.
4. Gable Mountain Pond is the largest of the 200 Areas ponds (71 acres).

6.3.2.2 Biological Transport Characterization

1. Cushing and Watson[3] studied the biotic and abiotic compartments of the Gable Mountain Pond ecosystem to evaluate biological transport. The most significant results of this study are:

   a. Most of the Cs-137 and other radionuclides discharged to the pond have accumulated in the sediments. Over 90% of the contamination was found in the upper 2 inches of the sediment cores.

   b. Goldfish were found to have maximum and average concentrations of 340 and 170 pCi Cs-137/g dry weight, respectively. It should also be noted that goldfish are a food source for several wide-ranging wildlife species utilizing the pond including herons, mergansers, and coyotes.

   c. Wild ducks experimentally restricted to Gable Mountain Pond were found to accumulate less Cs-137 than resident wild coots but significantly more than transient wild ducks. Coots accumulated the greatest concentration of Cs-137.

Table 6-3 reports the waterfowl uptake data collected for this study.

2. Waterfowl utilization and Cs-137 accumulation at Gable Mountain Pond were investigated and reported by Price and Fitzner.[11] As in the U-Pond discussion, waterfowl Cs-137 uptake appears related to pond size, degree of human disturbance, ecological stage, and Cs-137 concentration in sediments. As opposed to U-Pond, however, conditions at Gable Mountain Pond promote a higher utilization rate and level of biological uptake than any other Hanford pond. These conditions include:

   a. The largest pond size of all Hanford ponds. This attracts a greater total waterfowl population.

   b. The most remote location of the Hanford ponds. This results in the least amount of background noise and routine human disturbance. Noise and human disturbance may tend to discourage extended utilization, especially for breeding.

TABLE 6-3. Cs-137 Concentrations of Experimental and Wild Waterfowl, at Gable Mountain Pond (pCi/g dry weight).[3]

Experimental Ducks*			Wild Ducks			Coots		
Date	Muscle	Carcass	Date	Muscle	Carcass	Date	Muscle	Carcass
09-13-73	266.5	81.8	11-05-73	4.6	0.8	09-13-73	634.7	216.6
09-13-73	522.2	148.0	11-06-73	174.8	78.9	09-13-73	216.2	83.2
09-13-73	225.5	191.2	11-06-73	25.2	37.6	x =	375.5	149.9
09-13-73	109.6	51.2	11-06-73	3.2	3.5			
x[a] =	281.0	118.0	11-06-73	188.4	74.5	10-09-73	1154.6	868.0
			x =	79.2	40.3	10-09-73	12.3	29.0
10-23-73	414.4	217.8				10-09-73	442.7	115.6
			01-03-74	7.3	1.1	10-09-73	535.2	592.4
11-05-73	212.2	101.5	01-03-74	107.3	17.2	x =	537.2	401.4
11-05-73	288.0	116.1	01-03-74	65.4	10.9			
x =	254.6	108.8	01-03-74	36.5	10.0	01-03-74	767.4	276.0
			01-03-74	4.3	1.2	01-03-74	446.4	145.5
			x =	44.1	8.1	01-03-74	1220.1	616.7
						01-03-74	458.9	172.3
						01-03-74	914.1	262.4
						01-03-74	897.0	192.1
						x =	784.0	277.5

*Released August 8, 1973

[a]x is the average concentration (pCi/g dry weight).

c. Nutrient rich and biologically productive system. This results in preferred habitat and an abundant food supply which may tend to attract larger and more diverse wildlife populations.

d. Highest Cs-137 concentrations are in the sediments. Some of the waterfowl species feed directly on organic matter in the pond sediments and rooted pond macrophytes which accumulate from pond sediments.

Figure 6-4 shows Cs-137 concentrations for all ducks collected from Gable Mountain Pond 1971 to 1977.

3. Two related studies[2,9] conducted to examine nesting biology and Cs-137 accumulation in the American coot on Hanford ponds compared to selected offsite ponds. The coot was selected as the subject because previous data show that coots accumulate the greatest concentration of Cs-137 activity. Some relevent information from the nesting biology study includes:

   a. Population studies show substantial fluctuations indicating significant migration; however, some coots were observed on the ponds throughout the study period. The observed population ranged from less than 20 to nearly 600.

   b. Coots were observed nesting in cattail and bullrush stands. This breeding population was estimated to hatch as many as 200 young per year, 40 of which may reach flight age.

   c. Coots were found to feed primarily on algae, pondweed, water milfoil, and invertebrates.

4. The most significant results of the biological transport studies include:

   a. Cs-137 accumulated to far greater concentrations than other nuclides analyzed (Sr-90, gross Pu) (Table 6-4).

   b. Cs-137 occurred in greatest concentration in tissue from Gable Mountain coots (Table 6-5).

TABLE 6.4. Average Concentration of Sr-90 and Cs-137 and Gross Pu in Selected Tissues of Coots Collected at Gable Mountain Pond.[2]

Sample Type	Average Dry Weight per Coot, g	Concentration (pCi/g dry weight)					
		Sr-90 (n = 12)[a]		Cs-137 (n = 103)		Gross Pu (n = 24)	
		x[b]	SE[c]	x	SE	x	SE
Bone	24.0	2.60	0.60	200	30	0.023	0.006
Liver	4.3*	0.53	0.20	440	40	0.052	0.031
Muscle	59.0*	0.28	0.12	570	40	0.019	0.015**
Gut Contents	3.0	4.30	1.50	3400	200	0.140	0.030

*Multiply by 2.9 convert to wet weight.

**n = 16 for muscle only.

[a]n refers to sample size.

[b]x is the average concentration.

[c]SE is the standard error for the average concentration.

TABLE 6.5. Average Concentration of Cs-137 in Samples of Coots from the Study Areas.

Sample Type	Concentration (pCi/g dry weight)							
	Gable Mountain Pond (n = 103)[a]		U Pond (n = 18)		B Pond (n = 31)		Columbia Wildlife Refuge (n = 13)*	
	x[b]	SE[c]	x	SE	x	SE	x	SE
Bone	200	30	70	10	5.7	0.8	1.00	0.30
Liver	440	40	220	20	16.0	2.0	0.70	0.20
Muscle	570	40	360	30	30.0	4.0	0.02	0.05
Gut Contents	3400	200	1300	200	85.0	11.0	0.80	0.50

*Columbia Wildlife Refuge concentrations were near or below detection limits (~0.5 pCi/g), which varied with sample size.

[a] n refers to sample size.

[b] x is the average concentration.

[c] SE is the standard error for the average concentration.

c. Data indicate Cs-137 concentration in muscle tissue is probably a function of the amount of time an individual spends feeding on the pond. Cs-137 muscle concentration appears to increase until an equilibrium concentration is reached. This may take 1 to 2 months.

d. Average bone, liver, muscle, and gut content Cs-137 concentrations are shown in Table 6-5. The maximum muscle concentration exceeded 2000 pCi/g dry weight, average muscle concentration was 540 pCi/g dry weight. Muscle tissue is considered to be the edible portion of most waterfowl.

e. The total-body 50-year dose commitment from Cs-137 to an individual harvesting and ingesting all muscle tissue from one coot (0.03 μCi) was found to equal 2.1 mRem. The first year dose is 1.9 mRem.

6.3.3 B-Pond

6.3.3.1 Biological Transport Factors

1. B-Pond has received substantial quantities of fission product waste along with a lesser amount of transuranic waste.

2. B-Pond is the least biologically productive of the Hanford ponds. B-Pond was treated with aquatic herbicides in 1971 and again in 1972. A limited amount of aquatic vegetation has returned in the last several years. A maintained access road around the pond and a steep, riprap-stabilized bank on the east end has maintained the bank essentially free of any substantial vegetation growth.

3. B-Pond is located approximately 1 mile east of the 200 East controlled access area. This distance should significantly reduce the potential for local contamination spread to occupied areas in the 200 East Area.

6.3.3.2 Biological Transport Characterization

1. Waterfowl utilization and the resulting levels of Cs-137 accumulation at B-Pond was investigated and reported by Price and Fitzner.[11] As previously mentioned, that report suggests Cs-137 accumulations seem related to pond size, degree of human disturbance, ecological stage and sediment concentration of CS-137. Other significant results of this study include:

   a. Total waterfowl observations on B-Pond were greater than U-Pond while less than Gable Mountain Pond.

   b. Several diving duck species were observed more frequently on B-Pond than any other pond. This is attributed to the openness and lack of emergent aquatic vegetation on B-Pond.

   c. Cs-137 accumulation in ducks collected on B-Pond shows significantly lower levels than either U-Pond or Gable Mountain Pond. The three high values for Cs-137 concentration of ducks on B-Pond (Figure 6-4) do not follow the established pattern and may represent ducks recently arrived from another Hanford pond. Lower Cs-137 concentrations in B-Pond may be related to lower sediment concentrations and less contaminated vegetation; however, little data are available on sediment Cs-137 concentration in B-Pond.

6.3.4 Ditches

6.3.4.1 General Transport Factors. While open ditches have not been extensively studied, it is possible to discuss several factors which will influence potential biological transport.

1. Open ditches tend to accumulate nuclides faster than the ponds to which they discharge. This is attributed to the sorptive chemical processes, precipitation and settling that occurs along the length of the ditch prior to the pond inlet. Detailed ditch characterizations are not available at this time, however, preliminary Rockwell Research Department studies indicate that of

approximately 8000 grams of plutonium discharged to the Z-ditches only 200 grams has reached U-Pond. Routine environmental surveillance tends to confirm this (see Table A-7 for radionuclide concentrations in ponds and ditches).

2. All of the currently active open ditches have well developed and uncontrolled vegetation growth similar to that of the ponds.

3. All of the currently active ditches are near or within the 200 West controlled access areas. These ditches provide an available and attractive habitat for small mammals, birds, and other wildlife. These ditches are potential sources of local contamination spread.

4. Airborne resuspension of contaminated particulates attributable to ditches has not extensively studied. The only ditch with a permanent ambient air sample is 216-Z-19. This sample has shown elevated levels of gross alpha (above DOE Table II Concentration Guide for 1977) and plutonium (below Table II for 1978). Data on other ditches are not available.

7.0 CURRENT POND MANAGEMENT PRACTICES

7.1 WATER LEVEL CONTROL

Water level control in the ponds is critical to prevent overflow or to minimize exposure of contaminated sediments. At the present time water level is controlled by a standard operating procedure SOP No. TO-040-220, which calls for water level monitoring on each Monday, Wednesday, Friday, and Saturday. The procedure requires the operator to notify the tank farm supervisor in the event the water level exceeds certain upper or lower limits. If the water level should change 2 inches or more compared with the preceding reading, the supervisor is also notified. The supervisor then must review flow status and request an adjustment of flows from the source facilities or a diversion of flow from one pond to another.

The water level limits for each pond are:

Pond	Water Level Limits, inches	
	Minimum	Maximum
B-Pond	76	89
Gable Mountain Pond	25	40
U-Pond	12	30

7.2 CURRENT SURVEILLANCE OF THE POND SYSTEMS

Table 7-1 illustrates the current radiological surveillance performed by Rockwell Hanford Operations and Pacific Northwest Laboratories for the 200 Area waste ponds and associated transfer ditches and retention basins. The table describes routine effluent monitoring after discharge to the ponds, ditches, and retention basins, and any sediment, vegetation, and wildlife sampling performed at or relating to the ponds.

The Liquid Effluent Surveillance portion incorporates the sample codes, frequency of the samples, type of samples taken and their locations, and the laboratory analyses performed. The sample code is a letter/number symbol designated for each specific sample site. The Sample Type refers to the method of sampling, DIP meaning a one time manual grab sample and SEQUENTIAL SAMPLER being an automatic instrument that samples at predetermined time intervals.

TABLE 7.1. Current Surveillance of Ponds, Ditches and Retention Basins.

Rockwell Liquid Effluent Surveillance			Sample Type	Sample Location	Analyses Performed
Disposal System	Sample Code	Sample Frequency			
216-B-3 Pond	RM22	Weekly	DIP	Sampled at north side of pond near dam	Ta Tb
216-B-3 Pond	RM23	Weekly	DIP	Sampled at south end of pond	Ta Tb
216-A-25 Pond	RM24	Weekly	DIP	Sampled at inlet to pond	Ta Tb
216-A-25 Pond	RM25	Weekly	Automatic* Sequential Sampler	Sampled at north side of pond	Ta Tb
216-S-19 Pond (222-S Pond)	RM14	Weekly	DIP	Sampled near inlet to pond	Ta Tb
216-U-10 Pond	RM6	Weekly	Sequential* Sampler	Sampled in the center of the pond	Ta Tb
Honey Hill Pond (West Lake)	RM53	Weekly	DIP	Sampled at west side of lake	Ta Tb
216-B-63 Ditch	RM18	Weekly	DIP	Sampled at head of ditch	Ta Tb
216-B-3-3	RM21	Weekly	Automatic* Sequential Sampler	Sampled at ditch near B-3 Diverter Box	Ta Tb
216-A-29 Ditch	RM20	Weekly	DIP	Sampled at ditch	Ta Tb
216-A-29 Ditch	CSL	Weekly	Japanese Proportional Sampler	Sampled at head end of ditch	Ta Tb pH H^3 U
216-S-10 Ditch	S-11	Weekly	DIP	Sampled at head end of ditch	Ta Tb U pH
216-T-4-2 Ditch	RM3	Weekly	DIP	Sampled at head end of ditch	Ta Tb
216-U-14 Ditch	RM4	Weekly	DIP	Sampled at head end of ditch	Ta Tb
216-Z-19 Ditch	RM5	Weekly	Automatic* Sequential Sampler	Sampled near Z Plant inlet to ditch	Ta Tb
207-B Retention Basin	CBC	2/Shift	DIP	Sampled at basin before overflow into ditch	Tb
207-SL Retention Basin	207-SL	Daily	DIP	Sampled at basin before overflow	Ta Tb

*These samples are presently disconnected for maintenance purposes. Manual 1 liter DIP samples are taken in place of automatic samplers.

- All other Retention Basins are not sampled (207-A, 207-T, 207-U).
- 216-S-10 Pond and 216-T-4-2 Pond are dry due to minimal flow which leaches into the ditches.
- 216-T-1 Ditch sampling discontinued due to the low risk, low volume nature.
- 216-C-9 Pond is not sampled due to low risk, low volume nature.

ADDITIONAL ROCKWELL SURVEILLANCE

- Vegetation/mud/sediment sampling: Samples taken once/year on all ponds and ditches except the sites mentioned above.
- Wildlife: No routine wildlife sampling.

BATTELLE SURVEILLANCE

- Liquid: Liquid samples taken quarterly on 216-B-3 Pond, 216-A-25 Pond and 216-U-10 Pond.
- Vegetation/mud/sediment: Only surveillance is visual checks, i.e., vegetation growth, evidence of burrowing animals, erosion, status of enclosure, etc., on 216-B-3 Pond quarterly and 216-B-3-3 Ditch semi-annually.
- Wildlife: Ducks are sampled on 216-B-3 Pond, 216-A-25 Pond, and 216-U-10 Pond.

Mud and vegetation sampling by Rockwell at the ponds is listed, however, Rockwell does not routinely collect wildlife samples. Pacific Northwest Laboratory environmental sampling including wildlife at the ponds is also listed.

7.3 PROCEDURE FOR SURVEILLANCE RELATED TO UNPLANNED RELEASES

Radiation monitors (RM) and operators collect all of the liquid effluent samples. Each sample is surveyed when collected and survey readings are reported to Environmental Protection at the end of each day. In the event of an unusual discharge environmental Protection evaluates the data and notifies the appropriate facilities Operations Manager if the Emergency Procedures (RHO-MA-111) for the facility are to be implemented. Environmental Protection conducts a detailed investigation and reports the cause of the release with corrective action within 48 hours. An Occurrance Report, issued by the appropriate manager at the responsible facility is also initiated. If there is evidence that the release has spread beyond the 200 Areas fence, Environmental Protection contacts the designated Battelle Environmental Evaluation Team.

7.4 POND SYSTEM MAINTENANCE

- The perimeter road surrounding B pond and the east end dike is routinely maintained.
- Pond area access roads are routinely maintained.

8.0 CONCLUSIONS

8.1 BIOTRANSPORT

Past pond management practices at Hanford were designed to monitor effluents, prevent unusual discharges and detect significant environmental or safety hazards. These practices generally have not been directed at controlling ecological development. As a result, the ponds have developed natural ecosystems which are attractive to wildlife. The interactions between these ecosystems and the pond radionuclide inventory can result in the accumulation of small quantities of radionuclides within the plant and animal species using the ponds. As the pond ecosystems continue to develop and radionuclides accumulate in the more transient species (emergent insects, mammals, waterfowl and other birds), the movement of these radionuclides away from the disposal site can occur.

8.2 ENVIRONMENTAL OR SAFETY IMPACT TO THE GENERAL PUBLIC

A number of ecological studies have been performed to characterize the ponds, describe ecosystem-radionuclide interactions and assess specific biological transport pathways. These studies indicate that radionuclides have accumulated in transient wildlife, particularly waterfowl, at levels above background, but that the ponds and their operation have not resulted in a significant environmental or safety impact to the general public.

8.3 ONSITE CONTAMINATION SPREAD

Onsite contamination spread from the ponds and ditches has not been extensively studied. However, contamination spread resulting from wildlife utilization of pond and ditches. Mice inhabiting the U-Pond area are found to accumulate above background levels of several radionuclides.[13] Swallows have been observed removing contaminated sediment from the U-14 ditch to build nests in the 284-W powerhouse.[24] Though such isolated events have occurred, their frequency, extent and magnitude are not well known. Similar events could potentially occur from any open ditch, pond or other site where contaminated sediment and vegetation are available.

8.4 CURRENT POND MANAGEMENT PRACTICES

In general, current pond management practices which are limited to surveillance and maintenance of effluents and facilities appear to be adequate to monitor pond operations and prevent unusual discharges. However, the following items require appropriate action.

- Water Level Control - Compliance with established pond water level limits has not been completely satisfactory. Fluctuating water levels have exposed contaminated pond sediments at U-Pond, B-Pond, and Gable Mountain Pond in the last 2 years as shown in Tables A-16, A-17, and A-18.
- Effluent Sampling - Automatic effluent sampling stations are inadequately maintained and have been frequently out-of-service requiring a return to manual sampling.
- Wildlife Monitoring - Current wildlife sampling is limited and does not provide a quantitative estimate of onsite contamination transport by wildlife.
- Effluent Retention/Diversion - A number of effluents are discharged directly to the ponds. These are routinely below DOE Table II Concentration Guides and the probability that they could potentially contain activity levels in excess of current discharge data is considered essentially nil. Therefore sampling and emergency diversion capabilities have not been deemed necessary and have not been arranged.

8.5 SUMMARY

In summary, available data indicate that current pond management practices are sufficient to maintain pond operations without significant environmental or safety impact to the general public. Onsite radionuclide transport from the ponds has occurred and the potential exists for offsite transport. The principle of maintaining transport as low as technically and economically practicable (ALATEP) requires the evaluation and assessment of improved methods to reduce transport. The evaluation of alternative methods of pond management is described in a companion document Alternatives to 200 Area Pond Management (RHO-CD-799).

REFERENCES

1. C. D. Becker, "Aquatic Bioenvironmental Studies in the Columbia River at Hanford, 1945-71 - A Bibliography with Abstracts," Battelle (BNWL-1734), February 1973.

2. L. L. Cadwell, R. G. Schreckhise, and R. E. Fitzner, "Cesium - 137 in Coots on Hanford Waste Ponds: Contribution to Population Dose and Offsite Transport Estimates," Battelle (PNL-SA-7167), April 1979.

3. C. E. Cushing and D. G. Watson, "Aquatic Studies of Gable Mountain Pond," Battelle (BNWL-1884), December 1974.

4. P. A. Eddy, "Radiological Status of the Ground-Water Beneath the Hanford Project, January-December 1978," Battelle, (PNL-2899), April 1979.

5. R. M. Emery and M. C. McShane, "Comparative Ecology of Nuclear Waste Ponds and Streams in the Hanford Site," Battelle (PNL-2499), October 1978.

6. R. M. Emery and T. R. Garland, "The Ecological Behavior of Plutonium and Americium in a Freshwater Ecosystem: Phase II Implications of Differences Transuranic Isotopic Ratios," Battelle (BNWL-1879), December 1974.

7. R. M. Emery, D. C. Klopfer, T. R. Garland, and W. C. Weimer, "The Ecological Behavior of Plutonium and Americium in a Freshwater Pond," Battelle (BNWL-SA-5346), March 1975.

8. R. M. Emery, D. C. Klopfer, and M. C. McShane, "The Ecological Export of Plutonium from a Reprocessing Waste Pond," Health Physics, Vol. 34, pp. 255-269.

9. R. E. Fitzner and R. G. Schreckhise, "The American Coot on the Hanford Site Part 1: Nesting Biology," Battelle (PNL-2462), May 1979.

10. R. E. Fitzner and W. H. Rickard, "Avifauna of Waste Ponds ERDA Hanford Reservation Benton County, Washington," Battelle (BNWL-1885), June 1975.

11. R. E. Fitzner and K. R. Price, "The Use of Hanford Waste Ponds by Waterfowl and Other Birds," Battelle (BNWL-1738), February 1973.

12. J. J. Fix and P. J. Blumer, "Radiochemical Analyses of Game Birds Collected from the Hanford Environs, 1971-1975," Battelle (BNWL-2089), July 1977.

13. K. A. Gano, "Analysis of Small Mammal Populations Inhabiting the Environs of a Low-Level Radioactive Waste Pond," Battelle (PNL-2479), March 1979.

14. J. R. Houston and P. S. Blumer, "Environmental Status of the Hanford Site for CY-1977," Battelle (PNL-2677), June 1978.

15. J. R. Houston and P. J. Blumer, "Environmental Surveillance at Hanford for CY-1978," Battelle (PNL-2932), April 1979.

16. O. D. Markham (editor), "Ecological Studies on the Idaho National Engineering Laboratory Site," 1978 Progress Report.

17. H. L. Maxfield, "Handbook - 200 Areas Waste Sites," Rockwell Hanford Operations (RHO-CD-673), April 1979.

18. K. R. Price, "A Critical Review of Biological Accumulation, Discrimination and Uptake of Radionuclides Important to Waste Management Practices 1943-71," Battelle (BNWL-B-148), December 1971.

19. K. R. Price and R. E. Fitzner, "The Use of Hanford Waste Water Ponds by Waterfowl," Battelle (PNL-SA-7155), February 1979.

20. W. H. Rickard, J. D. Hedlund, and R. G. Schreckhise, "Mammals of the Hanford Reservation in Relation to Management of Radioactive Waste," Battelle (BNWL-1877), August 1974.

21. L. E. Rogers and W. H. Rickard, "Ecology of the 200 Area Plateau Waste Management Environs: A Status Report," Battelle (PNL-2253), October 1977.

22. G. A. Swanson and M. I. Meyèr, "Impact of Fluctuating Water Levels on Feeding Ecology of Breeding Blue-Winged Teal," J. Wildl. Manage. 41(3):1977.

23. United States Energy Research and Development Administration, "Waste Management Operations, Hanford Reservation, Richland, Washington - Final Environmental Statement," ERDA-1538, UC-70, (Vol. 1 & 2), December 1975.

24. Rockwell Hanford Operations, Occurrence Report, Report Number 78-71, "202S Dock Contamination," August 31, 1978.

25. R. E. Gephart, P. A. Eddy, R. C. Arnett, and G. A. Robinson, "Geohydrologic Study of the West Lake Basin," ARH-CD-775, October 1976.

26. G. A. Sehmal, "Radioactive Particle Resuspension Research on the Hanford Reservation," BNWL-2081, February 1977.

27. J. V. Panesko, et.al., "Environmental Protection Annual Report - CY-1977," RHO-LD-78-75, December 1978.

28. W. K. Summers, "Water Importation and Waste Disposal Measurements in the 200 Areas of the Hanford Reservation," August, 1975, CA-198-WKS-1.

APPENDIX A

TABLE A-1. Physical Characteristics of the Hanford Ponds.

Parameter	Gable Mt. Pond	B-Pond	U-Pond	West Pond	S-19 Pond
Surface Area, m^2	287,300	149,200	56,700	77,800	14,200*
Volume, m^3	431,000	233,200	22,700	31,100	--
Water Table Depth, m	10.6	47.5	56.4	--	60.6
Mean Depth, m	1.5	1.6	0.4	0.4	--
Retention Time, hr	504 ± 211	424 ± 183	37 ± 4	--	--
Sedimentation Rate mg/cm^2 per day	2.43 ± 0.76	0.81 ± 0.51	2.24 ± 1.42	11.20 ± 6.50	--

NOTE: Gable Mountain Pond, B-Pond, U-Pond and West Pond data from PNL-2499.
Water table depths from RHO-CD-673.
S-19 data from RHO-CD-673.

*The S-19 Pond is currently much smaller than this having little constant surface water.

TABLE A-2. Physical Characteristics of the Hanford Ditches.

Parameter	A-29	B-3	Z-19	U-14	T-4-2	T-1	B-63	S-10
Length, m	1325	1200	885	1740	533	550	427	685
Width, m	1.83	6.1	1.22	2.44	2.44	7.62	1.22	1.83
Maximum Depth, m	<0.5	<1	<0.5	*	*	*	*	*
Water Table Depth, m	33.8	70.4	60.3	61.3	60.6	80.4	68.9	54.8
Flow Rate, m^3/min	1.53 ± 0.40	10.77 ± 4.45	0.65 ± 0.08	8.6*	*	*	0.59**	0.38**

NOTE: Length, maximum depth, flow rate for A-29, B-3, Z-19 from PNL-2499.
Width and water table depths from RHO-CD-673.
All U-14, T-4-2, T-1, B-63, S-10 data from RHO-CD-673.

*No data available.

**Calculated from RHO-CD-78-34 4Q data.

TABLE A-3. Chemical Characteristics of Hanford Ponds.*

Characteristics	Gable Mt. Pond	B-Pond	U-Pond	West Pond
pH Range	7.8 - 8.7	7.0 - 9.0	7.0 - 9.5	9.7 - 10.0
Alkalinity, mg/ℓ as $CaCO_3$	58.4 ± 6.1	57.1 ± 4.8	95.2 ± 6.5	9009 - 1924
Total NO_3-NO_2-N, mg/ℓ	0.18 ± 0.07	3.65 ± 1.33	0.28 ± 0.08	--
Total NH_3-N, mg/ℓ	0.38 ± 0.10	1.04 ± 0.51	0.45 ± 0.20	2.61 - 0.40
Total PO_4-P, μg/ℓ	38.0 ± 10.0	40.4 ± 10.0	123.0 ± 56.0	2160 ± 140

NOTE: All data from PNL-2499.

*No data available for 216-S-19 Pond.

TABLE A-4. Chemical Characteristics of Hanford Ditches.*

Characteristic	A-29 Ditch	B-3 Ditch	Z-19 Ditch
pH Range	6.5 - 7.6	7.4 - 8.1	6.9 - 8.0
Alkalinity, mg/ℓ as $CaCO_3$	53.6 ± 4.5	55.2 ± 4.6	73.2 ± 4.9
Total NO_3-NO_2-N, mg/ℓ	0.19 ± 0.15	3.74 ± 1.28	0.30 ± 0.36
Total NH_3-N, mg/ℓ	0.67 ± 0.84	1.61 ± 1.10	0.09 ± 0.04
Total PO_4-P, μg/ℓ	45.1 ± 9.0	48.2 ± 10.8	105.0 ± 54.0

NOTE: All data from PNL-2499.

*No data for other ditches.

TABLE A-5. Total Discharges (Decayed) to Ponds and Leaching Ditches Through December 31, 1978.

Site	Volume, ℓ	Pu, g	Beta, Ci	Sr-90, Ci	Ru-106, Ci	Cs-134, Ci	Cs-137, Ci	Ce-144, Ci	Co-60, Ci
216-A-25 (Gable Mtn. Pond)	.203E+12	<.426E+03	.140E+04	.342E+03	.536E+00	*	.263E+03	<.332E-02	<.109E+02
B-Pond System[a]	.112E+12	<.241E+03	<.461E+03	.113E+03	.232E+00	*	.109E+03	<.248E-02	<.481E+01
216-B-63 Trench	.304E+10	<.415E+00	<.421E+01	.142E+01	<.790E-3	.222E-01	<.568E+00	*	<.799E-02
216-C-9 Pond	.103E+10	<.338E+00	<.859E+01	.330E+01	.482E-03	**	<.937E+00	**	<.916E+00
216-S-10 Ditch	.422E+10	<.283E+00	<.295E+01	<.724E+00	<.324E-03	*	<.744E+00	*	<.293E-01
216-S-19 (S-Pond)	.940E+09	.206E+02	<.679E+01	<.123E+01	<.129E-02	*	<.166E+01	*	<.110E+00
U-Pond System[b]	.150E+12	.821E+04	<.507E+02	<.142E+02	<.293E-01	*	<.103E+02	<.130E-02	<.983E+00
216-T-1 Ditch	**	<.10E+00	<.20E-00	<.50E-01	<.10E-01	**	<.50E-01	**	*
216-T-4-2 Ditch	**	**	**	**	**	**	**	**	**

NOTE: All data from RHO-CD-78-34 4Q, March 26, 1979, except 216-T-1 ditch data from RHO-CD-673, (decayed through 06/30/77).

*Below detectable limits.

**No data available.

[a]B-Pond System includes 216-B-3 (B-Pond) and the following ditches; (active) 216-B-2-3, 216-B-3-3, 216-A-29, (inactive) 216-B-2-1, 216-B-2-2, 216-B-3-1, 216-3-3-2.

[b]U-Pond System includes 216-U-10 (U-Pond) and the following ditches; (active) 216-U-14, 216-Z-19, (inactive) 216-Z-1, 216-Z-11.

TABLE A-5. Total Discharges (Decayed) to Ponds and Leaching Ditches Through December 1978 (Contd.).

Site	Sb-125, Ci	U-238, kg	H-3, Ci	U-233, g	Am-241, g	Eu-155, Ci	Eu-154, Ci	Mn-54, Ci
216-A-25 (Gable Mtn. Pond)	*	<.928E+03	<.125E+01	<.459E+03	*	.265E-02	*	*
216-B-3 (B-Pond)	*	<.578E+03	<.117E+02	<.300E+02	*	*	*	*
216-B-63 Trench	*	<.230E+02	<.169E+01	*	*	.923E-01	*	*
216-C-9 Pond	**	<.916E+00	**	**	**	**	**	**
216-S-10 Ditch	*	<.371E+02	*	*	*	*	*	*
216-S-19 (S-Pond)	*	.110E+03	*	*	*	*	*	.206E-02
216-U-10 (U-Pond)	*	<.167E+04	<.109E+01	*	.305E-03	.550E-02	*	*
216-T-1 Ditch	**	.45E+01	**	**	**	**	**	**
216-T-4-2 Ditch	**	**	**	**	**	**	**	**

NOTE: All data from RHO-CD-78-34 4Q, March 26, 1979, except 216-T-1 ditch data from RHO-CD-673.

*Below detectable limits.

**No data available.

TABLE A-6. Summary of Water Sample Results--200 Area Ponds.

Sample Site	Concentration, pCi/ml			
	Total Beta		Total Alpha	
	Annual Average	Maximum	Annual Average	Maximum
216-T-4 T Ditch	0.2	0.6	<0.04	0.2
216-Z-19 Ditch	<0.1	0.5	0.8	17.6
216-U-10 U Pond	<0.1	2.4	0.06	0.8
216-S-19 222-S Lab. Pond	<0.1	0.4	0.07	0.7
216-B-3 B Pond North Side	<0.1	0.2	<0.04	0.02
216-B-3 B Pond South Side	<0.1	1.0	<0.04	0.3
216-B-63 Retention Ditch	0.2	0.3	<0.04	0.2
216-A-25 Gable Mountain Pond Inlet	<0.1	0.6	<0.04	0.2
216-A-25 Gable Mountain Pond North Side	<0.1	0.4	<0.04	0.1
West Lake	0.5	1.2	0.1	0.4
Richland Drinking Water[a]	<0.0052	.0078	<0.0007	0.0023
Table I, DOE MC 0524[b]	10.0		100.0	
Table II, DOE MC 0524[b]	0.3		5.0	

NOTE: All information from 1978 Environmental Protection Annual Report (in preparation) and personal communication with R. E. Wheeler except as noted below.

[a]J. R. Houston and P. N. Blumer, "Environmental Surveillance at Hanford for CY-1978," PNL-2932, April 1979.

[b]Total Beta as Sr-90, total Alpha as Pu-239.

TABLE A-7. Radionuclides in Sediment Samples From 200 Area Ponds and Ditches, 1978.

Sample Sites	Concentration, pCi/g dry weight							
	K-40	Mn-54	Co-60	Sr-89,90	ZrNb-95	Ru-106	Cs-134	Cs-137
216-Z-19 Z Ditch at Pond Inlet	14.7	*	*	1.4	*	*	*	7.5
216-Z-19 Z Ditch at South Side of 6th	16.3	*	*	1.4	*	*	*	3.1
216-T-4-2 T-Plant Ditch	12.4	*	227.1	57.5	*	*	6.7	263.0
216-U-14 Laundry Ditch	8.7	179.4	569.3	164.0	187.3	3.5	8.9	128.5
216-Z-19 Z Ditch, 234-5 Outfall	14.6	*	*	0.7	*	*	*	4.5
216-Z-19 Z Ditch, 231-Z Outfall	13.4	*	*	0.5	*	*	*	18.9
216-U-10 U-Pond North	14.7	*	1.8	1.0	*	*	*	744.5
216-U-10 U-Pond South	19.9	*	*	3.2	*	*	*	49.9
216-S-19 222-S Lab. Pond	26.4	*	*	8.4	*	*	*	152.9
216-B-63 Retention Ditch	26.0	*	*	484.0	*	*	*	180.6
216-A-29 Purex Chem. Sewer	24.0	*	*	0.7	*	*	*	8.1
216-B-3 Ditch to B-Pond	19.3	*	*	12.7	*	*	*	23.9
216-B-3 B-Pond North	26.8	*	*	0.6	*	*	*	152.5
216-B-3 B-Pond South	13.8	*	*	0.4	*	*	*	135.9
216-A-25 Gable Mountain Pond Inlet	11.0	*	*	0.4	*	*	*	68.0
216-A-25 Gable Mountain Pond North	10.6	*	*	0.6	*	*	*	245.3
West Lake	15.4	*	*	1.5	*	*	*	1.5

NOTE: All information from 1978 Environmental Protection Annual Report (in preparation) and personal communication with R. E. Wheeler.

*Below detectable limits.

TABLE A-7. Radionuclides in Sediment Samples from 200 Area Ponds and Ditches, 1978 (Contd).

Sample Sites	Concentration, pCi/g dry weight							
	Ce-141	Ce-144	Eu-154	Eu-155	Ra-226	Pu-238	Pu-239,240	Am-241
216-Z-19 Z Ditch at Pond Inlet	*	*	*	*	1.2	981.0	7304.0	1380.0
216-Z-19 Z Ditch at South Side of 6th	*	*	*	*	1.2	522.0	4237.0	1690.0
216-T-4 T-Plant Ditch	*	*	*	15.0	*	2.6	35.4	6.4
216-T-4-2 T-Plant Ditch	145.5	115.8	66.0	70.5	5.3	8.3	30.2	6.9
216-Z-19 Z Ditch, 234-5 Outfall	*	*	*	4.0	1.0	1168.0	5320.0	6092.0
216-Z-19 Z Ditch, 231-Z Outfall	*	*	*	*	0.9	10.2	116.3	20.2
216-U-10 U-Pond North	*	*	*	*		16.8	57.5	10.3
216-U-10 U-Pond South	*	*	*	1.2	*	7.3	39.5	2.7
216-S-19 222-S Lab. Pond	*	*	*	3.8	*	57.5	407.8	503.6
216-B-63 B Retention Ditch	*	*	*	*	*	2.7	13.4	6.5
216-A-20 Purex Chem. Sewer	*	2.7	*	0.9	1.4	1.1	18.2	4.8
216-B-3 Ditch to B-Pond	*	*	*	0.9	1.8	2.6	9.6	11.0
216-B-3 B-Pond North	*	*	*	*	*	6.5	20.9	152.0
216-B-3 B-Pond South	*	*	*	*	*	11.9	34.6	1.4
216-A-25 Gable Mountain Pond Inlet	*	*	1.5	4.4	*	*	1.2	1.2
216-A-25 Gable Mountain Pond North	*	*	*	1.9	*	*	5.0	1.6
West Lake	*	*	*	0.5	0.7	3.9	17.0	5.7

*Below detectable limits.

TABLE A-8. Radionuclides in Aquatic Vegetation Samples From 200 Area Ponds and Ditches, 1978.

Sample Sites	Concentration, pCi/g dry weight						
	K-40	Co-60	Sr-89,90	Cs-137	Pu-238	Pu-239,240	Am-241
216-T-4-2 T-Plant Ditch	31.0	66.9	240.0	346.1	2.0	10.6	4.5
216-U-14 Laundry Ditch	15.4	*	16.7	14.7	2.6	11.3	1.3
216-Z-19 Z Ditch, 234-5 Outfall	11.1	*	5.3	5.2	7.8	52.2	15.6
216-Z-19 Z Ditch, 231-Z Outfall	26.0	*	1.7	4.6	*	1.6	*
216-U-10 U-Pond North	22.6	*	21.9	77.8	4.2	16.4	*
216-U-10 U-Pond South	15.6	*	27.8	10.7	2.9	4.8	*
216-S-19 222-S Lab. Pond	20.3	*	72.0	133.2	10.2	25.1	4.9
216-B-63 B Retention Ditch	27.9	*	218.0	4.5	19.6	89.1	*
216-A-29 Purex Chem. Sewer	24.1	*	3.5	7.8	*	2.8	0.9
216-B-3 Ditch to B-Pond	23.0	*	2.0	39.0	8.8	26.5	*
216-B-3 B-Pond North	26.9	*	11.9	16.1	1.7	8.8	*
216-B-3 B-Pond South	17.6	*	92.7	25.0	22.6	59.2	*
216-A-25 Gable Mountain Pond Inlet	21.3	*	2.0	6.4	13.7	46.4	*
216-A-25 Gable Mountain Pond North	18.6	*	3.4	163.0	16.4	53.0	*
West Lake	26.9	*	2.0	1.5	*	5.5	*
Off-Site Vegetation Samples[a]	11.0	NDA	0.09	<0.2	<0.003	<0.009	NDA

NOTE: All information from 1978 Environmental Protection Annual Report (in preparation) and personal communication with R. E. Wheeler.

*Below detectable limits.

[a]Data from Environmental Surveillance at Hanford for CY-1978, PNL-2932.

TABLE A-9. Average Radionuclide Concentration of Effluents, 1978.

Sample Site	Volume, ℓ	Concentration, μCi/mℓ						
		Pu	Beta	Sr-90	Ru-106	Cs-137	Ce-144	Co-61
216-A-25 Gable Mountain Pond	0.106E+11	<0.324E-08	<0.793E-07	0.260E-07	<0.289E-08	<0.122E-09	<0.120E-09	<0.174E-08
216-B-3 B-Pond	0.437E+10	<0.124E-07	<0.865E-07	<0.734E-08	<0.819E-08	0.395E-08	<0.737E-09	<0.106E-07
216-B-63 Trench	0.314E+09	<0.512E-08	0.698E-07	<0.531E-08	*	<0.659E-09	*	<0.984E-09
216-S-10 Ditch	0.199E+09	<0.620E-08	<0.152E-07	*	*	*	*	*
216-S-19 S-Pond	0.559E+08	<0.794E-08	0.813E-07	0.375E-08	*	0.230E-08	*	
216-U-10 U-Pond	0.578E+10	<0.259E-07	<0.573E-07	0.243E-08	<0.303E-08	<0.226E-08	<0.139E-09	<0.142E-08

NOTE: Data from RHO-CD-78-34 4Q, March 26, 1979.

*Below detectable limits.

TABLE A-9. Average Radionuclide Concentration of Effluents, 1978 (Contd.).

Sample Site	Concentration, µCi/mℓ				
	U-238	H-3	Am-241	Eu-155	Mn-54
216-A-25 Gable Mountain Pond	<0.296E-08	<0.144E-07	*	*	*
216-B-3 B-Pond	<0.442E-08	<0.274E-05	*	*	*
216-B-63 Trench	<0.336E-08	<0.203E-05	*	*	*
216-S-10 Ditch	<0.335E-08	*	*	*	*
216-S-19 S-Pond	<0.336E-08	*	*	*	0.382E-07
216-U-10 U-Pond	<0.296E-08	<0.105E-06	0.354E-10	0.101E-08	*

*Below detectable limits.

TABLE A-10. Transuranic Content of Vegetation Samples, U-Pond.

Vegetation Sampled	Concentration, pCi/g dry weight		
	Pu-238	Pu-239,240	Am-241
Watercress	313.90	218.40	124.80
Submerged Cattail	32.60	26.60	51.40
Algae	30.60	17.90	--
Emergent cattail	3.90	3.00	3.80
Emergent Bulrush	0.58	0.35	0.34

NOTE: Data from BNWL-5346.

TABLE A-11. Radionuclides in Vegetation Samples From the Laundry and Z-Plant Ditches, 1977.

Vegetation Sampled	Concentration, pCi/g dry weight												
	K-40	Mn-54	Co-60	Sr-89,90	Nb-95	Zr-95	Cs-137	Ce-141	Ce-144	Eu-155	Pu-238	Pu-239,240	Am-241
Laundry Ditch (U-14)													
Phlox	17.8	2.5	4.3	35.6	0.8	1.22	134	12.0	*	*	0.1	0.7	*
Goldenrod	10.0	1.9	*	28.5	2.0	1.9	437	25.6	*	33.2	0.03	0.2	*
Smart Weed	15.2	17.3	2.4	59.7	*	*	147	*	*	*	0.2	1.1	*
Z-Plant Ditch (Z-19)													
Horsetail	11.0	*	*	6.3	1.25	1.5	13.2	13.4	1.7	*	0.18	2.2	*
Cattail	14.6	*	*	17.7	1.79	2.6	5.1	19.1	1.3	*	0.12	1.2	*
Goldenrod	14.4	*	*	*	*	*	5.0	*	*	*	0.07	1.5	*
Bulrush	16.9	*	*	107.0	14.6	1.7	8.6	16.6	2.3	*	0.1	2.6	93.6
Bunchgrass	10.6	*	*	1.7	1.1	0.9	2.9	10.8	*	*	0.3	2.8	*
Smartweed	10.6	*	*	3360.0	0.6	0.8	25.2	8.4	*	2.7	1.2	8.5	*
Sweet Bull Clover	9.4	*	*	8.6	2.8	3.7	5.2	29.8	3.0	*	0.2	2.9	*

NOTE: Data from RHO-LD-78-75 Report CY-1977.

*Less than detectable.

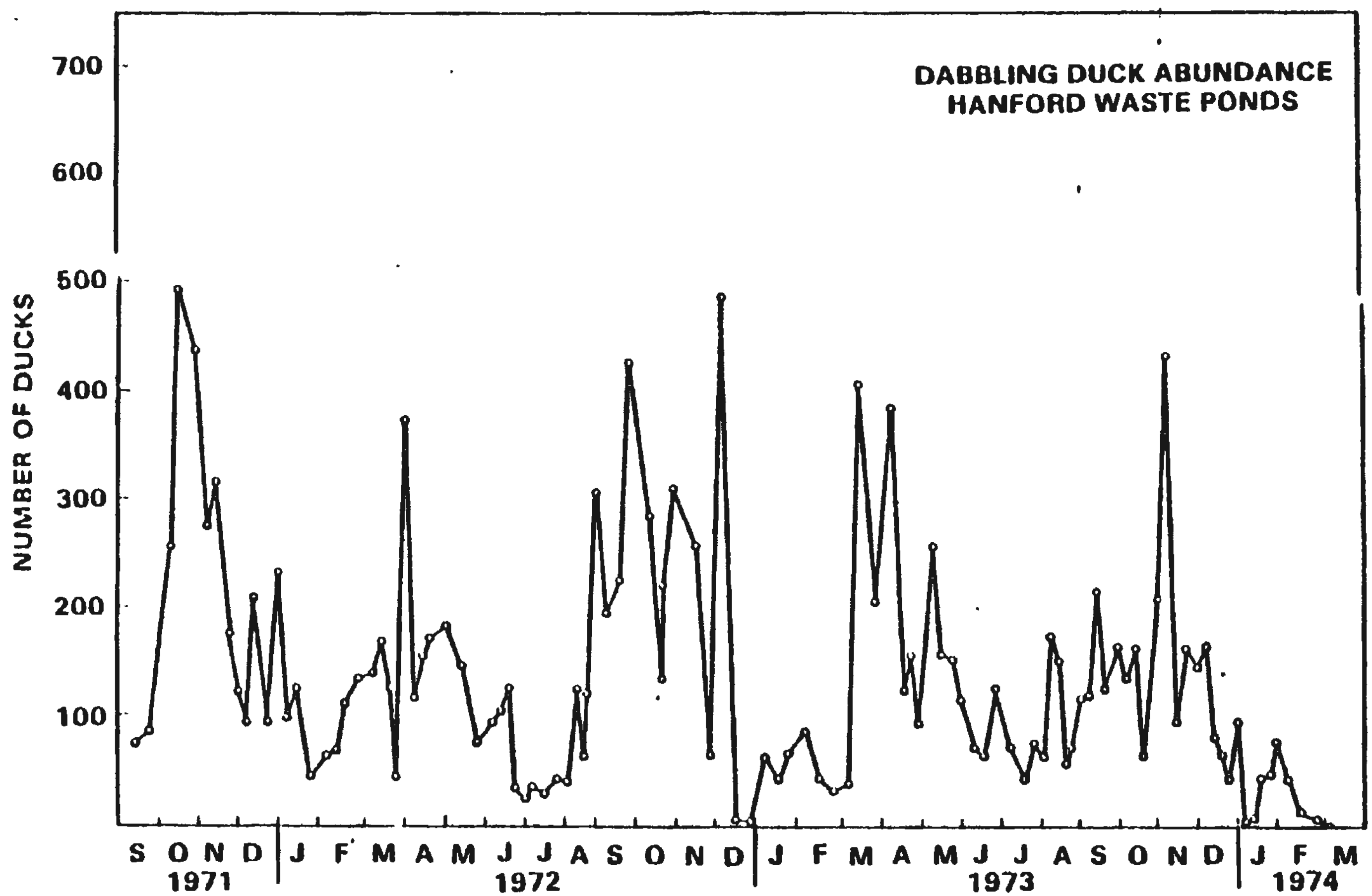


FIGURE A-12
WEEKLY TOTALS OF DABBLING DUCKS OBSERVED AT HANFORD WASTE WATER PONDS(19)

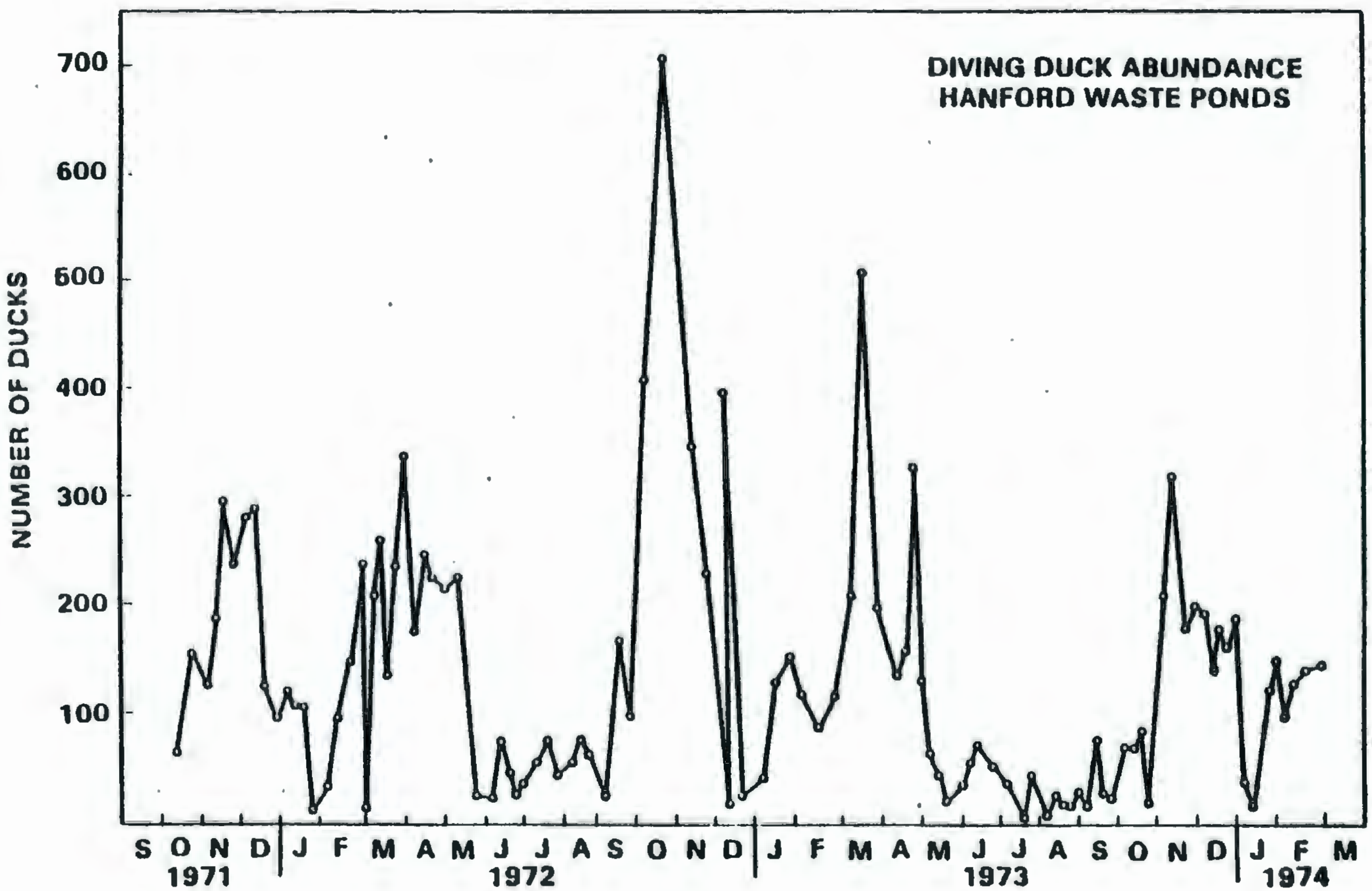


FIGURE A-13
WEEKLY TOTALS OF DIVING DUCKS OBSERVED AT HANFORD WASTE WATER PONDS(19)

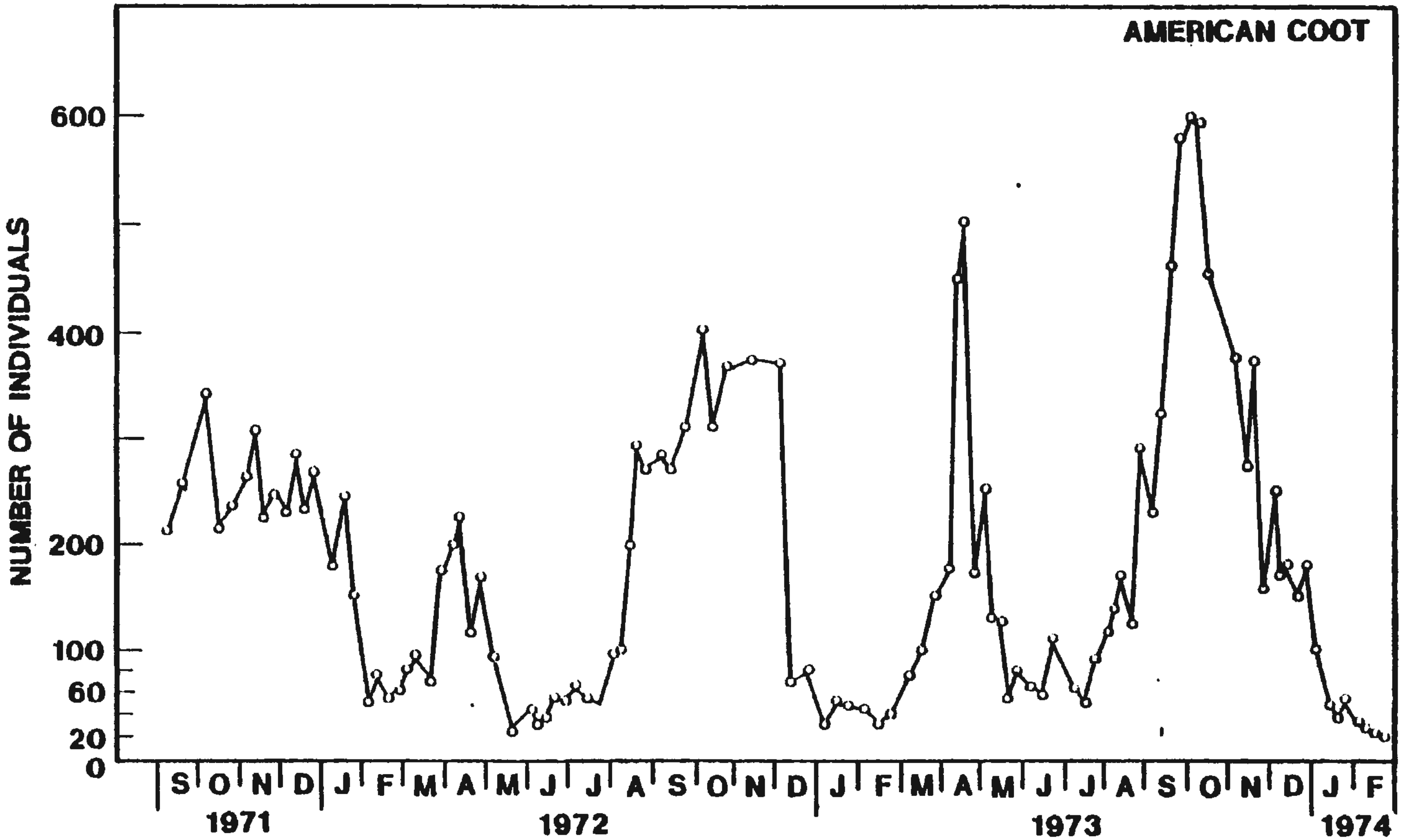


FIGURE A-14

WEEKLY TOTALS OF COOTS OBSERVED AT HANFORD WASTE WATER PONDS(19)

TABLE A-15. Total Count of Waterfowl Observed on Hanford Waste Ponds, September 1971 through March 1974(19)

Type	B-Pond	U-Pond	Gable Mountain Pond
Dabbling Ducks			
Mallard	1390 (26)*	1373 (26)	2494 (48)
Gadwall	8 (1)	32 (5)	578 (94)
American Wigeon	80 (5)	482 (27)	1214 (68)
Green-Winged Teal	271 (48)	131 (23)	164 (29)
Blue-Winged Teal	24 (28)	39 (45)	23 (27)
Cinnamon Teal	29 (18)	37 (23)	93 (59)
Shoveler	326 (54)	120 (20)	159 (26)
Pintail	137 (17)	70 (9)	579 (74)
Total Dabbling Ducks	2265 (23)	2284 (23)	5304 (54)
Diving Ducks			
Redhead	199 (25)	25 (3)	568 (72)
Canvasback	0	4 (1)	570 (99)
Greater Scaup	293 (26)	120 (11)	694 (63)
Lesser Scaup	429 (42)	12 (1)	572 (57)
Ring-Necked Duck	951 (23)	113 (3)	3107 (74)
Common Goldeneye	626 (65)	24 (3)	299 (32)
Barrow's Goldeneye	39 (91)	4 (9)	0
Bufflehead	1870 (62)	61 (2)	1097 (36)
Old Squaw	1 (9)	0	10 (91)
Ruddy Duck	108 (14)	62 (8)	579 (77)
Total Diving Ducks	4516 (36)	425 (3)	7496 (61)
Mergansers			
Hooded	0	2 (67)	1 (33)
American	1 (1)	3 (1)	531 (98)
Canada Goose	926 (21)	0	3520 (79)
Whistling Swan	0	0	25(100)
American Coot	1257 (7)	330 (2)	17352 (91)

*Percent distribution among ponds

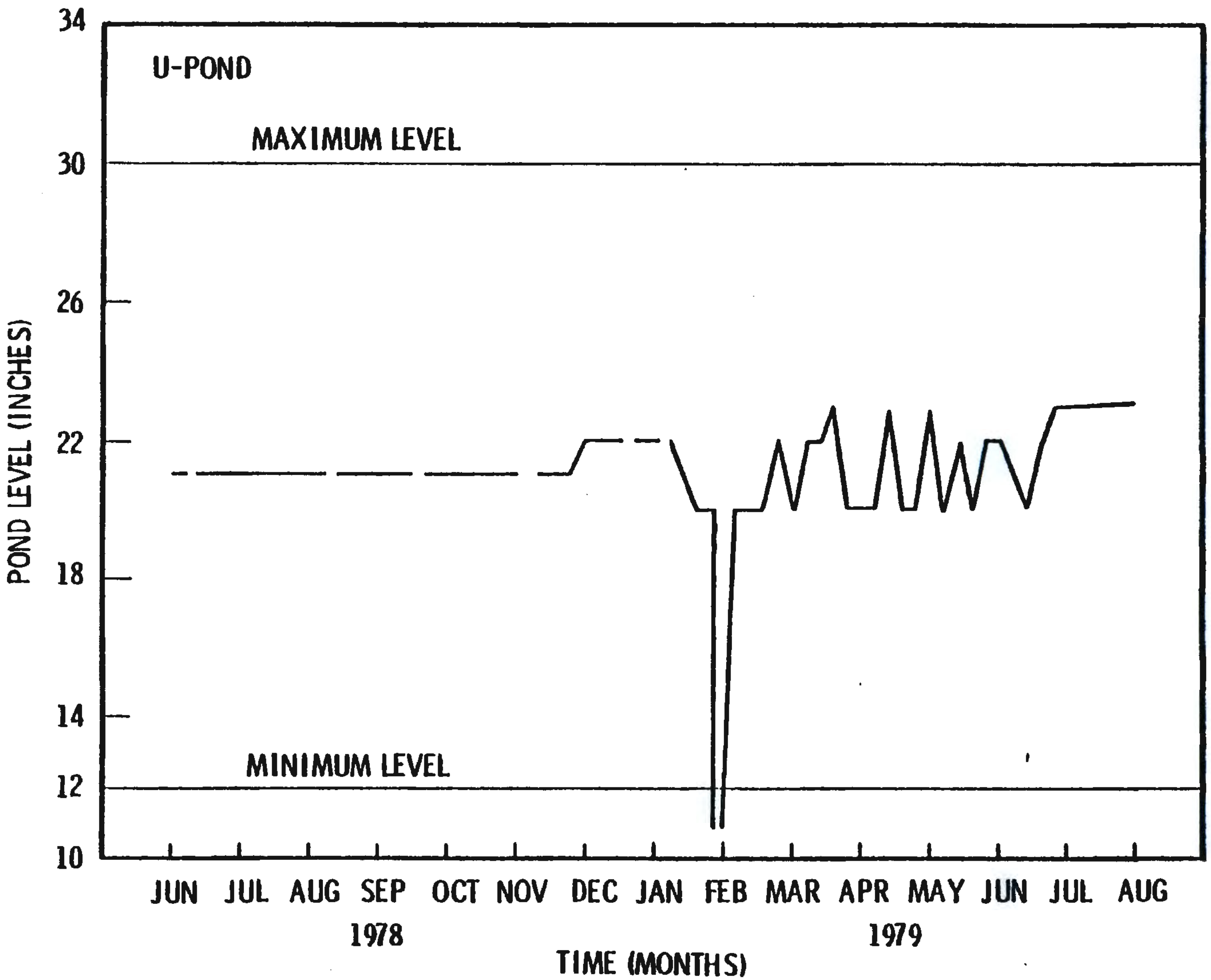


FIGURE A-16 POND LEVEL RECORDS FOR U-POND, 1978-1979

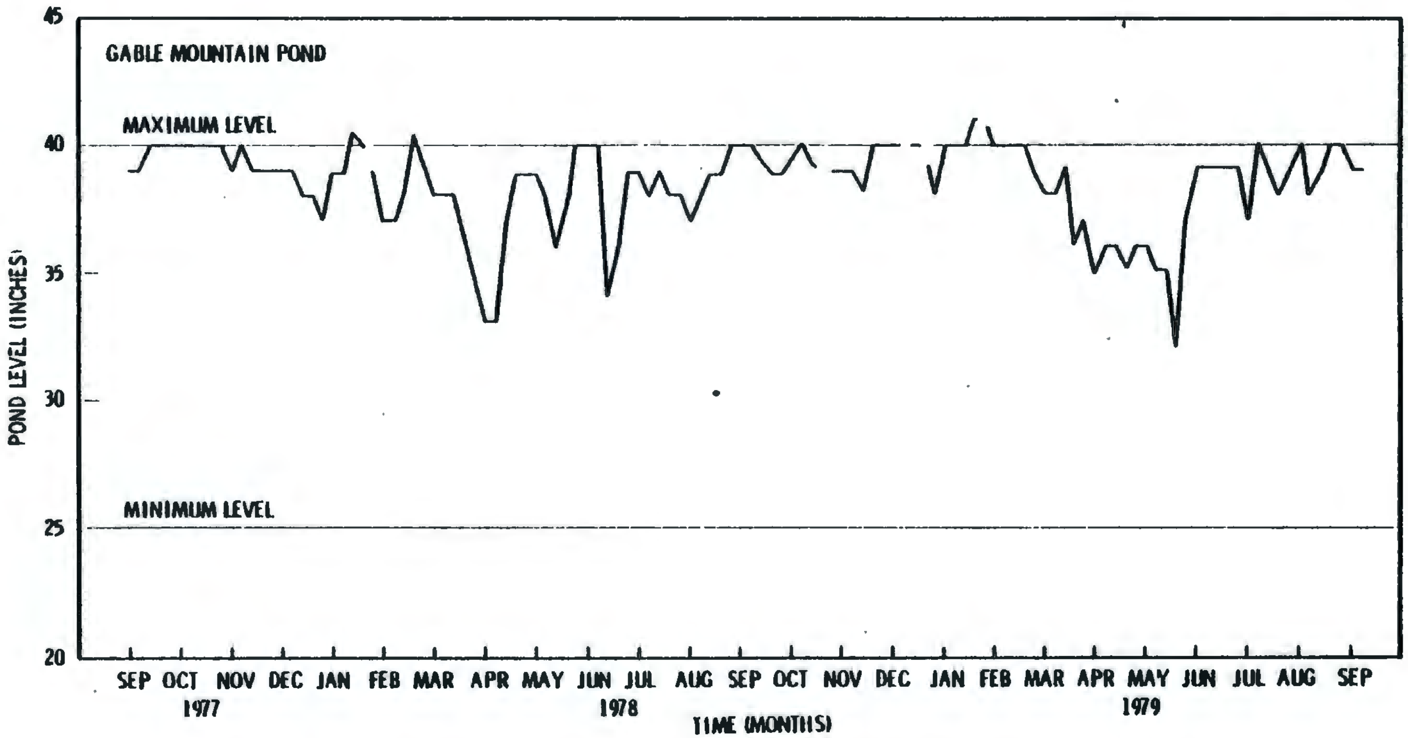


FIGURE A-17 POND LEVEL RECORDS FOR GABLE MOUNTAIN POND, 1977-1979

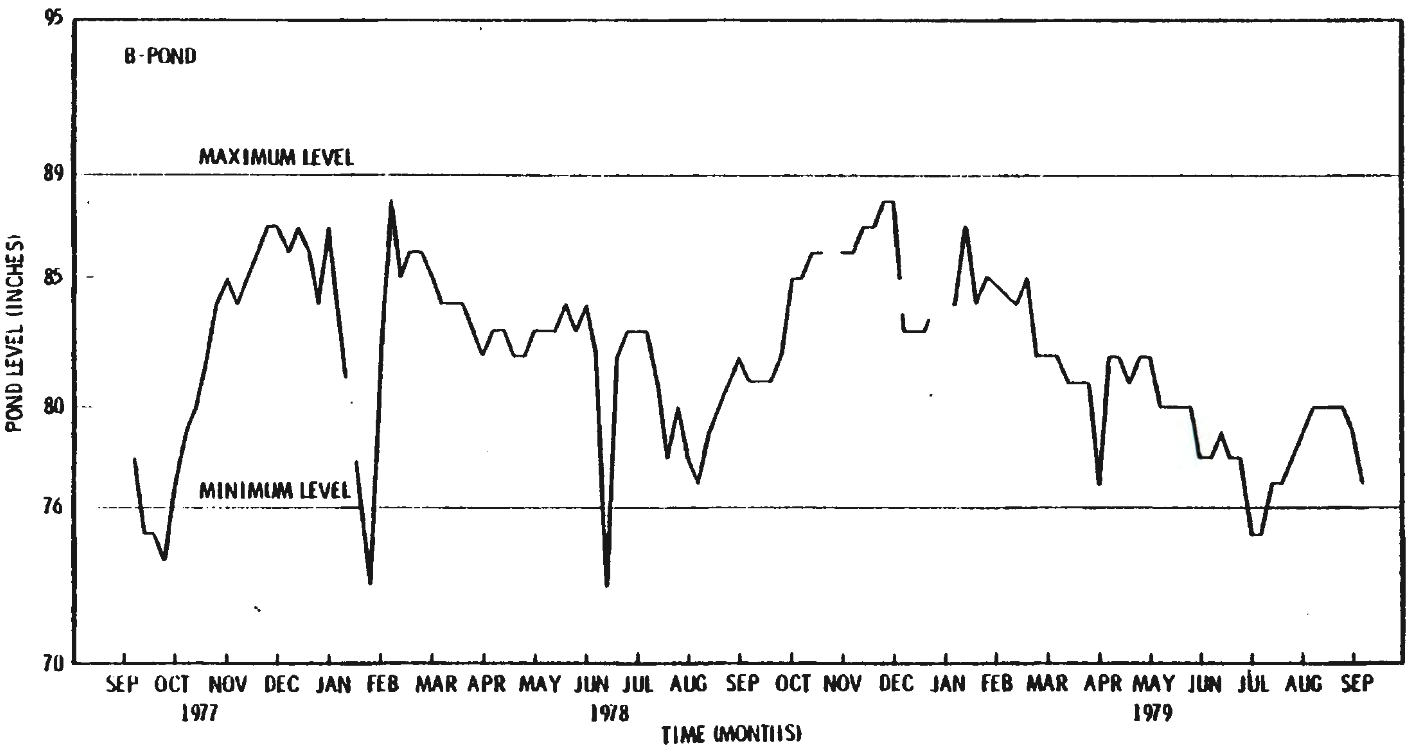


FIGURE A-18 POND LEVEL RECORDS FOR B-POND, 1977-1979

APPENDIX B

APPENDIX B

LITERATURE REVIEW

B.1 Ecological Studies

Aquatic Studies of Gable Mountain Pond, C. E. Cushing and D. G. Watson, Battelle (BNWL-1884), December 1974.

A study of the biotic and abiotic components of Gable Mountain Pond was undertaken to determine potential problems for offsite transfer of radioactivity to man originating with the aquatic food web. Concentrations in neither waterfowl nor goldfish exceeded acceptable limits. Sediment could be a source of high contamination concern if the pond dried up.

Comparative Ecology of Nuclear Waste Ponds and Streams on the Hanford Site, R. M. Emery, M. C. McShane, Battelle (PNL-2499), October 1978.

This report profiles the history, ecology, limnology and radiological characteristics of ponds and streams on the Hanford Site. The data provides no conclusive evidence that the nuclear wastes affect the colonization, diversity or activity of biota in the ponds or streams.

A Critical Review of Biological Accumulation, Discrimination and Uptake of Radionuclides Important to Waste Management Practices 1943-71, K. R. Price, Battelle (BNWL-B-148), December 1971.

Data available in the literature indicate the relative ease with which radionuclides circulate through ecosystems in accord with biogeochemical processes. This study also concludes that waste management practices should draw on general ecological principles.

The Ecological Behavior of Plutonium and Americium in a Freshwater Pond, R. M. Emery, D. C. Klopfer, T. R. Garland and W. C. Weimer, Battelle (BNWL-SA-5346), March 1975.

A Pu processing waste pond (U-Pond) has been studied since 1973 to determine the ponds limnology and determine the ecological behavior. Sediments are the principal repository of Pu and Am. Algal floc is the major concentration of Pu and Am in the pond.

The Ecological Behavior of Plutonium and Americium in a Freshwater Ecosystem: Phase II Implications of Differences in Transuranic Isotopic Ratios, R. M. Emery and T. R. Garland, Battelle (BNWL-1879), December 1974.

The ecological behavior of Pu and Am in a freshwater processing waste pond was studied to define the isotopic distributions in this ecosystem. The discharge of transuranics to the pond has created a complex combination of isotopic ratios. Sediments in a trench carrying processing wastes to the pond may be the primary source of "available" Pu and Am.

Ecology of the 200 Area Plateau Waste Management Environs: A Status Report, L. E. Rogers, W. H. Rickard, Battelle (PNL-2253), October 1977.

This document summarizes past ecological work on the 200 Area plateau, assesses the present data base, and projects future research needs for the RHO-sponsored biotic transport program.

The Ecological Export of Plutonium from a Reprocessing Waste Pond, R. M. Emery, D. C. Klopfer and M. C. McShane, Health Physics, Vol. 34, pp. 255-269.

The biological export of Pu from a waste pond was studied. Most of the Pu is retained in the sediment. Emergent insects are the only direct biological export route. There is no apparent significant export by wind, and percolation of Pu to ground water is not likely.

B.2 Environmental Reports

Aquatic Bioenvironmental Studies in the Columbia River at Hanford 1945-1971 - A Bibliography with Abstracts, C. D. Becker, Battelle (BNWL-1734), February 1973.

This document abstracts articles concerned with the central Columbia River for 4 areas of interest. They are:

1. biology and ecology of river organisms
2. thermal and chemical effects of reactor effluent discharges
3. radioactivity releases from reactor operations
4. hydrology of the Columbia River

Environmental Status of the Hanford Site for CY-1977, J. R. Houston and P. J. Blumer, Battelle (PNL-2677), June 1978.

Environmental data collected during 1977 showed continued compliance by Hanford operations with all applicable state and federal regulations.

Environmental Surveillance at Hanford for CY-1978, J. R. Houston and P. J. Blumer, Battelle (PNL-2932), April 1979.

This document reports the results of environmental surveillance at the Hanford Site for calendar year 1978. The report demonstrates negligible impact attributable to either current operations or cumulative environmental effects from past operations.

Radiological Status of the Ground-Water Beneath the Hanford Project, January-December 1978, P. A. Eddy, Battelle (PNL-2899), April 1979.

Data collected during 1978 describe the movement of major plumes that respond to the influences of ground-water flow, ionic dispersion, and radioactive decay. The majority of contaminants are stratified in the upper portions of the unconfined aquifer.

B.3 Mammals

Analysis of Small Mammal Populations Inhabiting the Environs of a Low-Level Radioactive Waste Pond, K. A. Gano, Battelle (PNL-2479), March 1979.

The kinds of small mammals living near U-Pond were determined. The radiation exposures mice received and the level and type of radionuclides assimilated were also determined.

Mammals of the Hanford Reservation in Relation to Management of Radioactive Waste, W. H. Rickard, J. D. Hedlund and R. G. Schreckhise; Battelle (BNWL-1877), August 1974.

Twenty four species of mammals (exclusive of bats) are known to exist in or near waste management areas. Radionuclide behavior in relation to the mammals is dealt with as are fences as potential barriers. The mule deer has the greatest potential for transferring radioisotopes to man.

B.4 Waterfowl and Other Birds

The American Coot on the Hanford Site Part 1: Nesting Biology, R. E. Fitzner and R. G. Schreckhise, Battelle (PNL-2462), May 1979.

No apparent differences were found in the nesting habits of coots on Hanford radioactive waste ponds and on control ponds located in the Columbia National Wildlife Refuge.

Avifauna of Waste Ponds ERDA Hanford Reservation Benton County, Washington, R. E. Fitzner and W. H. Rickard, Battelle (BNWL-1885), June 1975.

During a 29 month period, 126 bird species were observed utilizing the 200 Area ponds and associated areas. The greatest abundance occurred during the autumn migration. The most abundant breeding bird was the American coot.

Cesium-137 in Coots on Hanford Waste Ponds: Contribution to Population Dose and Offsite Transport Estimates, L. L. Cadwell, R. G. Schreckhise and R. E. Fitzner, Battelle (PNL-SA-7167), April 1979.

American coots from ponds receiving low-level radioactive waste on the Hanford Site were analyzed for ^{137}Cs, ^{90}Sr and gross Pu. The concentration of ^{137}Cs in coot flesh was the highest of the radioelements measured. Total ^{137}Cs export from Gable Mountain Pond via coots was estimated to be 46 μCi per year.

Impact of Fluctuating Water Levels on Feeding Ecology of Breeding Blue-Winged Teal, G. A. Swanson and M. I. Meyer, J. Wildl. Manage. 41(3): 1977.

Foods consumed by breeding Blue-Winged Teal before and after a hydrological change are compared on a study area located in the prairie pothole region of south-central North Dakota.

Radiochemical Analyses of Game Birds Collected from the Hanford Environs, 1971-1975, J. J. Fix and P. J. Blumer, Battelle (BNWL-2089), July 1977.

In general, radionuclide concentrations in game birds attributable to Hanford operations were only slightly greater (within a factor of 10) or indistinguishable from expected levels attributed to worldwide fallout. An exception was ^{137}Cs concentrations primarily in ducks and coots.

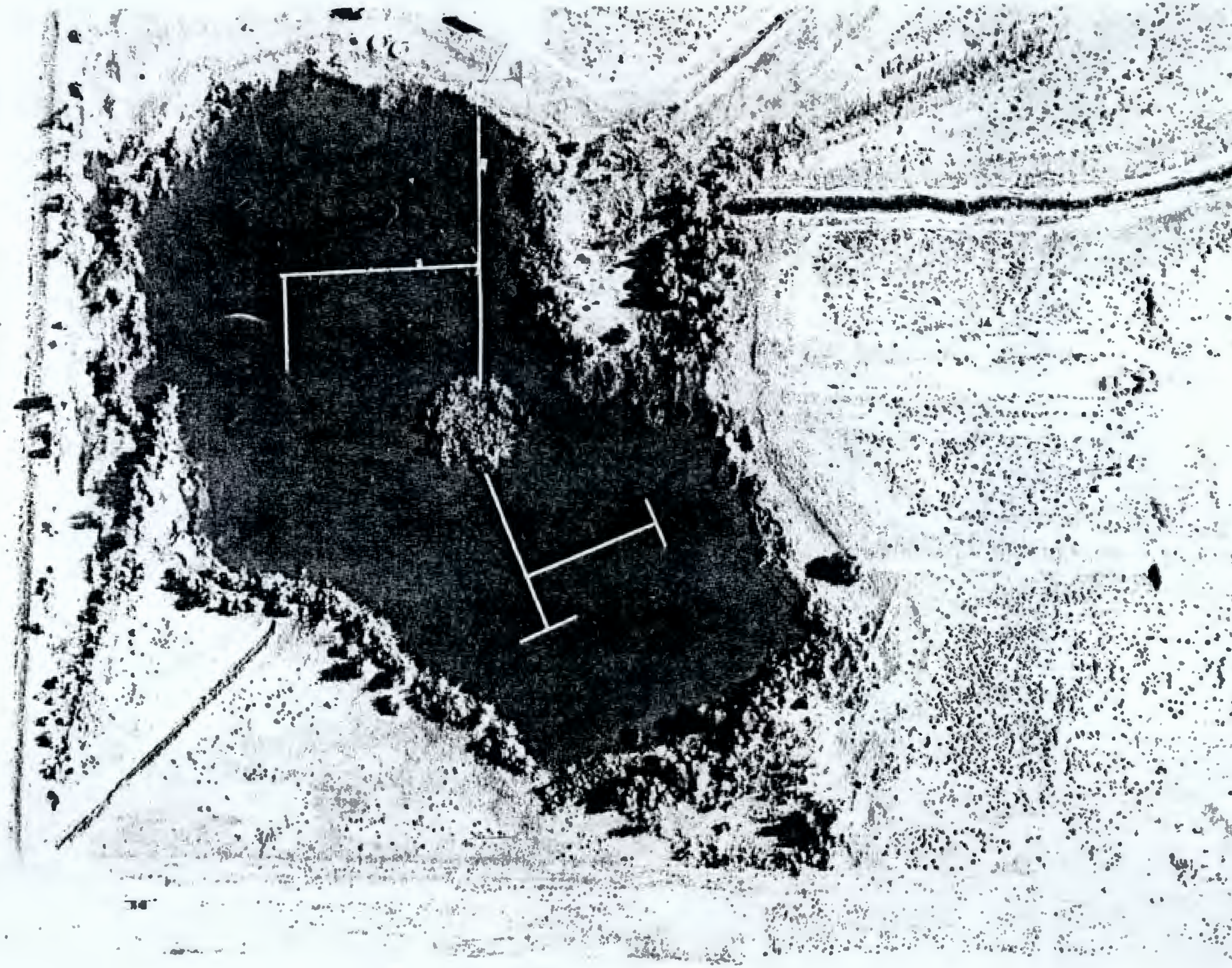
<u>The Use of Hanford Waste Ponds by Waterfowl and Other Birds</u>, R. E. Fitzner and K. R. Price, Battelle (BNWL-1738), February 1973.

A survey and census of birds observed at the Hanford waste water ponds is described and evaluated. Migration and behavior of waterfowl were given special attention due to their importance in radioactive waste management.

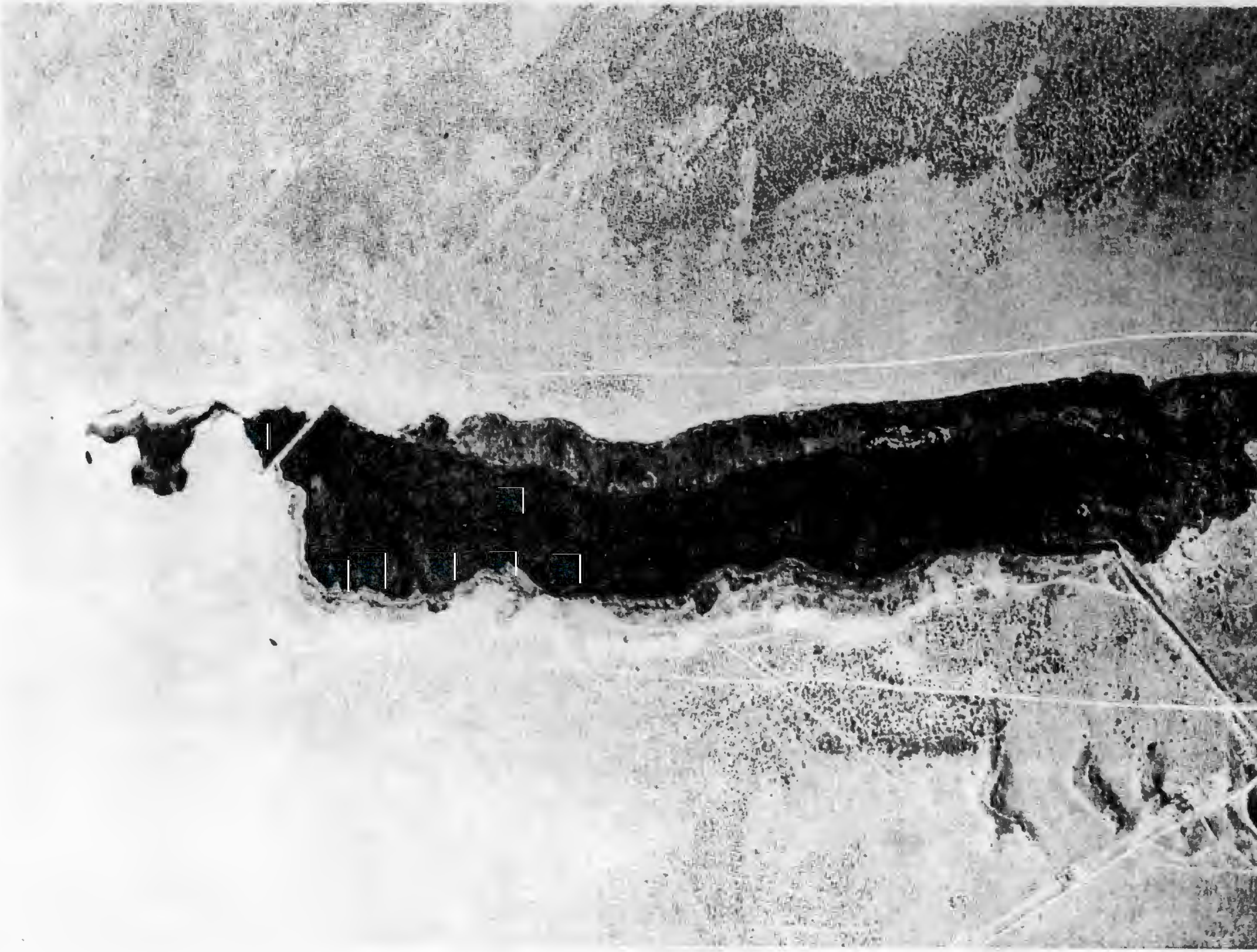
<u>The Use of Hanford Waste Water Ponds by Waterfowl</u>, K. R. Price and R. E. Fitzner, Battelle (PNL-SA-7155), February 1979.

Several comparisons were made for the accumulation of ^{137}Cs in muscle tissue of waterfowl. These comparisons were made between Columbia River and Hanford pond waterfowl, different species of waterfowl on Hanford ponds, and like species on specific Hanford ponds.

APPENDIX C

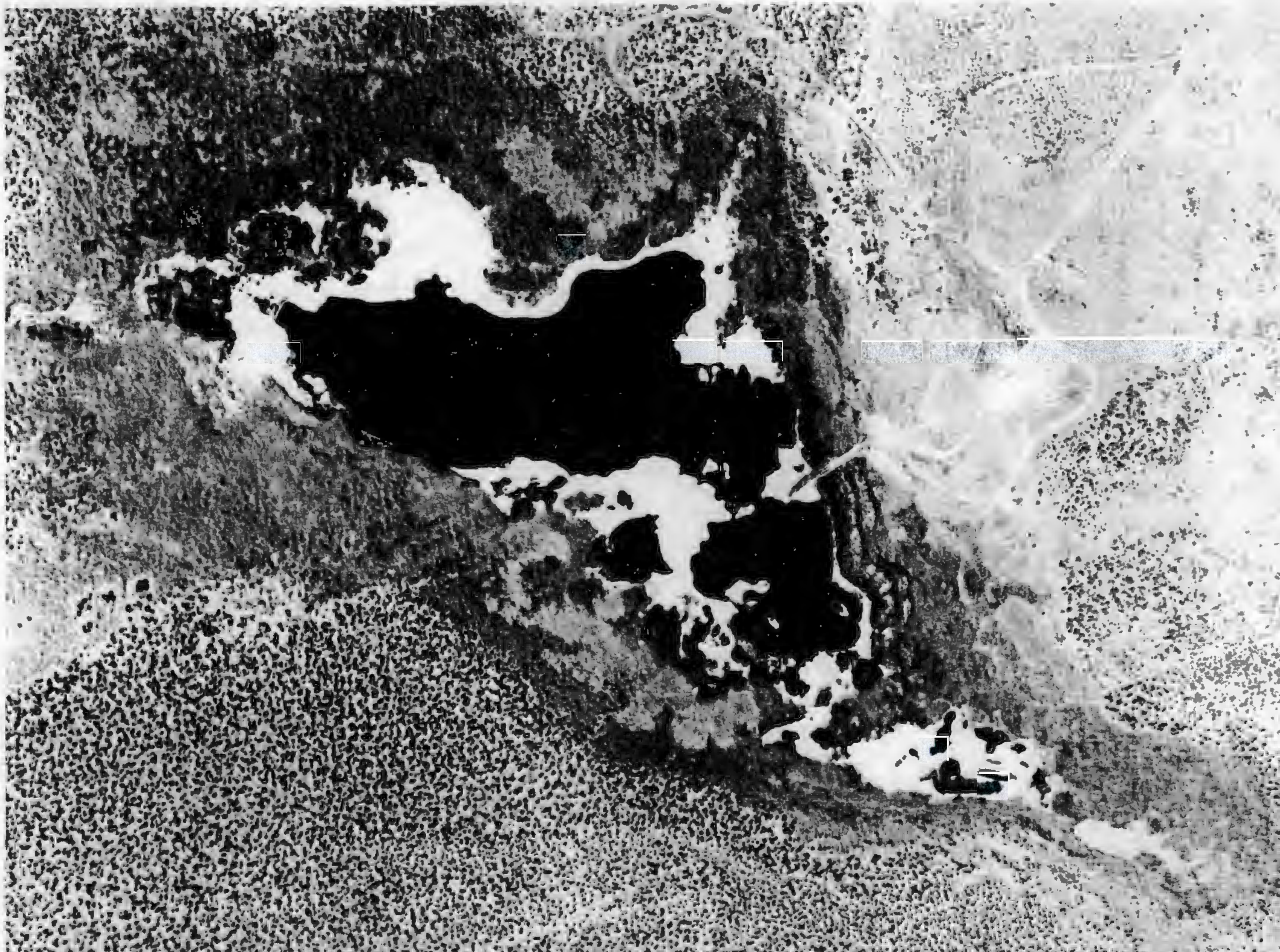


C-1. U-POND, 1979.

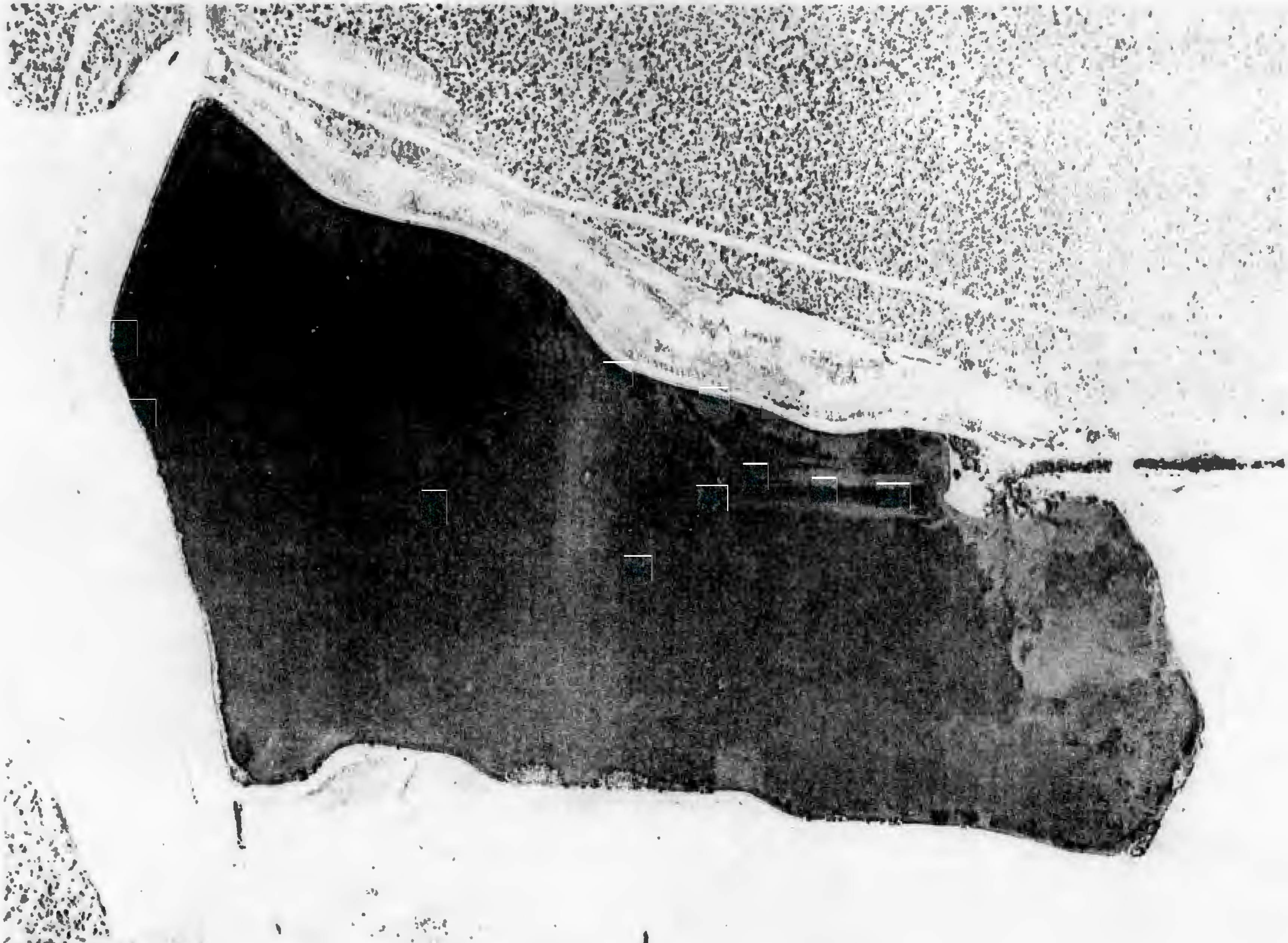


C-2. GABLE MOUNTAIN POND, 1979.

DOE- Richland, WA



C-3. WEST POND, 1979.



C-4. B-POND, 1979.