EAGLE RIVER FLATS
WATERFOWL MORTALITY INVESTIGATION
PROGRESS REPORT

Prepared by:

Randy G. Tweten, Project Leader

Eagle River Flats Task Force

AUGUST 1989

Participating Task Force Agencies:

U.S. Fish and Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99507

Department of the Army
6th Infantry Division (Light)
Fort Richardson, Alaska 99505

Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518

Alaska Department of Environmental Conservation
3601 C Street, Suite 1350
Anchorage, Alaska 99513

U.S. Environmental Protection Agency
701 C Street, Box 19
Anchorage, Alaska 99513

ABSTRACT

A migratory bird die-off is occurring on Eagle River Flats (Flats), a wetland/riverine complex used as a principal waterfowl resting area during spring and fall migration periods. This tidally-influenced delta is located on Fort Richardson Army Installation in southcentral Alaska, and is used as an impact area for live-fire training. Species groups affected to date include ducks, swans, shorebirds, and geese. Bald eagles and gull carcasses were found however, cannot be included in the affected group at this time.

Original documentation of the migratory bird die-off on the Flats, Fort Richardson, Alaska, occurred in 1980 when aerial overflights noted dead swans. In August of 1982, Army biologists conducted a ground search of the military impact area and discovered several waterfowl carcasses. Periodic searches of the Flats by Army, Fish and Wildlife Service, and Alaska Department of Fish and Game biologists between 1983 and 1986 have counted over 500 carcasses of various species.

A joint federal/state agency task force was established in 1987 to investigate the die-off. During systematic searches of 7 percent of the 2,500-acre impact area, 358 bird carcasses and 573 piles of remains were discovered between April 20, and November 3, 1988. Disease and trauma were ruled out as cause of death by the U.S. Fish and Wildlife Service's National Wildlife Health Research Center in Madison, Wisconsin. Results of specimen analyses conducted at Patuxent Wildlife Research Center ruled out trace metals and trace elements as the cause of die-off.

The present investigation is focusing on chemical components of the military munitions as a possible cause of mortality.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

In November of 1987, after several years of irregular investigative efforts, a joint state-federal agency task force was established to address the reoccurring avian die-off problem of Eagle River Flats (Flats), Fort Richardson, Alaska. The Eagle River Flats Task Force (Task Force) charter agencies consists of representatives from the Department of Army - Fort Richardson, U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, U.S. Environmental Protection Agency, and Alaska Department of Environmental Conservation. The Task Force developed a Memorandum of Understanding (Appendix A) signed by all participating agencies that implemented the General Study Plan (Appendix B) and the remaining three objectives: Identify roles of each participating agency within the Task Force; oversee the implementation of the General Study Plan; and conduct follow-up monitoring of the recommended actions.

The U.S. Department of Interior, Fish and Wildlife Service (Service) has management authority for migratory birds via the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 715-715a, Part 25, 26, 27, 28) and the Bald Eagle Protection Act, as amended (16 U.S.C. 688-688d).

The responsibility of assuring clean water and air rests with the U.S. Environmental Protection Agency and the Alaska Department of Environmental Conservation. The Department of Army, land owner of the Flats, has responsibility for compliance with applicable legislation for activities on their land. The Alaska Department of Fish and Game is a co-signatory for the 1986 Memorandum of Understanding between the Service and Army regarding the cooperative management of fish and wildlife resources on military lands in Alaska.

II. BACKGROUND

Fort Richardson Military Installation is located between the urban areas of Anchorage and Eagle River-Chugiak, the waters of the Knik Arm of Cook Inlet, and the mountains of Chugach State Park (Figure 1).

Spring aerial surveys of the Upper Cook Inlet by the U.S. Fish and Wildlife Service (USFWS 1987) documented over 51,000 geese in 1986 and twice this number during the 1985 waterfowl census (Figure 2). The number of tundra and trumpeter swans using Upper Cook Inlet peaked in early May of 1986 with approximately 3,700 birds; one-third of the 1985 count. Swans, ducks, and geese concentrate on the Flats less in the spring than the fall. Bald eagle surveys indicate that approximately 75% of the birds sighted in Upper Cook Inlet use 10% of the area (e.g. Eagle River Flats).

Fall aerial survey data from the Flats indicate that different migrant species peak at different times in the fall; geese in late-August to early-September; ducks, late-August through late-September; and swans, early-October (Figure 2).

The Flats is a twenty-five-hundred-acre, tidally-influenced, river-delta/wetland complex which serves as an important staging area for waterfowl and various shorebird species during the spring and fall migrations (Figure 3). Migratory birds also use the Flats for nesting and rearing young. Spring waterfowl migrants have been estimated at 3,000 to 5,000.

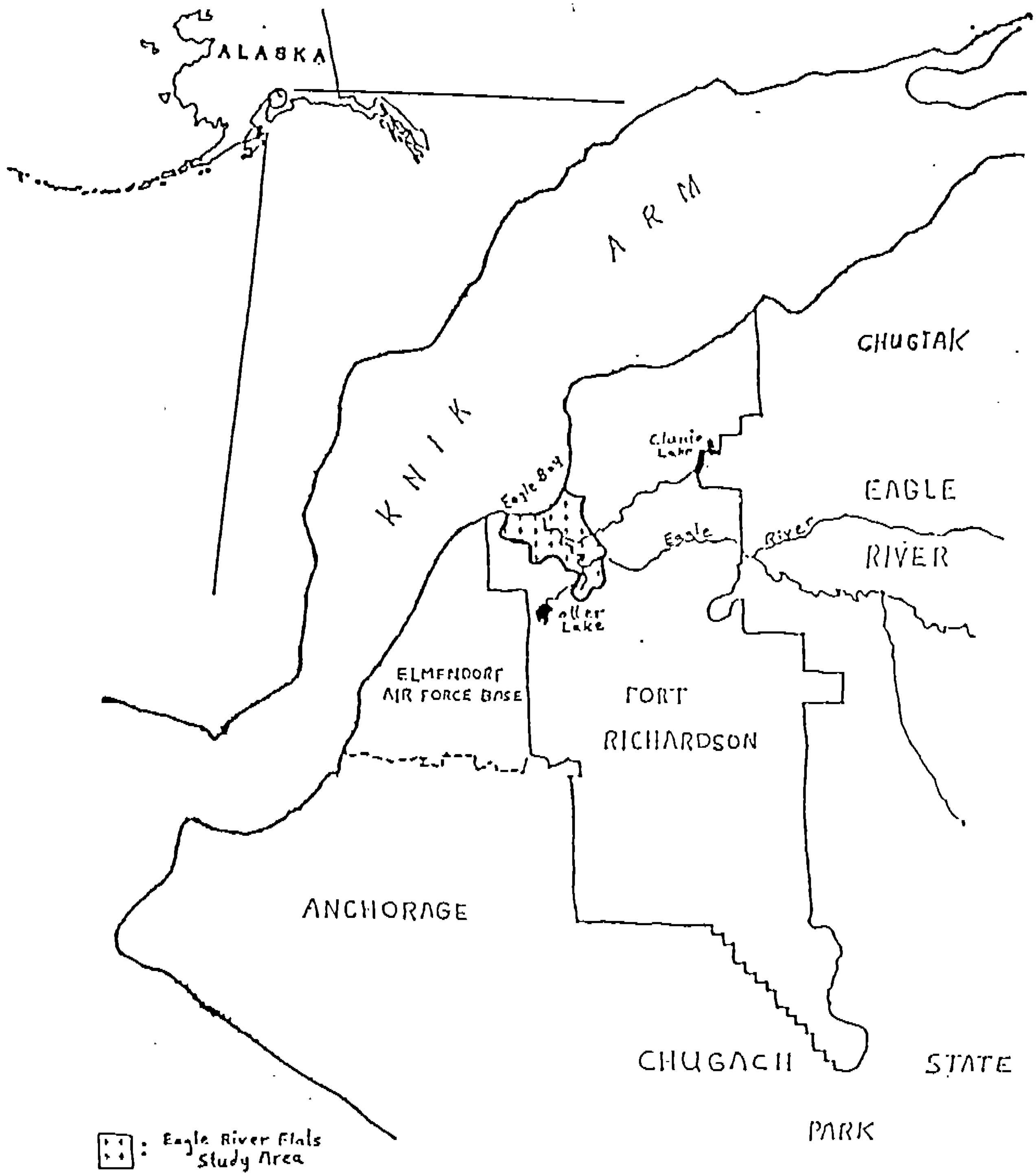


Figure 1. Eagle River Flats, Fort Richardson, Alaska and vicinity.

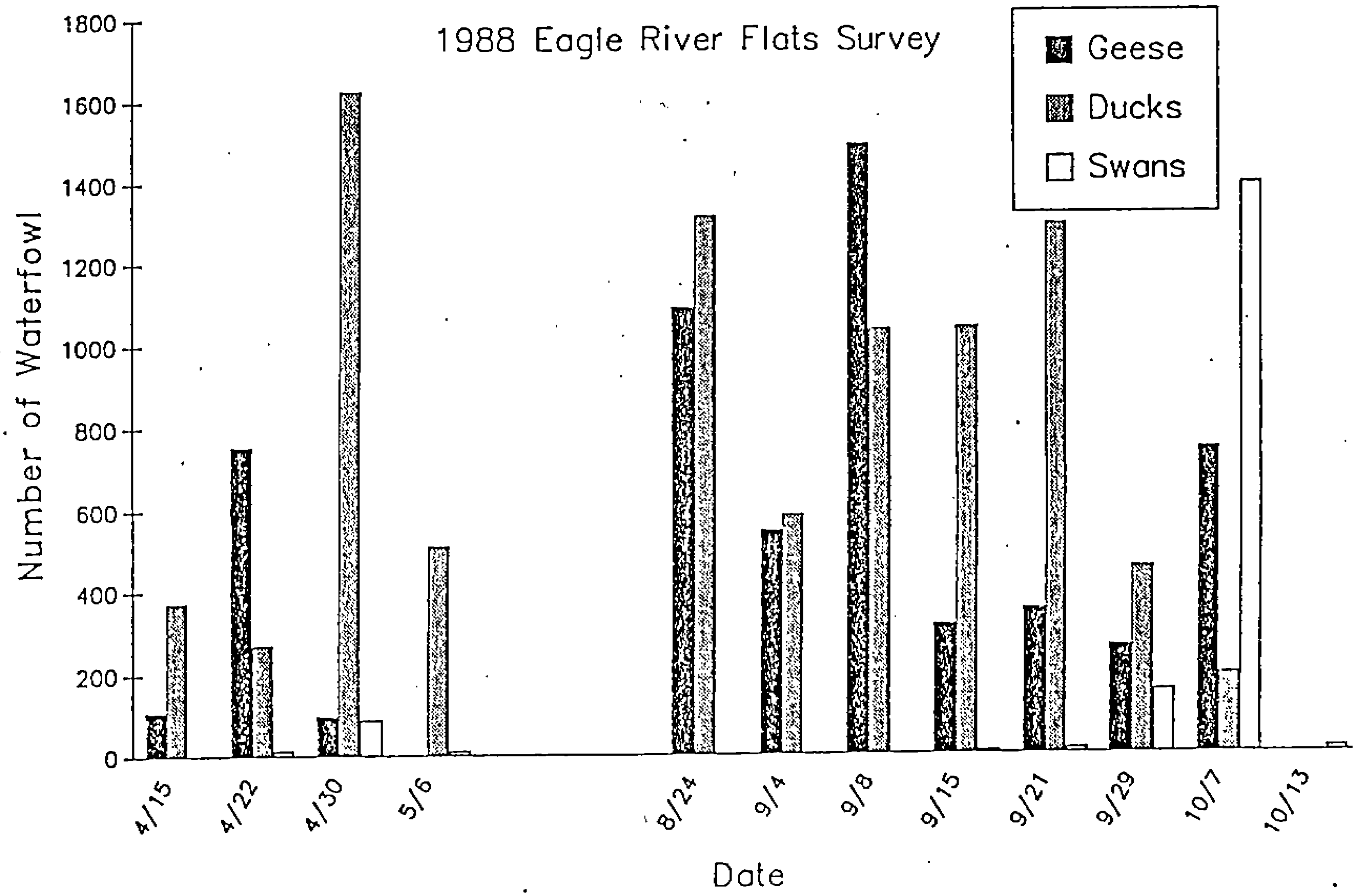


Figure 2. 1988 aerial waterfowl survey data of Eagle River Flats, Fort Richardson, Alaska.

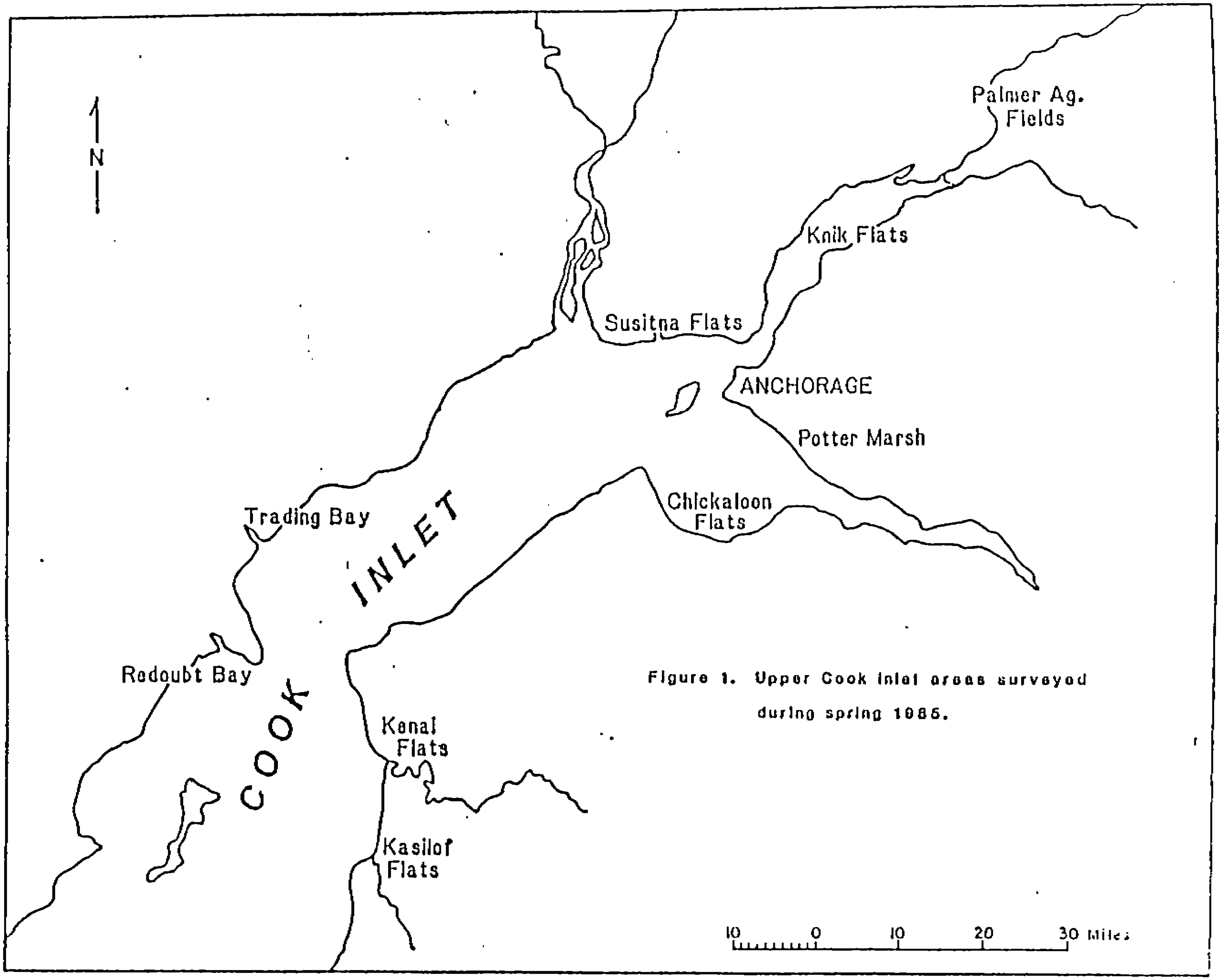


Figure 1. Upper Cook Inlet areas surveyed during spring 1985.

Figure 3. Upper Cook Inlet and vicinity (Alaska) map.

During the summer, bird use declines significantly, but a resident population of ducks and shorebirds remain on the Flats (Corps of Engineers 1978).

The Flats has four principal waterfowl concentration areas (A through D in Figure 4). Areas A and D are saltwater marshes comprised of intertidal estuarine vegetation with narrow-leaved persistent emergents. Areas B and C are nonestuarine palustrine, composed of narrow-leaved, persistent emergents with both semi-permanently and permanently flooded areas mixed with open water ponds.

Cook Inlet experiences tidal variations to a maximum of 36.5 feet. The largest differences between successive high and low tides occur in late August and early September (U.S. Dept. of Commerce 1987), with the high tides frequently flooding the flats.

The primary water source for Eagle River is glacial melt water from Eagle Glacier, 11 smaller glaciers, and two tributaries; Raven Creek and South Fork Eagle River. The mean annual flow of Eagle River is 314.7 million gallons per day (MGD) with a maximum of 1435.5 MGD in late summer (Corps of Engineers 1979).

Eagle River Basin is situated in a part of the Transitional Climatic Zone of Alaska with annual precipitation between 13-20 inches; the heaviest precipitation occurs in July and August. Prevailing summer winds are from the west to southwest, with winter winds from the northeast.

The soils of the Flats consist of silt and clay, fine-grained deposits with low permeability. The low-land soils are composed of the Salamatof peat series and the Cryaquents (loamy) Unit as descibed in the Metropolitan Anchorage Urban Study (U.S. Army Corps of Engineers, 1979). Poorly drained Salamatof soils occur in area A and along the eastern edge of Area D (Figure 4) with the remaining soils consisting of sandy, silty, clay Cryaquents.

Since World War II, the Army has used the Flats as a primary impact area for weapons training (U.S. Army Toxic and Hazardous Materials Agency 1983). Munitions fired onto the Flats are listed in Table 1. Detonations of out-dated munitions also occur immediately adjacent to the Flats on the Explosive Ordnance Disposal (EOD) site.

Overflights of the Flats conducted in the fall of 1980 provided the first documentation that dead birds (swans) existed on the Army's training area. Army biologists conducted initial ground searches of the Flats in 1982 and identified high numbers of dead waterfowl (primarily ducks) near Fox Point (area B in Figure 4). Subsequent waterfowl die-offs were documented during late summer and early fall of 1983 and 1984 (U.S. Army Memoranda For Record dated August 16, and August 23, 1984). The annual number of waterfowl deaths occurring on the Flats was estimated at 1,500 to 2,000 birds (U.S. Army Memorandum For Record dated August 23, 1984). Although minimal ground searches were conducted, no significant avian die-offs were reported during the 1985 migration periods. However, waterfowl did not congregate on the Flats during the 1985 fall migration, possibly due to the mild seasonal transition into winter. Reduced fall concentrations could also result from bird hazing caused by extensive firing onto the Flats which occurred during peak of fall migration period.

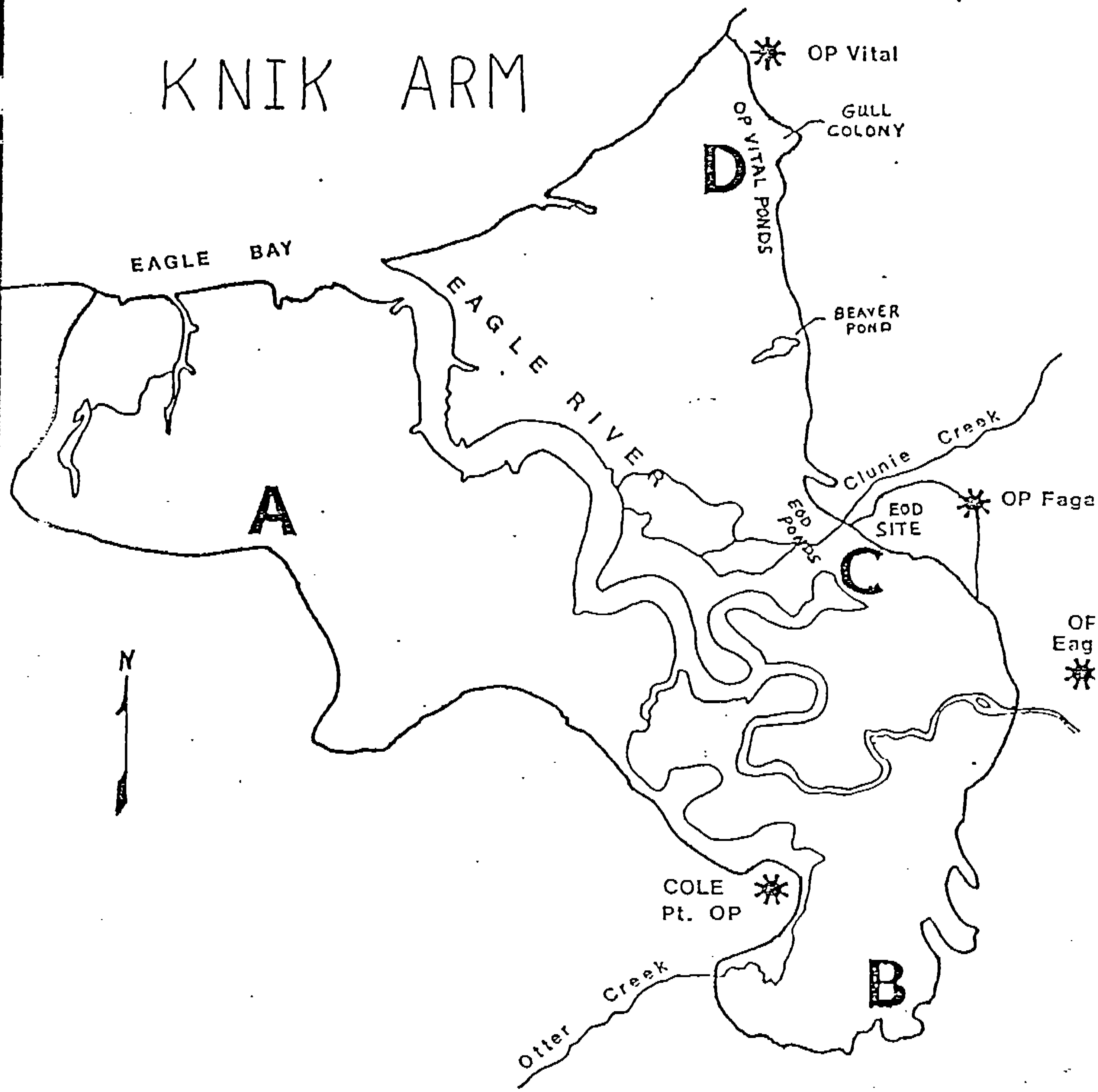


Figure 4.- Eagle River Flats, Fort Richardson, Alaska

Table 1. Military munitions likely to have been fired onto Eagle River Flats, Fort Richardson, Alaska.

---

1. High Explosives (HE): 105mm howitzer, 4.2-inch mortar, 81mm mortar, 60mm mortar, 90mm recoilless rifle, 66mm Light Anti-tank Weapon (LAW), 40mm grenades.

   Filler material for HE:
   TNT, RDX, HMX, Comp A3, Comp A5, Comp B, Comp B Grade A, or Octol.

2. Smokes: 106mm howitzer, 4.2-inch mortar, 81mm mortar, 60mm mortar, 40mm grenades.

   Filler material for smoke rounds:
   WP, FS (not used since 1985), and HC.

3. Small arms ammunition: 7.62mm, 5.56mm, and .50-caliber (uses no filler material).

4. Bombs: Air Force inert (training) bombs.
   (25, 100, and 300-pounds)

5. Demolition material: bulk TNT and C-4.

Component fillers breakdown:

TNT = Trinitrotoluene
RDX = Cyclotrimethylenetrinitramine
HMX = Cyclotetramethylenetetranitramine
Comp A3 = 90% RDX, 10% wax
Comp A5 = 98.5% RDX, 1.5% stearic acid
Comp B = 60% RDX, 39% TNT, 1% wax
Comp C-4 = RDX, wax
Octol = HMX, TNT
WP = phosphorus pentoxide
FS = sulfur trioxide, chlorosulfonic acid
HC = hexachloroethane-zinc mixture

Note: The following munitions potentially exist on the Flats since they were discovered on an adjacent impact area:

--Shillelagh missiles
--155mm high explosive artillery
--3.5-inch rockets

The magnitude of this mortality heightened concern by resource agencies, since it appeared to be much higher than had been observed in other bird use areas; secondly, the mortality could have severe impacts on local and migratory bird populations; and thirdly, contaminated waterfowl could pose a problem for human consumption.

Three possible causes of the mortality were initially identified; disease/lead poisoning; concussion (impact of the munitions); and contaminants, either from the munitions since they do contain chemical compounds known to be toxic to avifauna, or from urban runoff. The following list identifies the chemical composition of one type of munition (smoke rounds) fired onto the Flats:

--Hexachloroethane (HC Smoke)
--Hexachlobenzene
--Carbon Tetrachloride
--Ethylene Dichloride
--Phosgene (byproduct) (or Carbonyl Chloride)
--Ethyl Tetrachloride
--Hydrogen Chloride
--Zinc Chloride
--Arsenic Chloride
--Lead Chloride
--Mercuric Chloride

In June of 1985, the U.S. Army Environmental Hygiene Agency, from Aberdeen Proving Ground, Maryland, conducted a water quality study on the Flats. This study focused on contaminants occurring in water samples collected upriver of, and within the Flats, and a control site across Knik Arm (Figure 5). Study results did not indicate any unusual levels of water contamination at any of the sample sites.

The 1988 field season initated the first systematic investigation of the avian die-off problem occurring on the Flats. Figure 18 shows the flow chart developed by the Task Force for the investigation of avian mortality.

III. STUDY AREA

Along the northwest side of the Flats, 194 acres were identified as potentially safe (from live dud munitions) for foot access. This section became the focus of ground searches conducted on the Flats in 1988 (Figure 6). The study area is bisected by a deep-water beaver pond-Area D to the north and Area C to the south. One additional deep-water pond exists in the northeast corner of the study area (Area D). Connecting the two deep-water ponds is an active beaver channel providing more deep water habitat. Road access to the site is from the north at OP Vital and from the south at the EOD site. The shallower ponds adjacent to the EOD site have an accumulation of metal debris along the shoreline that has been pushed into the Flats over the past years.

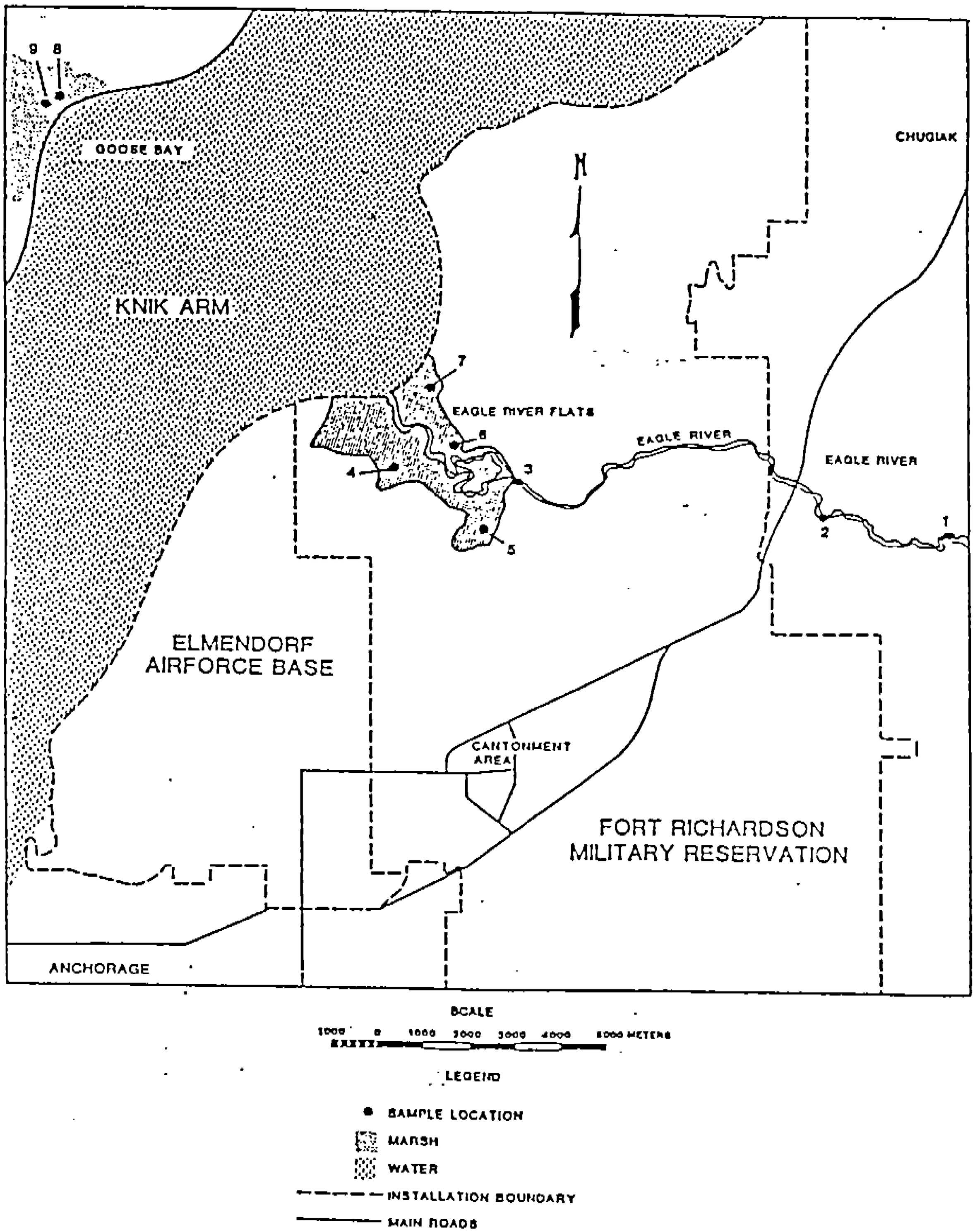


Figure 5. Map depicting U.S. Army Environmental Hygiene Agency's 1985 water quality sampling sites.

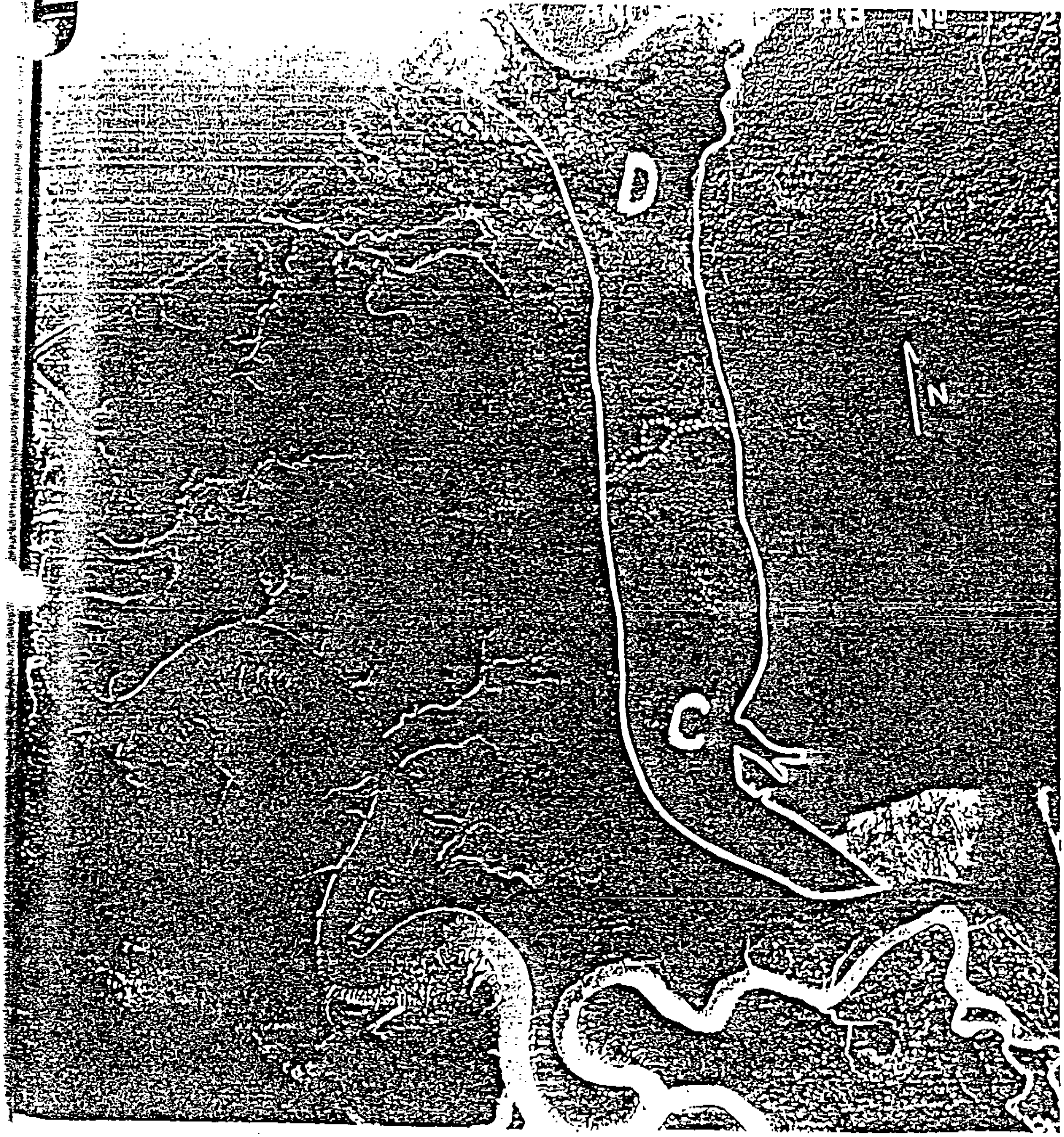


Figure 6. 1988 avian mortality study site, Eagle River Flats, Fort Richardson, Alaska.

EAGLE RIVER FLATS FLOW CHART

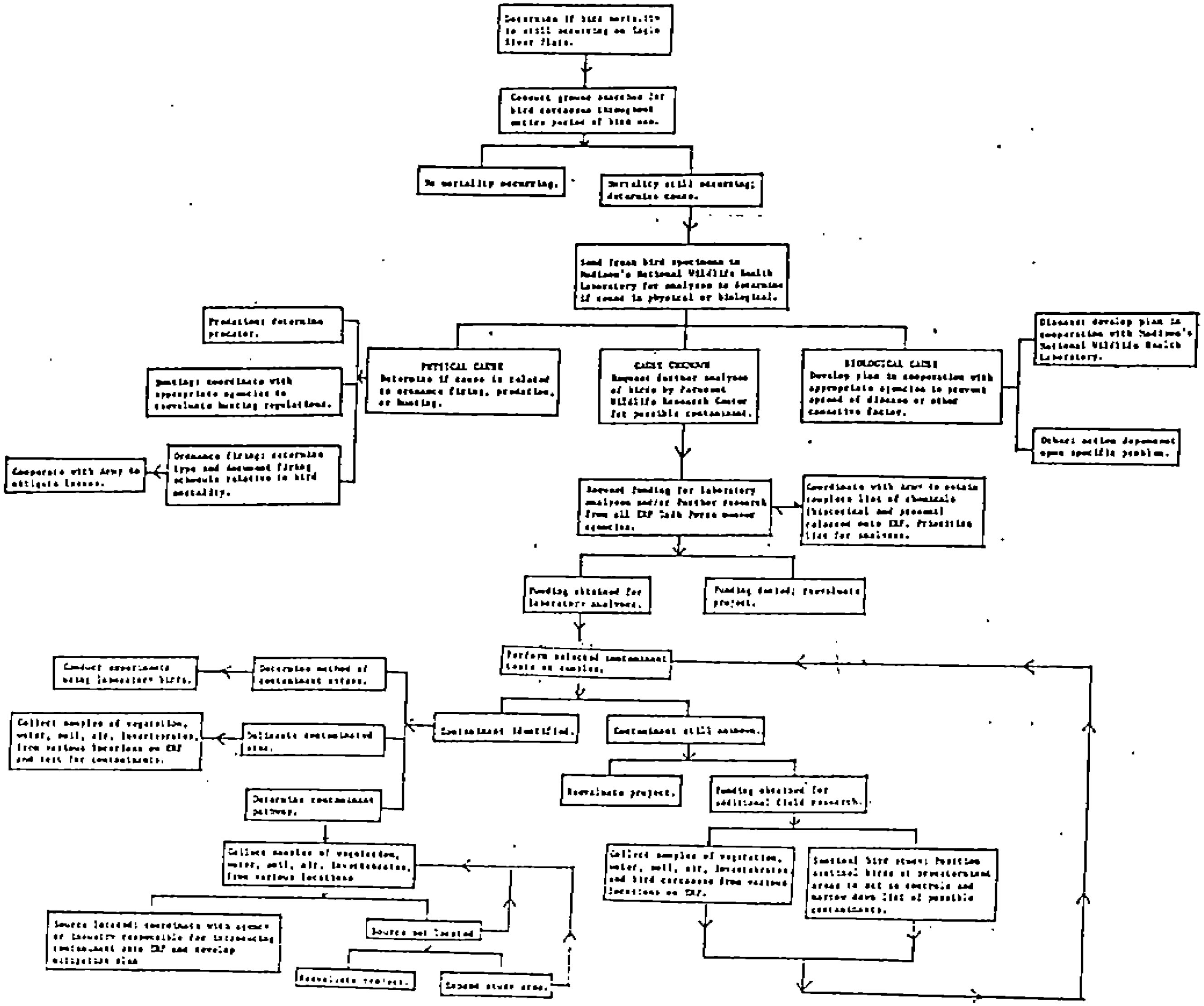


Figure 18. Eagle River Flats investigation flow chart.

IV. METHODS

A. Phase I: Field Investigation

1. Ground Search; Documentation of Mortality

Two crews of two or more individuals opportunistically searched (on foot) Areas C and D for birds between mid-April and early October, 1988. Timing and frequency of searches were dictated by several factors: (1) military training needs (ordnance firing), (2) availability of search crew staff, (3) climatic conditions, and (4) need to obtain fresh specimens. The latter factor mandated a maximum of three days between searches.

Decomposed carcasses (or those showing signs of predation) and feather piles/remains were identified to species when possible, recorded and field marked by flagging to avoid duplicate counting. Fresh specimens - those with intact bodies, no skin sloughing, clear eyes, no decaying odor - were identified, body condition described, and placed in plastic bags. Collected specimens were either express-mailed (on ice) to the Service's National Wildlife Health Research Center, or frozen and retained for later analyses.

2. Ground observation; Species Composition/Use of Area

Search crews concurrently identified and recorded live birds and nests, with locations recorded on field maps. Eleven surveys (in addition to ground searches) were conducted from adjacent bluffs to document fall bird use. All birds observed during the study are listed in Table 2.

3. Aerial Surveys

Aerial surveys (100 miles per hour at 100 feet elevation) were conducted along transects from mid-April through early-May and mid-August through late-September. These data supplemented the ground surveys and were particularly useful for gulls, large shorebirds, swans, cranes, geese, and ducks.

4. Bird Behavior Observations

Initially, the effort to document the effect(s) military firing had on bird behavior required observations of individual birds and groups of birds during firing and non-firing periods on the Flats. Behavior categories described in Ward et al. (1986), and Davis and Wisely (1974), were modified and used as the criteria for the proposed study.

B. Laboratory Investigations

Four laboratories with differing testing capabilities were employed for analyses:

1. Madison National Wildlife Health Reserach Center

,tandard methods were followed for gross necropsy examinations and bacterial, viral and histological testing. Results are presented in Tables 3 and 4. Tissues and organs from some of these samples were subsequently sent to the Patuxent Center for trace metal analyses.

Table 2. List of bird species documented within and adjacent to the Eagle River Flats, Fort Richardson, Alaska.

Red-necked Grebe (Podiceps grisegena)
Tundra Swan (Cygnus columbianus)
Trumpeter Swan (Cygnus buccinator)
Greater White-fronted Goose (Anser albifons)
Snow Goose (Chen caerulescens)
Canada Goose (Branta canadensis)
Green-winged Teal (Anas crecca)*
Mallard (Anas platyrhynchos)*
Northern Pintail (Anas acuta)*
Blue-winged Teal (Anas discors)
Northern Shoveler (Anas clypeata)*
Gadwall (Anas strepera)
American Wigeon (Anas americana)*
Canvasback (Aythya valisineria)
Ring-necked Duck (Aythya collaris)
Greater Scaup (Aythya marila)*
Barrow's Goldeneye (Bucephala islandica)
Red-breasted Merganser (Mergus serrator)
Bald Eagle (Haliaeetus leucocephalus)*
Northern Harrier (Circus cyaneus)
Sharp-shinned Hawk (Accipiter striatus)
Northern Goshawk (Accipiter gentilis)
Red-tailed Hawk (Buteo jamaicensis)
Rough-legged Hawk (Buteo lagopus)
American Kestral (Falco sparverius)
Merlin (Falco columbarius)
Sandhill Crane (Grus canadensis)*
Black-bellied Plover (Pluvialis squatarola)
Lesser Golden-Plover (Pluvialis dominica)
Semipalmated Plover (Charadrius dubius)
Greater Yellowlegs (Tringa melanoleuca)
Lesser Yellowlegs (Tringa flavipes)
Solitary Sandpiper (Tringa solitaria)
Spotted Sandpiper (Actitis macularia)
Whimbrel (Numenius phaeopus)
Hudsonian Godwit (Limosa haemastica)
Bar-tailed Godwit (Limosa lapponica)
Ruddy Turnstone (Arenaria interpres)
Semipalmated Sandpiper (Calidris pusilla)
Western Sandpiper (Calidris mauri)
Least Sandpiper (Calidris minutilla)
Pectoral Sandpiper (Calidris melanotos)
Short-billed Dowitcher (Limnodromus griseus)
Long-billed Dowitcher (Limnodromus scolopaceus)
Common Snipe (Gallinago gallinago)
Wilson's Phalarope (Phalaropus tricolor)
Red-necked Phalarope (Phalaropus lobatus)*

(Table 2. List of birds continued.)

Bonaparte's Gull (Larus philadelphia)*
Mew Gull (Larus canus)
Herring Gull (Larus argentatus)
Glaucous-winged Gull (Larus glaucescens)*
Glaucous Gull (Larus hyperboreus)*
Arctic Tern (Sterna paradisaea)
Northern Hawk-Owl (Surnia ulula)
Belted Kingfisher (Ceryle alcyon)
Hairy Woodpecker (Picoides villosus)
Olive-sided Flycatcher (Contopus borealis)
Western Wood-Peewee (Contopus sordidulus)
Alder Flycatcher (Empidonax alnorum)
Tree Swallow (Tachycineta bicolor)
Violet-green Swallow (Tachycineta thalassina)
Bank Swallow (Riparia riparia)
Cliff Swallow (Hirundo pyrrhonota)
Common Raven (Corvus corax)
Boreal Chickadee (Parus hudsonicus)
Ruby-crowned Kinglet (Regulus calendula)
Swainson's Thrush (Catharus ustulatus)
Varied Thrush (Ixoreus naevius)
American Robin (Turdus migratorius)
Water Pipit (Anthus spinoletta)
Bohemian Waxwing (Bombycilla garrulus)
Orange-crowned Warbler (Vermivora celata)
Yellow-rumped Warbler (Dendroica coronata)
Blackpoll Warbler (Dendroica striata)
Wilson's Warbler (Wilsonia pusilla)
Savannah Sparrow (Passerculus sandwichensis)
Song Sparrow (Melospiza melodia)
Lincoln's Sparrow (Melospiza lincolnii)
Golden-crowned Sparrow (Zonotrichia atricapilla)
White-crowned Sparrow (Zonotrichia leucophrys)
Dark-eyed Junco (Junco hyemalis)
Red-winged Blackbird (Agelaius phoeniceus)
Rusty Blackbird (Euphagus carolinus)
White-winged Crossbill (Loxia leucoptera)
Common Redpoll (Carduelis flammea)

*Known to have nested on Eagle River Flats prior to 1988.

Table 3. Analytical results from specimens sent to the U.S. Fish and Wildlife Service National Wildlife Research Center, Madison, Wisconsin from 1983, 1984, 1985, and 1988 (combined).

LAB TESTS CONDUCTED	# TESTED	RESULTS
DISEASES:		
Avian botulism	45	Negative
Bacterial isolation	38	Non-contributory
Viral isolation	21	Negative
Parasitology	1	Coccidia
Methemoglobin	2	18.5%, 47.8%
Histopathology	21	Pulmonary congestion, enteritis, nephrosis, pneumonicosis, possible hemosiderin, non-contributory
Cholinesterase inhibition	15	Negative(14), 13% inhibition(1)
METALS:		
Lead	3	.05ppm w/w; .20ppm d/w* .02ppm w/w; .09ppm d/w 1.99ppm w/w; 7.49ppm d/w
		Mean (range); ppm d/w*
Phosphorous, GI tract	4 4	3672 (1730-8500) 1040 (920-1190)
Phosphorous, Lung	1	6200 (N/A)
Phosphorous, Liver	6	2647 (1661-3280)
Phosphorous, Kidney	6	2938 (2690-3114)
Zinc, Liver	6	21.0 (15.9-27.3)
Zinc, Kidney	6	14.0 (13.3-15.1)
Magnesium, Liver	6	135.2 (75.8-182.6)
Magnesium, Kidney	6	168.9 (143.1-209.5)
Arsenic, Liver	6	less than 0.24
Arsenic, Kidney	6	less than 1.16
Mercury, Liver	6	less than 0.01
Mercury, Kidney	6	less than 0.04

* w/w = wet weight; d/w = dry weight

Table 4. Summary of Lab test findings

DIAGNOSIS	NUMBER
Undetermined	51
Gunshot	1
Nephrosis	2
Pulmonary congestion, pulmonary edema, enteritis	27

2. Patuxent Wildlife Research Center

Tissues were analyzed for the trace metals listed in Tables 1, 2, and 3, of Appendix C. Lead, copper, chromium, zinc, manganese, cadmium, nickel, antimony, thallium, and iron were determined by using HGA methodologies. AAH methodologies were employed for arsenic and selenium. Mercury was determined via the cold vapor technique. Appendix C describes the detailed analytical methods.

3. Alaska Department of Environmental Conservation

Surface water samples, sediment samples, and a green-winged teal were collected on September 15, 1988, from three locations (EOD Pond and Beaver Pond on Eagle River Flats, and Potters Marsh, located south of Anchorage, as a control) and analyzed for the presence of trace metals, volatile oraganics (halogenated and aromatic hydrocarbons), and seven components of military ordnances (cyclotrimethylenetrinitramine, trinitrophenylmethylnitramine, hydrazine, trinitrototoluene, mercury fulminate, copper fulminate, and silver fulminate).

Three surface water samples from each location were collected in three types of clean containers: a 40-ml purge vial preserved with HCl for colatile organic analyses, a 1-liter plastic bottle for trace metals testing, and a 1-liter glass bottle for ordnance components analyses.

Three sediment samples were collected on September 15, 1988, from each location mentioned above. Clean containers were used (a 40-ml purge vial, a 125-ml plastic bottle, and a 125-ml glass bottle); analyses were the same as those conducted on surface water samples.

The heart, lungs, and gastrointestinal tract of a fresh, male, green-winged teal carcass were excised and placed in a sterilized jar sealed with aluminum foil. All samples were kept cool until air shipment to Alaska Department of Environmental Conservation's Douglas Laboratory in Juneau, Alaska.

4. Environmental Protection Agency - Corvallis, Oregon

On July 11, 1988, three quarts of water from each of three sites (EOD Pond, Beaver Pond, and OP Vital Pond - Figure 4) were collected in acid-washed containers, refrigerated, and forwarded to the Corvallis laboratory for analyses of organochlorine and organophosphate pesticides (via gas chromatography with an N-P detector). A complete list of analyses is presented in Table 5.

Three additional gallons of water from each of the above sites were collected July 22, 1988, for use in bioassys. Part 1: Nine 6-week-old mallard chicks were dosed twice daily with pond water - 5 birds by oral gavage (20 ml) and 4 birds by intraperitoneal inoculation (10 ml) - for each of the 3 sites. Treatment proceeded for 10 days; birds were then placed in individual pens, trained to drink distilled water, and fed purina game bird maintenance chow ad lib for one week. Part 2: Birds were assigned to their previous pond group (of Part 1) and provided with water only - no food - according to the following schedule: Beaver Pond = 5 days; OP Vital Pond = 5 days; EOD Pond = 7 days. Birds/droppings were observed daily for one week.

Table 5. Environmental Protection Agency's list of chemicals analyzed in Eagle River Flats' water samples.

Organophosphates	Organochlorines
malathion	DDT and analogs
Diazinon	PCBs
Ronnel	Chlordane
Carboturan	BHC isomers
Methamidophos	Aldrin
Acephate	Toxaphene
Dicrotophos	2,4-D
2,4,5-T	
2,4,5-TP	
MCPA	
DCPA	
phthalates	

V. RESULTS

A. Phase I: Field Investigations

1. Ground Search; Documentation of Mortality

Eight species of birds were collected during the 1988 field season on the Flats. Thirty-four investigators conducted a total of 26 ground searches for a total of 350 man-hours between April 20, and October 7, 1988. Eleven additional late-fall surveys were conducted specifically to monitor swan use of the area. The first mortalities of the 1988 field season were documented during a ground search on May 9, 1988. A total of 358 whole avian carcasses were identified in the survey area in 1988 (Table 6). Two hundred eighteen of the dead birds were identified to sex; 125 were males and 93 were females. Most of the dead birds (95.5%) were ducks. Nearly one-third were northern pintails; mallards comprised 32%, green-winged teal comprised 27%, and northern shovelers, 3.6%. American wigeon and gadwall consisted of one bird each. The majority of dead birds (82%) were collected from, or adjacent to, the beaver pond and EOD Pond (Figure 7).

A total of 573 feather piles were found within the survey area (Table 7). Of the 217 remains that could be identified, pintail (n=110) and green-wing teal (n=43) were most numerous. Featherpiles were found throughout the survey area; however, greatest concentrations were found on the perimeter of the EOD and beaver ponds. A large proportion of the feather piles were located near eagle perching sites.

Twenty-five bird specimens collected between May 9 and October 7, 1988, were sent to the Madison laboratory. Fourteen were sent fresh and eleven were sent frozen. An additional 49 carcasses were frozen for future analyses.

2. Ground Observations; Species Composition/Use of Area

Eighty-three species of birds were identified within the survey area and the adjacent forest perimeter between April 20, and November 3, 1988 (Table 3). Juveniles of six species (sandhill crane, Bonaparte's gull, mallard, American wigeon, Hudsonian godwit, and Wilson's phalarope) were observed on the Flats during the 1988 season. The occurrence and probable nesting of the Wilson's phalarope on the Flats is the first such recording of this kind for the state of Alaska.

Shorebirds were first sighted on May 9 and migrant numbers peaked July 8 (Figure 8). Sandpipers (Figure 9) were more numerous in late May and mid-July than in June. Peak spring numbers of ducks occurred in late-May and early-June; fall migration occurred from mid-August to mid-September (Figure 10). Geese were sighted sporadically, with the greatest numbers occurring on April 20 (n=420) and October 7 (n=750); this corresponds to spring and fall migration peaks, respectively (Figure 11). Neither swans nor geese were prevalent during June, July, and August; however, large concentrations of both species were observed in September and October (Figure 11). Gulls on the Flats averaged 71, which reflects the existence of a nesting colony near OP Vital; peak numbers occurred late-May throughout June (Figure 12). Numbers of arctic terns varied between 2 and 12 until July 15, when 40 were observed (Figure 12). Highest numbers of bald eagles (n=16) were sighted in early May

Table 6. Species composition of fresh avian carcasses on Eagle River Flats, Fort Richardson, Alaska, between April 20, and November 3, 1988.

SPECIES	# Collected	# Not Collected	Total
Mallard	21	92	113
Northern Pintail	25	92	117
Green-winged Teal	22	75	97
Northern Shoveler	7	6	13
American Wigeon	1	-	1
Gadwall	-	1	1
Least Sandpiper	1	-	1
Semipalmated Sandpiper	1	-	1
Dowitcher Spp.	1	-	1
Yellow-legs Spp.	-	1	1
Swan Spp.	6	4	10
Bald Eagle	1	-	1
Mew Gull	-	1	1
TOTAL:	86	272	358

Table 7. Feather piles found on Eagle River Flats between April 20, and September 23, 1988.

SPECIES	NUMBER
Mallard	46
Northern Shoveler	28
Green-winged Teal	62
Northern Pintail	118
American Wigeon	5
Unknown Duck	254
Unknown shorebird	14
Unknown Gull	1
Raven	1
Unknown Swan	2
Canada Goose	2
TOTAL:	573

Table 8. Bird groups using Eagle River Flats, Fort Richardson, Alaska, in 1988 - Summary of ground observations

	Apr	May									Jun						Jul				Aug		Spt		
	20	2	6	9	13	16	20	24	27	31	3	7	10	13	17	30	8	11	15	22	12	19	8	15	23
Gulls	60		62	25	38	61	81	63	152	157	111	127	167	113	135	93	79	45	57	17	18	26	46	31	40
Sandpipers					15	25	129	22	124	13	11	5	20	3	17	96	11	7	132	133	1		24	8	30
Shorebirds				6	51	55	80	60	134	73	136	99	72	157	250	302	583	169	387	370	127	61	16	57	130
Ducks	59		113		44	29	49	17	135	80	107	112	61	42	43	57	37	109	54	62	280	240	150	300	433
Geese	420				1	2	1	1															450	179	104
Swans			16	14	29	31	23	7	10	6	4				1									9	35
Passerines					10		23	84	192	54	30	43	38	86	35	20	13		18	58					
Raptors	7	16	3	1	8	8	7	2	1	2		1			2	1		2	1	2	1		4	3	4
Others	2	6	8	22	8	9	7	9	16	12	20	16	17	13	16	25	10	12	44	33	7	3	40	29	
TOTAL	548	22	202	68	160	220	398	265	764	397	419	403	375	414	499	594	733	344	693	675	434	330	730	616	776

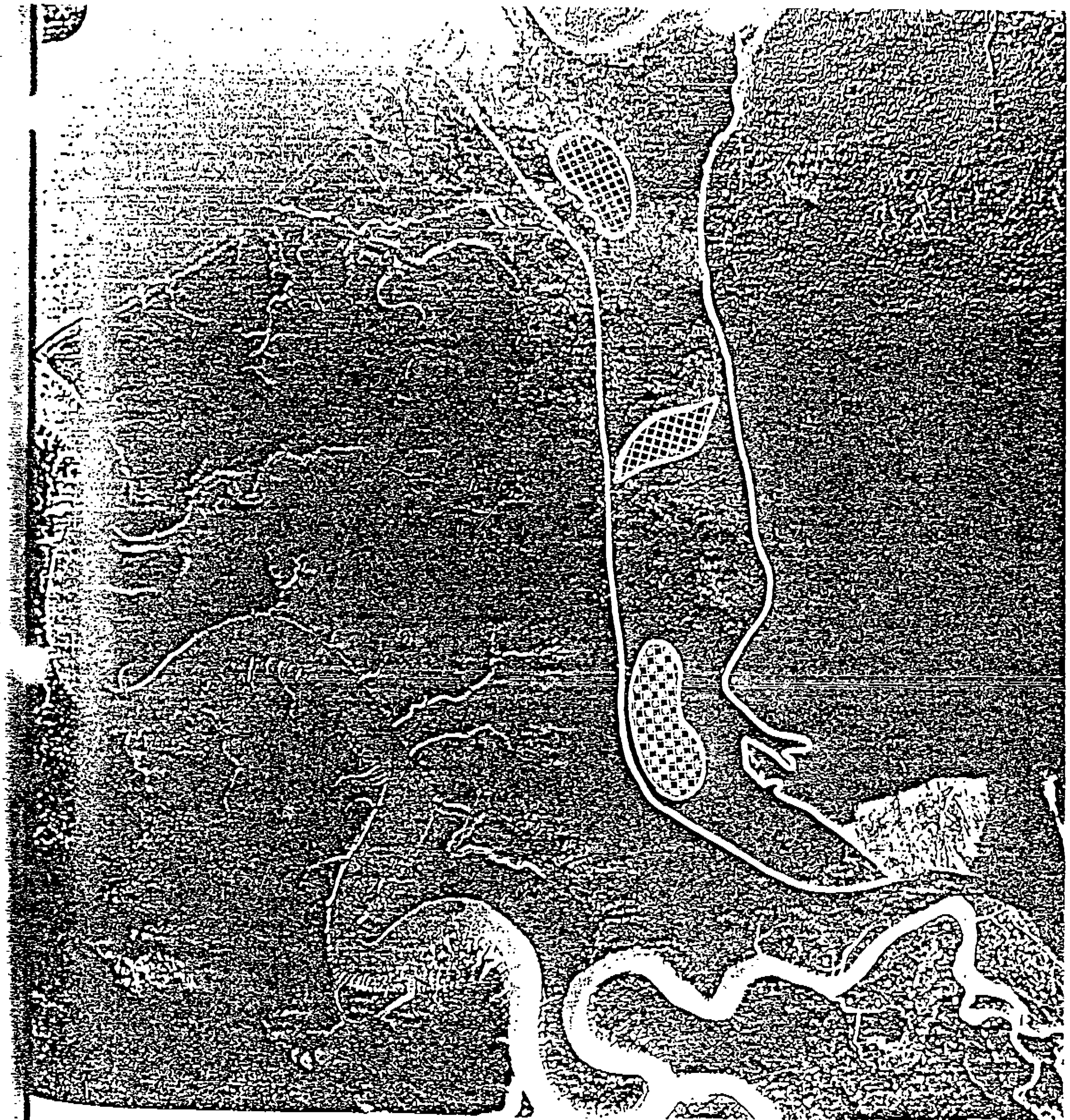


Figure 7. Location of bird carcass concentrations on Eagle River Flats, Fort Richardson, found between May 9, and September 23, 1988.

▩ = 30-40 carcasses ▩ = greater than 100 carcasses.

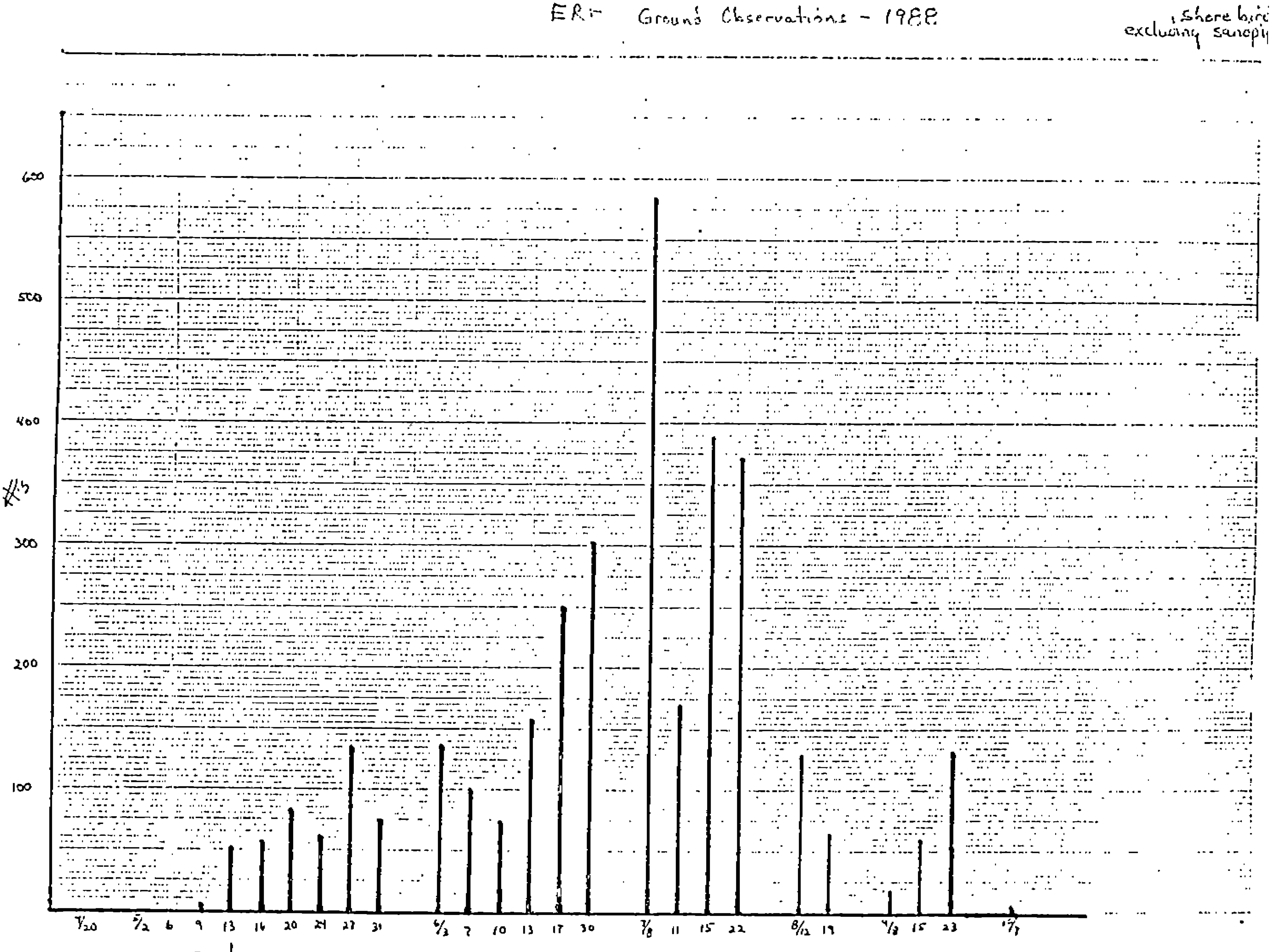


Figure 8. Shorebird use (excluding sandpipers) of Eagle River Flats as documented by ground searches conducted in 1988.

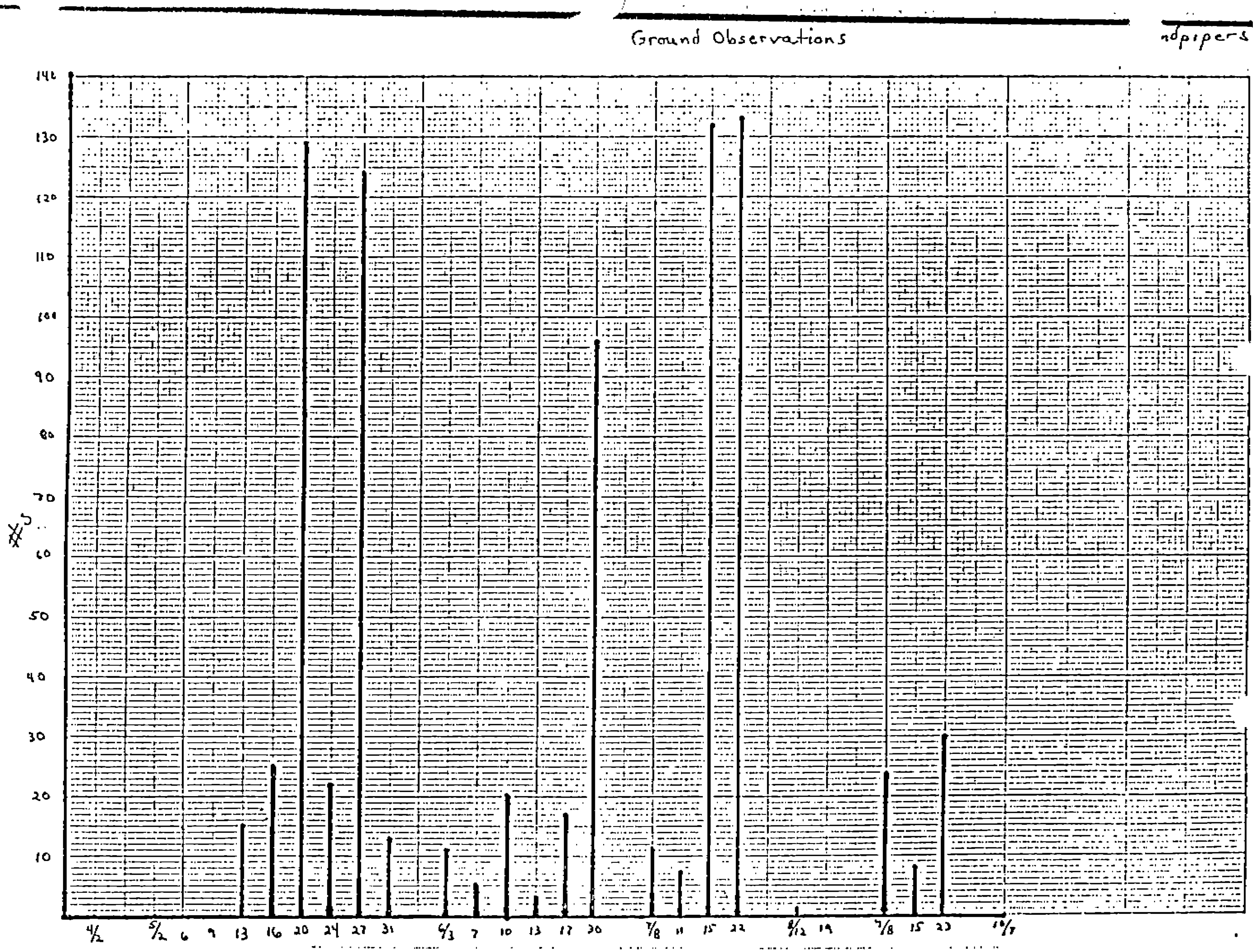


Figure 9. Sandpiper use of Eagle River Flats as documented by ground searches conducted in 1988.

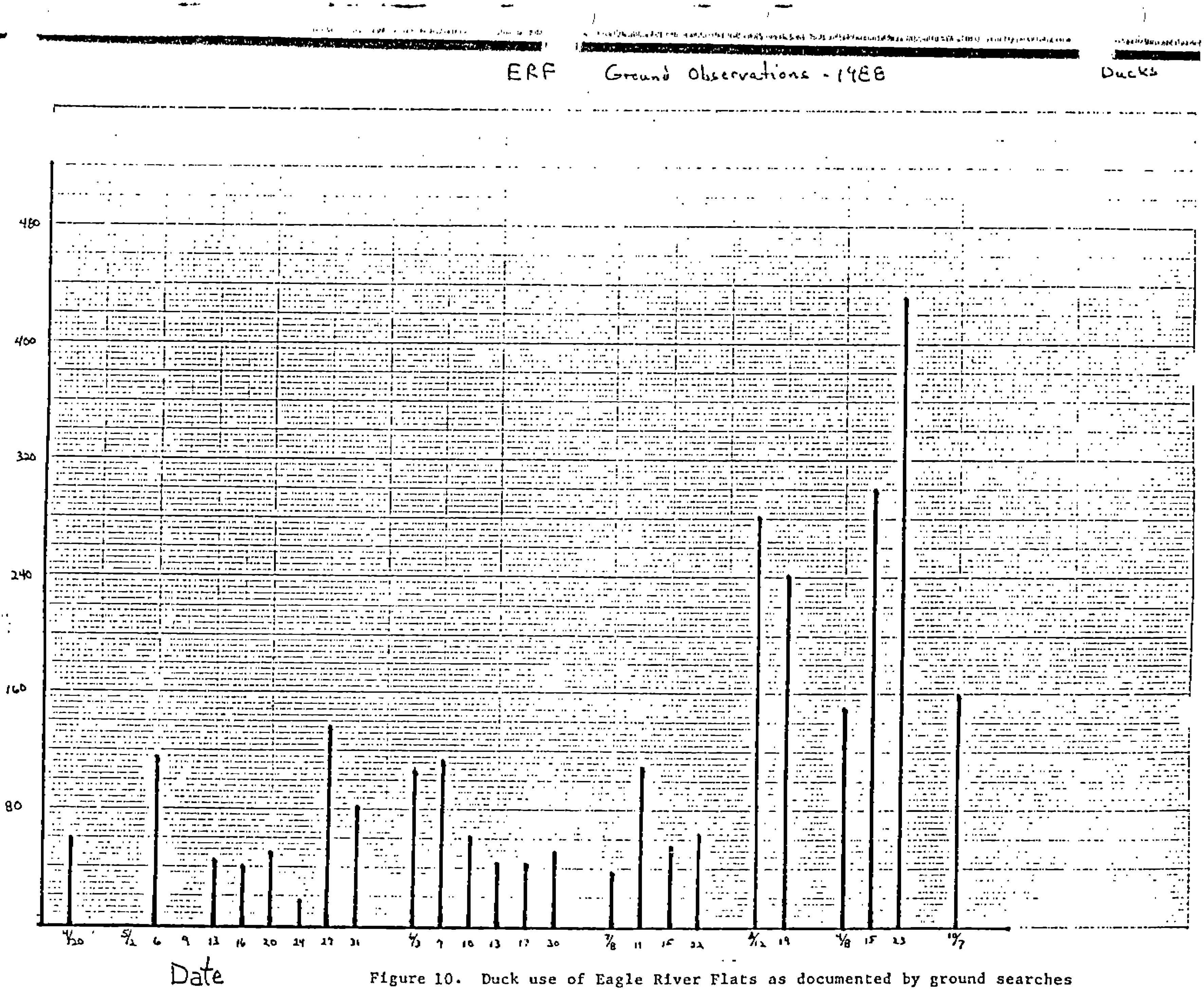


Figure 10. Duck use of Eagle River Flats as documented by ground searches conducted in 1988.

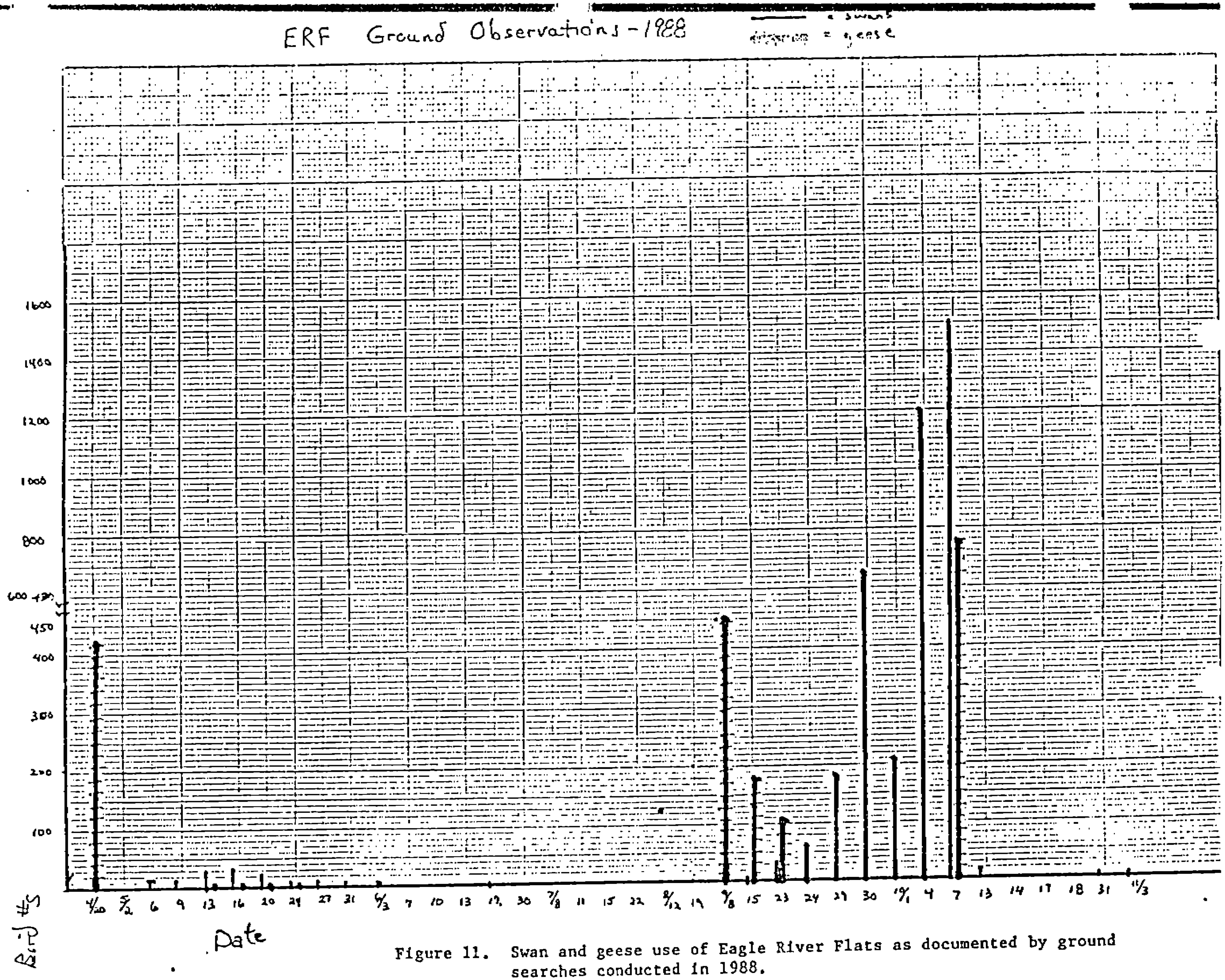


Figure 11. Swan and geese use of Eagle River Flats as documented by ground searches conducted in 1988.

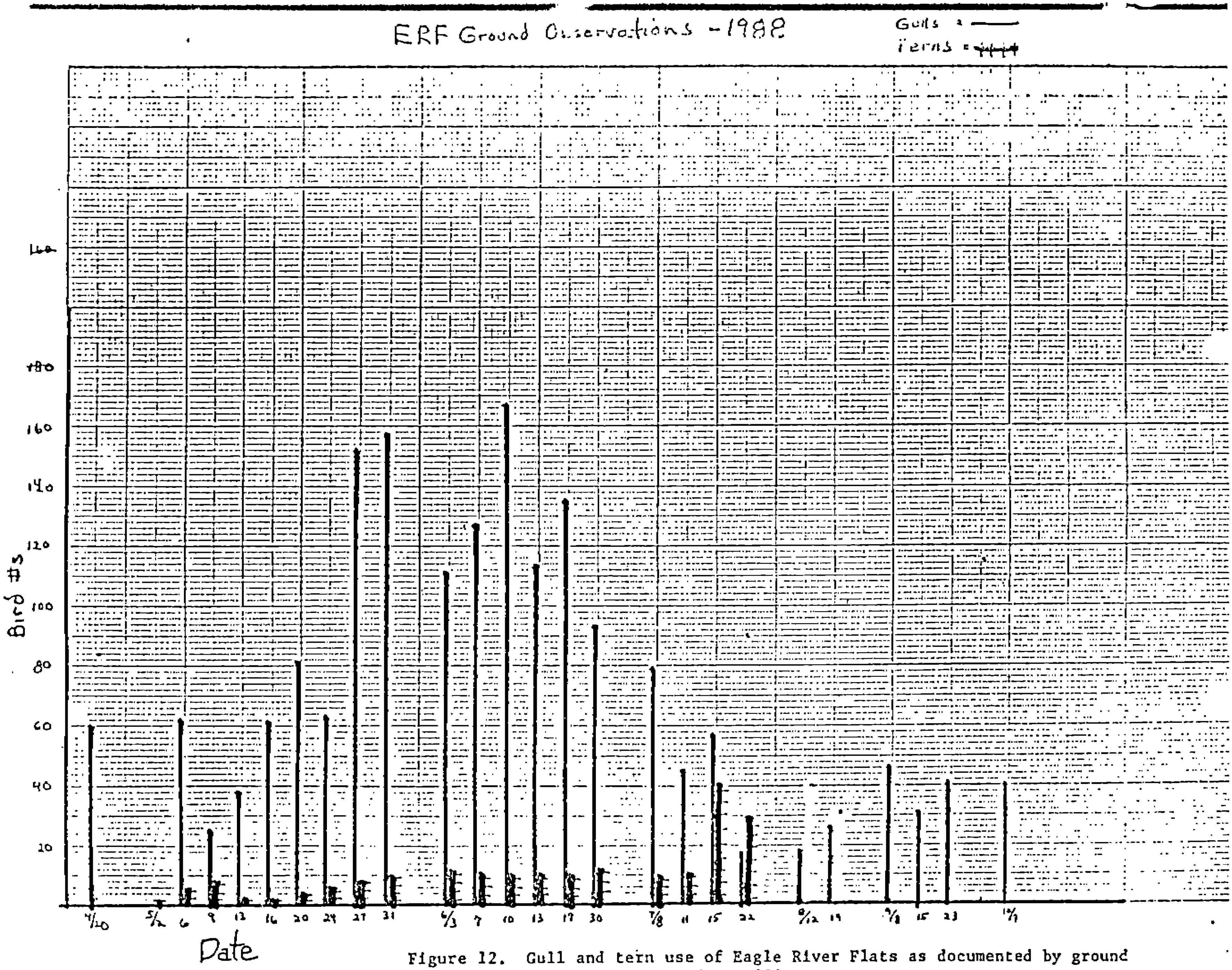


Figure 12. Gull and tern use of Eagle River Flats as documented by ground searches conducted in 1988.

(Figure 13). Sandhill crane observations ranged between 2 and 13 until migrant numbers peaked at 30 on September 8 (Figure 13).

Table 8 summarizes ground observation data obtained for the search area throughout the 1988 field season; total counts are displayed in Figure 13.

3. Aerial surveys

Aerial survey results (1988) for swans, geese, ducks, gulls, sandhill cranes, shorebirds, and bald eagles are compiled in Figure 15 and Table 9. Swan, geese, and duck numbers peaked in late-April for spring migration, while geese and swan numbers peaked in early-October and duck migrants peaked in late-September for fall migration. No aerial surveys were conducted during late-May, June, and July due to lack of plane, pilot, or observer availability.

The majority of bird concentrations observed from the air used the northern section of the Flats; geese primarily distributed along the Cook Inlet coast, with ducks and swans on ponds (Figure 16).

B. Phase II: Laboratory Investigations

Samples were sent to various laboratories for analyses. Laboratories within the Service include the Madison National Wildlife Health Research Center and the Patuxent Wildlife Research Center. Additional samples were sent to the Alaska Department of Environmental Conservation laboratory in Douglas, Alaska, and the U.S. Environmental Protection Agency in Corvallis, Oregon.

1. Madison National Wildlife Health Research Center

Since 1982, 85 bird specimens have been sent to Madison National Wildlife Health Laboratory for analyses. Of these, 25 bird carcasses were collected during the 1988 field season.

Tests for common avian diseases, cholinesterase inhibition, and lead were performed on twelve of the 25 specimens (5 green-winged teal, 3 Northern shovelers, 1 trumpeter swan, 1 least sandpiper, 1 semipalmated sandpiper, and 1 bald eagle) sent in 1988. Laboratory results ruled out the probability of bacterial, viral, or parasitic disease, predation, and trauma as the primary cause of death. However, the laboratory has suggested the possibility of contaminants as the cause of avian die-off on the Flats. Table 3 and 4 summarizes the tests conducted and the results.

An additional three birds (mallard ducklings) were sent to Madison lab for necropsy from the Environmental Protection Agency's experiment with ingestion of water obtained from Eagle River Flats. Results obtained from these ducklings indicated that liver and intestine samples had no pathogenic bacteria; no significant lesions were identified.

2. Patuxent National Wildlife Research Center

Sixteen biological samples were sent to Patuxent for various chemical analyses. Appendix C describes in detail the methods and results of

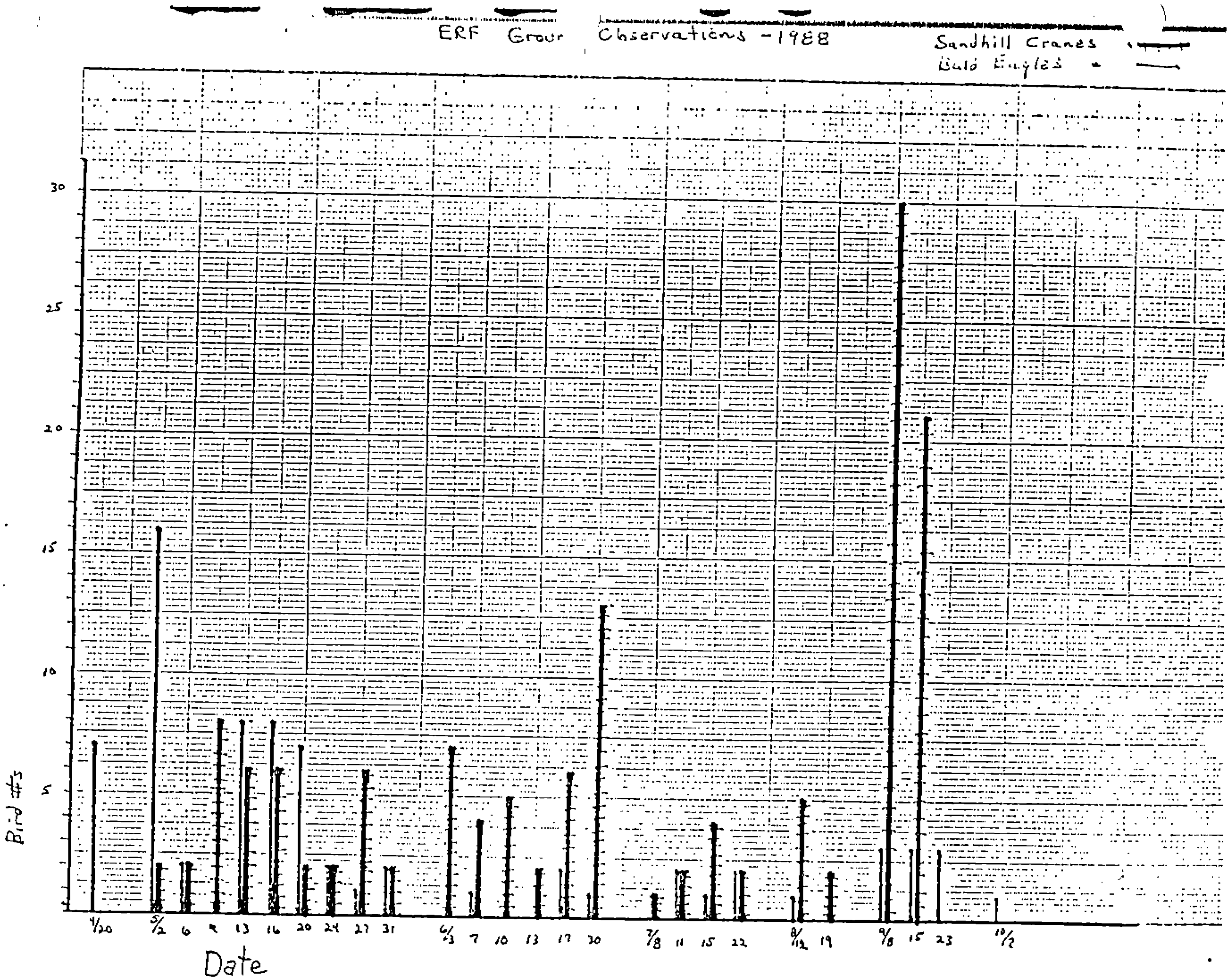


Figure 13. Sandhill crane and bald eagle use of Eagle River Flats as documented by ground searches conducted in 1988.

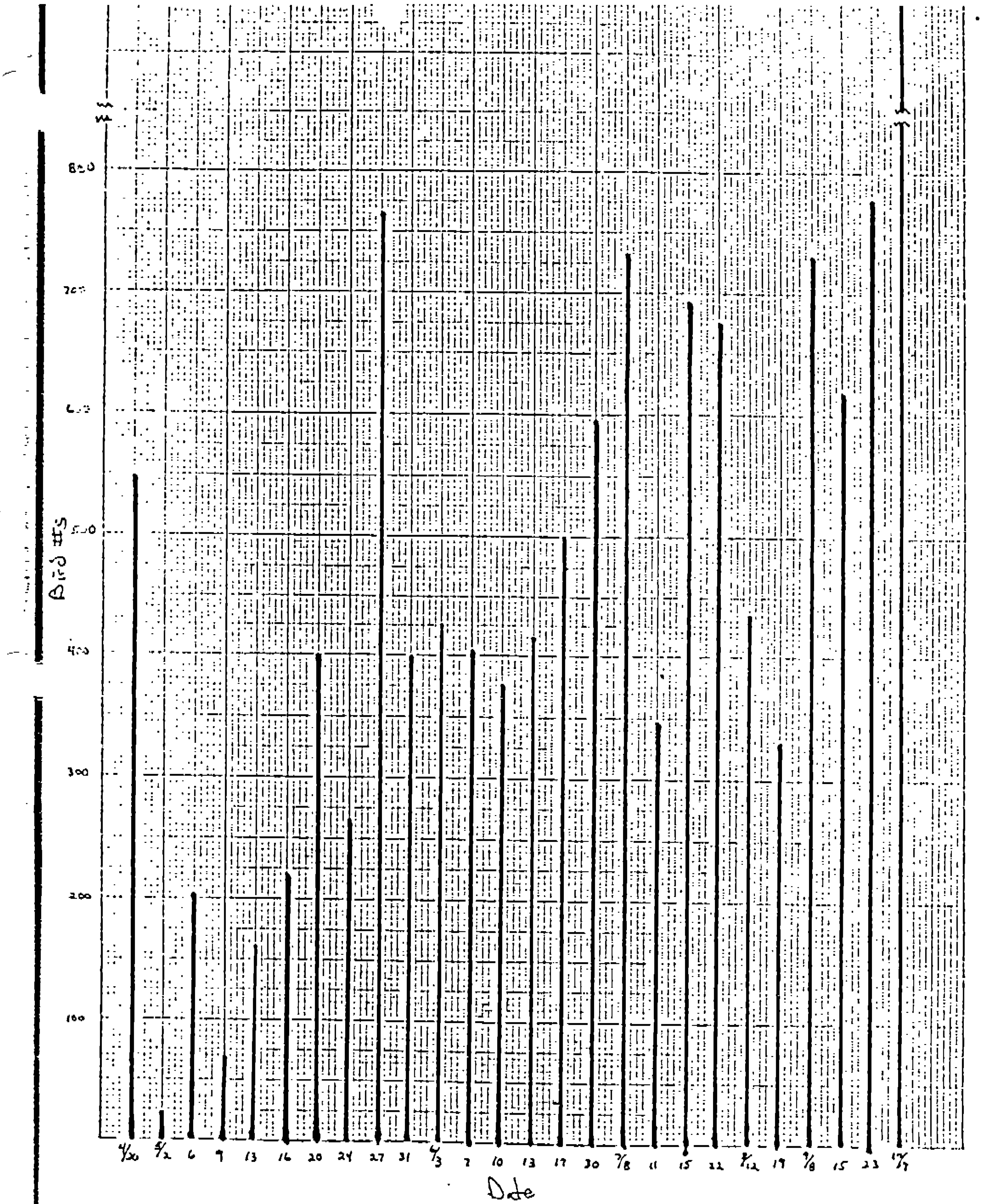
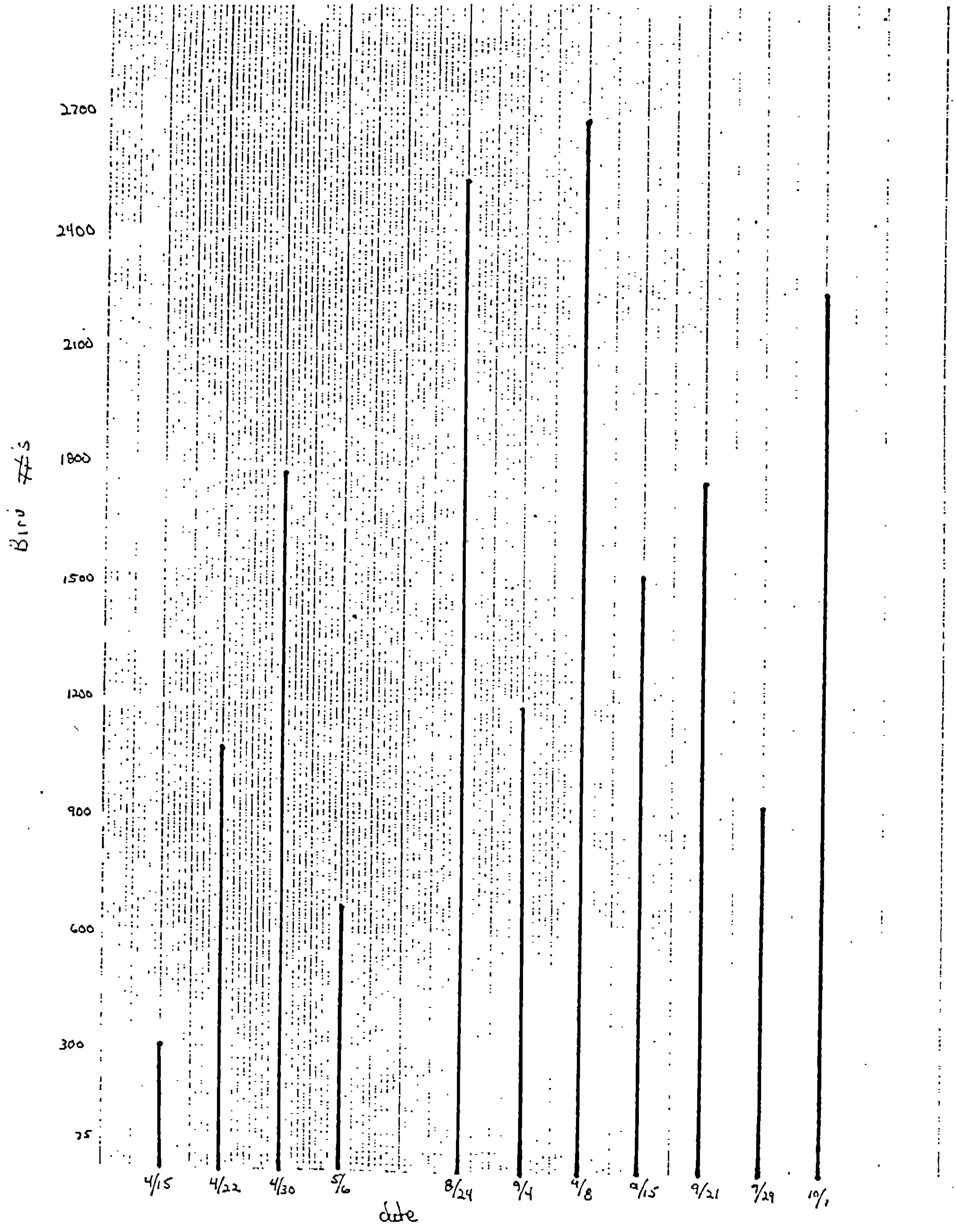


Figure 14. Bird use summary for 1988 Eagle River Flats ground observations (Areas C and D).



Bird #'s
2700
2400
2100
1800
1500
1200
900
600
300
75
4/15
4/22
4/30
5/6
8/24
9/4
9/8
9/15
9/21
9/29
10/1
date

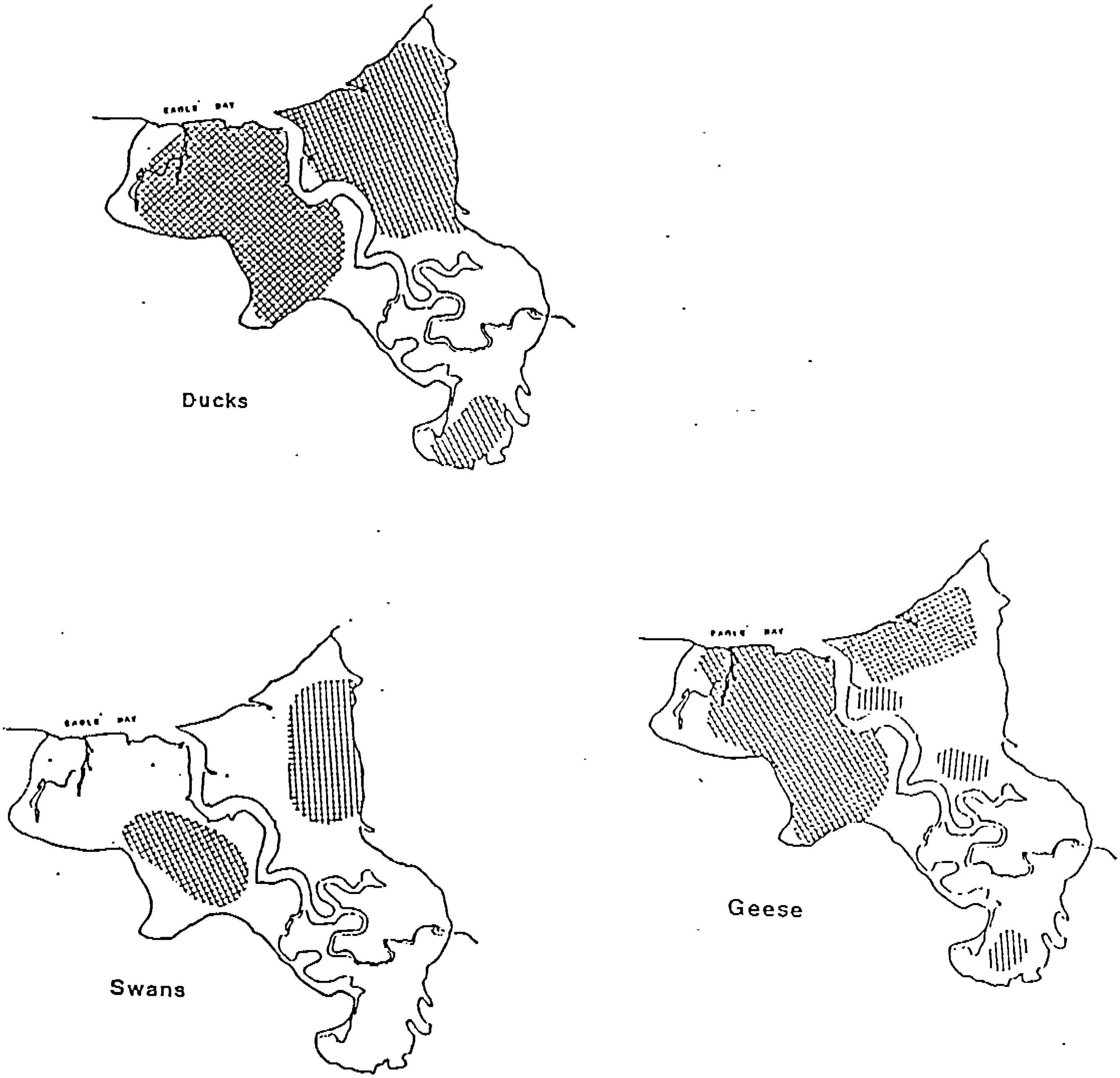


Figure 16. Distributions of ducks, swans, and geese as observed during aerial surveys of Eagle River Flats (combined spring and fall).

Table 9. 1988 aerial surveys of birds On Eagle River Flats, Fort Richardson, Alaska.

	Number of Birds Observed										
Species (Bird Group)	4/15	4/22	4/30	5/6	8/24	9/4	9/8	9/15	9/21	9/29	10/7
Geese	82	756	98		1095	552	1497	320	358	268	1080
Ducks	208	279	1530	515	1320	590	1042	1047	1299	461	295
Gulls	10	109	50	102	40		66	20	23	47	1
Arctic Terns				25	2						
Swans		17	91	14				9	15	160	875
Cranes				1	24	44	68	22			
Shorebirds					55		9	100+	50+		1
Bald Eagle	6	13	17	15			2	3	9	1	8
Northern Harrier					1			1	1		
Raven		1	1	2	2		8	6	7	6	1
Unknown Raptor	1				1			1	1		
TOTAL:	307	1175	1787	674	2540	1186	2692	1529	1763	943	2261
*Species breakdown:											
Canada Geese	82	756	90		1020	552	1440	320	358	268	1080
Snow Geese			8								
White-fronted Geese					75		57				
Mallard	54	83	216	100	115	380	270	377	549	421	220
N. Pintail	150	124	727	285	490	130	602	520	248	40	25
N. Shoveler				4	30			5			
A. Wigeon	4	5	114	39	110		55	50	300		50
Green-Winged Teal		30	330	87	55	80	25	95	202		
Canvasback			3								
Unknown Duck		37	140		520		90				
TOTAL:	300	1035	1628	515	2415	1142	2539	1367	1657	729	1375
% of Day Total	98%	88%	91%	76%	95%	96%	94%	89%	94%	77%	61%

laboratory analyses conducted at the Patuxent laboratory on specimens obtained from Eagle River Flats during the 1988 field season. In summary the cause of death could not be linked to any of the organic compounds or trace metals for which analyses were conducted.

3. Alaska Department of Environmental Conservation

Toxic compounds were not found in water or sediment samples collected from the Flats in concentrations expected to cause waterfowl deaths. Explosives were not identified in samples; particularly, cyclotrimethylenetrinitramine, trinitrophenylmethylnitramine, hydrazine, mercury, copper, and silver fulminates.

Water sample (#88091628) and sediment sample (#88091627) were chosen for gas chromatography/mass spectroscopy analysis because of unusual peaks in the gas chromatograms. Diethyl phthalate was tentatively identified in the water sample with an estimated concentration level of 26 ug/l which is well below known toxic levels for bluegill, flathead minnows, and water fleas: approximately 98,2000 ug/l (Alaska Department of Environmental Conservation Laboratory Report, Project #88SCR0032). This compound was likely a laboratory contaminant.

The sediment sample contained a multitude of organic compounds (organic acids, aliphatic hydrocarbons, 4-methyl phenol, methyl substituted benzenes, polyaromatic hydrocarbons) commonly found in sediment. Concentrations were too low to cause the death of birds.

4. U.S. Environmental Protection Agency - Corvallis, Oregon

No deaths occurred throughout the bioassay period. During Part 1 of the water ingestion test, some birds did develop diarrhea; but due to initial study design, it was impossible to differentiate the ill birds from the healthier birds.

Part 2 of the water testing experiment resulted in most birds that consumed EOD Pond water having loose stools, with one bird showing severe diarrhea. No birds died during this second test. Three of the birds from the EOD Pond group with the worst diarrhea were frozen at -75 degrees Celsius and shipped to the Service's Madison laboratory for additional testing. Results are described in Part 1 of this section.

Analysis of water was complicated due to the high salinity of the samples. Lack of funding and available time restricted the completeness of water sample analyses.

The Corvallis lab's analytical results suggest the problem cannot be identified with an organochlorine or organophosphate insecticide.

VI. DISCUSSION

The discovery of 573 featherpiles and 358 dead birds during the 1988 field season confirms that bird mortality continues to occur on Eagle River Flats.

Ducks appear affected by the mortality agent more than other species, and within this category, males more so than females. However, several factors could bias the mortality data.

Males in breeding plumage are more noticeable during searches than the cryptic females, especially when hidden in pond vegetation. Additionally, females with eggs would be tending nests, and later broods, in thick vegetation during a majority of the field season.

The 184-acre area was not tranversed equitably during each search. The beaver pond was the focal point for ground searches after several bald eagles were observed perched and/or feeding around the pond perimeter. The majority of the duck carcasses were subsequently found in the vicinity of this water body. Less concentrated search efforts on other ponds and sections of the survey area, plus the difficulty of finding small shorebirds and sandpipers in the tall vegetation, may account for the high proportion of ducks discovered. However, as duck use of the beaver pond decreased, mud flats and shallow ponds heavily used by shorebirds and sandpipers were more thoroughly searched. Few carcasses were found. Possibly because predators are able to consume an entire small bird, leaving minimal evidence. Increasing height and density of vegetation within the study area as the field season progressed may also explain why so few shorebird carcasses were found.

Estimation of total bird deaths within the study area and extrapolation to the entire Flats (based on featherpile and carcass remains) must be made with caution. Futhermore, the locations of featherpiles may not be representative of the place the bird died, but rather a preferred eating place of the predator.

In summary, limited numbers of investigators per search, predators carrying carcasses to/from search area; birds dying after leaving the search area, dense, high vegetation; and inaccessability of certain parts of the search area (due to high water) would all contribute to underestimation of mortality.

The level of expertise in bird identification varied with each of the 34 observers. Consequently, bird spcies were pooled into categories when summarizing field data. Due to this variability between observers, interpretations and conclusions of count data are tentative.

VII. CONCLUSIONS AND RECOMMENDATIONS

Field investigations conducted on the Flats during 1988 documented a large number of dead birds occurring on a small portion of the potential impact area. Birds were observed in various states of sickness and death; from flightless, convulsive, to the various positions of death. Given the short time period (about 1 week) that a large number of swans (approximately 1,500) were present in the fall, and the number of deaths (9) resulting, the cause of death to waterfowl is apparently acute. Since deaths of individuals from several species were documented, the causative factor is also indiscriminant.

It is important to note that predatory species such as bald eagles do not appear to be severely affected. Although one bald eagle was found during the extensive ground searches, 16 eagles were noted feeding in the area on dead or dying waterfowl. In addition to this apparent differential effect on species, the toxicant seems to be geographically and/or temporally localized. Were this not true, more of the birds using the flats would be affected; the result would be far more deaths than have been noted.

The Environmental Protection Agency laboratory recommends that sediments, vegetation, water from the Flats should be tested for toxicants such as phosphate compounds and trace metals (preferably using gas chromatography/mass spectrometry). In addition, sampling of invertebrates and fish species found in the area may also provide information on method of contaminant uptake or extent.

The inaccessibility of a major portion of the Flats to ground searches and sample collection greatly restricted the scope of this study. A method of obtaining required sample data (carcasses, soil, water, and vegetation) must be developed to improve the integrity of future investigative efforts. One technique, suggested by the Service's Wildlife Research Center in Alaska, is to use sentinal birds to determine method of contaminant uptake by birds. Control of food and water intake by caged birds (placed in strategic locations on and around the Flats) would be part of the study design. Health of each bird may provide data on the contaminants in the environment. Birds could also be placed during firing exercises to determine effect(s) of different munitions on birds.

Information must be generated that will assist laboratories in isolating chemical compounds found in military ordnances. Documentation of chemical changes that occur in these compounds over time (and in different environments), and their associated reactions with other military ordnance compounds, are integral parts of solving this die-off puzzle.

Documentation of seasonal bird use of the Flats should continue throughout the investigation. Aerial surveys should be scheduled for once every three days to identify high and low use periods in spring, summer, and fall. Surveys should continue from spring thaw until all water bodies of the Flats are frozen over in late fall. The continued use of fixed-wing aircraft using standardized Service techniques will allow comparison of yearly data sets.

Progress reports (reviewed by the Task Force) should be issued after each year of investigation and should address current findings and additional needs of the study. Communication between the investigative team and the Task Force must be maintained throughout the life of the project to ensure that objectives of the study are met. Field investigation and laboratory analytical methodologies will require continuous evaluation and adjustment to meet the changing investigative needs as additional project information is obtained. The flow chart developed by the Task Force (Figure 18) depicts this strategy, which was followed throughout the 1988 field season.

Once the cause of avian die-off is determined, efforts must be made to minimize the annual number of deaths that occur on the Flats. The implementation of a proposed solution should be thoroughly monitored, reviewed, and adjusted. If the contaminant can not be identified, a form of mitigation should be developed that prevents birds from using the Flats, but in turn creates an equal amount of similar habitat.

III. LITERATURE CITED

1. Davis, R. A., and A. N. Wisely. 1974. Normal behavior of snow geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behavior, September, 1973. Pages 1-85 in W. W. H. Gunn, W. J. Richardson, R. E. Schweinsburg, and T. D. Wright, eds. Studies of snow geese and waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1973. Arctic Gas Biol. Rep. Ser. 27. 85pp.

2. U.S. Army, Memorandum For Record, AFZT-EH-PSN, Fort Richardson, Alaska: Waterfowl Mortality, Eagle River Flats. August 16, 1984.

3. U.S. Army, Memorandum For Record, AFZT-EH-PSN, Fort Richardson, Alaska: Waterfowl Mortality - Eagle River Flats. August 23, 1984.

4. U.S. Army, Corps of Engineers, Alaska District. 1978. Working Draft Environmental Impact Statement for Installation Utilization at Fort Richardson, Alaska. Anchorage, Alaska.

5. U.S. Army, Corps of Engineers, Alaska District. 1979. Metropolitan Anchorage Urban Study Final Report, Volume 2; Water Supply Summary. Anchorage, Alaska.

6. U.S. Army Corps of Engineers, Alaska District. 1979. Metropolitan Anchorage Urban Study Final Report, Volume 7; Soils of the Anchorage area, Alaska. Anchorage, Alaska. 126pp. plus maps.

7. U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground. 1983. Installation Assessment of Headquarters 172d Infantry Brigade (Alaska), Fort Richardson, Alaska.

8. U.S. Department of Commerce. 1987. Tide tables 1988, high and low water predictions; west coast of North and South America. National Oceanic and Atmospheric Administration, National Ocean Service. 234pp.

9. U.S. Fish and Wildlife Service. 1987. Spring 1986 aerial surveys of geese and swans staging in the Upper Cook Inlet. Progress Report 20p.

10. Ward, D. H., R. A. Stehn, D. V. Derksen, C. J. Lensink, and A. J. Loranger. 1986. Behavior of Pacific black brant and other geese in response to aircraft overflights and other disturbances at Izembek Lagoon, Alaska. Unpubl. Rep., U.S. Fish and Wildlife Service, Anchorage, Alaska. 33pp.

APPENDIX A

MEMORANDUM OF UNDERSTANDING

AMONG

DEPARTMENT OF THE ARMY

6TH INFANTRY DIVISION (LIGHT) AND U.S. ARMY GARRISON ALASKA

FORT RICHARDSON, ALASKA

AND

DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

ANCHORAGE, ALASKA

AND

ENVIRONMENTAL PROTECTION AGENCY

REGION 10

ANCHORAGE, ALASKA

AND

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

JUNEAU, ALASKA

AND

STATE OF ALASKA

DEARTMENT OF ENVIRONMENTAL CONSERVATION

JUNEAU, ALASKA

FEBRUARY 1988

SUBJECT: Eagle River Flats Migratory Bird Die-Off

I. PURPOSE. The purpose of this Memorandum of Understanding is to promote interagency and intergovernmental coordination in assessing the extent and causes of the migratory bird die-off on the Eagle River Flats, Fort Richardson, Alaska, and to identify and recommend corrective actions to mitigate the losses while accommodating the military mission. This Memorandum of Understanding is intended to promote effective use of each agency's resources in fulfilling its responsibilities under the Migratory Bird Treaty Act, Bald Eagle Protection Act, Clean Water Act, and other applicable legislation, and the Cooperative Agreement for Management of Fish and Wildlife Resources on Army lands in Alaska.

II. Scope.

a. Whereas all agencies share in the responsibility of upholding the laws and regulations of the United States and the state of Alaska affecting migratory birds, the agencies involved and their respective mission in the investigation of the Eagle River Flats migratory bird die-off are:

1. The Department of the Army, 6th infantry Division (Light) is to be prepared to deploy rapidly worldwide in support of United States interests and objectives. Additionally, defend Alaska, including the initial defense of the Aleutian Islands. The U.S. Army Garrison, Alaska, in addition to supporting the Division's mission, has a responsibility for maintaining, protecting and improving the environmental quality on Army lands in Alaska.

2. The Department of the Interior, U.S. Fish and Wildlife Service, has the technical expertise and the responsibility for the management and protection of migratory birds.

3. The Environmental Protection Agency, Region 10, has a shared responsibility to protect and restore the quality of air, land and water resources.

4. The State of Alaska, Department of Fish and Game, assists with the management of fish and wildlife populations and their habitat on military lands in Alaska.

5. The State of Alaska, Department of Environmental Conservation, has a responsibility to conserve, improve and protect the state's natural resources and environment and to control water, land and air pollution.

b. The above listed agencies agree to designate a representative(s) to serve as a member(s) of the Eagle River Flats Migratory Bird Die-Off Task Force, referred throughout this Memorandum of Understanding as Task Force, whose purpose will be to expeditiously accomplish the objectives of this Memorandum of Understanding.

III. RESPONSIBILITIES.

a. Each Task Force member/agency will:

1. Participate in the development and completion of the General Study Plan and its Detailed Work Plan components by February 1, 1988.

2. Commit resources, as appropriate and available to fulfill each participating agency's responsibilities for implementing the General Study Plan.

3. Coordinate activities, share information with Task Force member(s)/agencies and support appropriate information releases to the public as jointly developed and approved by the Task Force.

4. Sign a Hold Harmless Agreement (Attachments I-IV). All parties recognize the inherent danger of conducting a field study in the Eagle River flats because it is an impact area for Army ordnance. The flats contain many unexploded (dud) rounds that are capable of exploding at any time, or upon the slighest impact. As a result, only the portion of the flats designated for entry as shown on the map attached to this agreement may be entered by the employees of any agency participating in this study. Individuals who proceed outside the designated safety area, do so in violation of this agreement and proceed at their own risk.

5. Coordinate requests for access to the Eagle River Flats Training Area in advance with the Fort Richardson Range Control.

b. U.S. Fish and Wildlife Service will act as the lead agency for all Task Force public news releases and queries, ensuring each of the agencies concerned are in agreement with the proposed release.

c. 6th Infantry Division (Light) and U.S. Army Garrison Alaska will:

1. Support the requirements of this Memorandum of Agreement and those deemed necessary by the Task Force subject to availability of resources and approval of the installation commander.

2. Provide access to the Eagle River Flats Training Area to the Task Force in the execution of this agreement. Access will be granted to the greatest extent possible, unless security and/or military training considerations or military emergencies prevent the granting of such access.

IV. GENERAL PROVISIONS. This agreement does not diminish the independent authority or coordination responsibilities of the agencies concerned.

V. REVISIONS. This agreement will be reviewed by all parties concerned not less than triennially at least 120 days prior to the anniversary date. It may be revised at any time upon the mutual consent in writing of all parties concerned.

VI. EFFECTIVE DATE AND TERMINATION. This agreement becomes effective upon consummation of signatures. This agreement may be cancelled at any time by mutual consent of the parties concerned. This agreement may also be cancelled by any of the parties giving at least 60 days written notice to all the parties concerned.

ATTACHMENTS:

I - Hold Harmless Agreement
U.S. Fish and Wildlife

II - Hold Harmless Agreement
Environmental Protection Agency

III - Hold Harmless Agreement
State of Alaska
Department of Fish and Game

IV - Hold Harmless Agreement
State of Alaska
Department of Environmental Conservation

V - Map
Eagle River Flats Training Area

SUBJECT: Eagle River Flats Migratory Bird Die-Off

APPROVING OFFICIALS:

Ted Medley
Colonel, Field Artillery
U.S. Army Garrison Alaska
Fort Richardson, Alaska

9 February 1988
DATE

Walter O. Stieglitz
Regional Director
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska

2/8/88
DATE

Alvin L. Ewing
Asst. Regional Administrator
Envirnmental Protection Agency
Region 10
Anchorage, Alaska

2/11/88
DATE

W. Lewis Pamplin, Jr.
Director, Game Division
State of Alaska
Department of Fish and Game
Anchorage, Alaska

2/9/88
DATE

Bill Lamoreaux
South Central Regional Supervisor
Alaska Department of Environmrntal
Conservation
Anchorage, Alaska

DATE

ATTACHMENT I

HOLD HARMLESS AGREEMENT

for
Memorandum of Understanding
January 1988

SUBJECT: Eagle River Flats Migratory Bird Die-Off

In consideration of permission granted by the United States Army to use Army facilities, ranges, equipment, and personnel, the user named below hereby agrees:

To release the United States Army, its agencies, and personnel from all liability arising out of the use of Army facilities, ranges, supplies, or services while located on, or in direct vicinity of, Eagle River flats and engaging in an activity directly related to this field study. This includes, but is not limited to, all activities conducted on Fort Richardson associated with investigating the Eagle River flats migratory bird die-off, whether individual or group in nature. The user will defend, pay or settle all claims or suits against the United States Army, its agencies, or personnel by agents or employees of the user or persons claiming through them, or by third parties, and will hold the United States Army, its agencies, and personnel, harmless against every such claim or suit, including attorney fees, costs, and expenses, arising out of the use of any Army facilities, ranges, supplies, or services, by the user. EXCEPT THAT, this agreement is not operative where death, injury, loss or damage to persons or property results solely from the willful misconduct or gross negligence of United States Army personnel.

For the Supplying Agency:

BY [signature]

Ted Medley
Colonel, Field Artillery
Garrison Commander
U.S. Army Garrison Alaska
Fort Richardson, Alaska

9 February 1988
DATE

For the Using Agency:

BY [signature] for

Walter O. Stieglitz
Regional Director
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska

2/8/88
DATE

ATTACHMENT II

HOLD HARMLESS AGREEMENT

for
Memorandum of Understanding
January 1988

SUBJECT: Eagle River Flats Migratory Bird Die-Off

In consideration of permission granted by the United States Army to use Army facilities, ranges, equipment, and personnel, the user named below hereby agrees:

To release the United States Army, its agencies, and personnel from all liability arising out of the use of Army facilities, ranges, supplies, or services while located on, or in direct vicinity of, Eagle River flats and engaging in an activity directly related to this field study. This includes, but is not limited to, all activities conducted on Fort Richardson associated with investigating the Eagle River flats migratory bird die-off, whether individual or group in nature. The user will defend, pay or settle all claims or suits against the United States Army, its agencies, or personnel by agents or employees of the user or persons claiming through them, or by third parties, and will hold the United States Army, its agencies, and personnel, harmless against every such claim or suit, including attorney fees, costs, and expenses, arising out of the use of any Army facilities, ranges, supplies, or services, by the user. EXCEPT THAT, this agreement is not operative where death, injury, loss or damage to persons or property results solely from the willful misconduct or gross negligence of United States Army personnel.

For the Supplying Agency:

BY [signature]

Ted Medley
Colonel, Field Artillery
Garrison Commander
U.S. Army Garrison Alaska
Fort Richardson, Alaska

9 February 1988
DATE

For the Using Agency:

BY [signature]

Alvin L. Ewing
Asst. Regional Administrator
Environmental Protection Agency, Region 10
Anchorage, Alaska

2/11/88
DATE

ATTACHMENT III

HOLD HARMLESS AGREEMENT

for
Memorandum of Understanding
January 1988

SUBJECT: Eagle River Flats Migratory Bird Die-Off

In consideration of permission granted by the United States Army to use Army facilities, ranges, equipment, and personnel, the user named below hereby agrees:

To release the United States Army, its agencies, and personnel from all liability arising out of the use of Army facilities, ranges, supplies, or services while located on, or in direct vicinity of, Eagle River flats and engaging in an activity directly related to this field study. This includes, but is not limited to, all activities conducted on Fort Richardson associated with investigating the Eagle River flats migratory bird die-off, whether individual or group in nature. The user will defend, pay or settle all claims or suits against the United States Army, its agencies, or personnel by agents or employees of the user or persons claiming through them, or by third parties, and will hold the United States Army, its agencies, and personnel, harmless against every such claim or suit, including attorney fees, costs, and expenses, arising out of the use of any Army facilities, ranges, supplies, or services, by the user. EXCEPT THAT, this agreement is not operative where death, injury, loss or damage to persons or property results solely from the willful misconduct or gross negligence of United States Army personnel.

For the Supplying Agency:

BY Ted Medley

Ted Medley
Colonel, Field Artillery
Garrison Commander
U.S. Army Garrison Alaska
Fort Richardson, Alaska

9 February 1988
DATE

For the Using Agency:

BY W. Lewis Pamplin Jr.

W. Lewis Pamplin, Jr.
Director, Game Division
State of Alaska
Department of Fish and Game
Anchorage, Alaska

2/9/88
DATE

ATTACHMENT IV

HOLD HARMLESS AGREEMENT

for
Memorandum of Understanding
January 1988

SUBJECT: Eagle River Flats Migratory Bird Die-Off

In consideration of permission granted by the United States Army to use Army facilities, ranges, equipment, and personnel, the user named below hereby agrees:

To release the United States Army, its agencies, and personnel from all liability arising out of the use of Army facilities, ranges, supplies, or services while located on, or in direct vicinity of, Eagle River flats and engaging in an activity directly related to this field study. This includes, but is not limited to, all activities conducted on Fort Richardson associated with investigating the Eagle River flats migratory bird die-off, whether individual or group in nature. The user will defend, pay or settle all claims or suits against the United States Army, its agencies, or personnel by agents or employees of the user or persons claiming through them, or by third parties, and will hold the United States Army, its agencies, and personnel, harmless against every such claim or suit, including attorney fees, costs, and expenses, arising out of the use of any Army facilities, ranges, supplies, or services, by the user. EXCEPT THAT, this agreement is not operative where death, injury, loss or damage to persons or property results solely from the willful misconduct or gross negligence of United States Army personnel.

For the Supplying Agency:

BY [signature]

Ted Medley
Colonel, Field Artillery
Garrison Commander
U.S. Army Garrison Alaska
Fort Richardson, Alaska

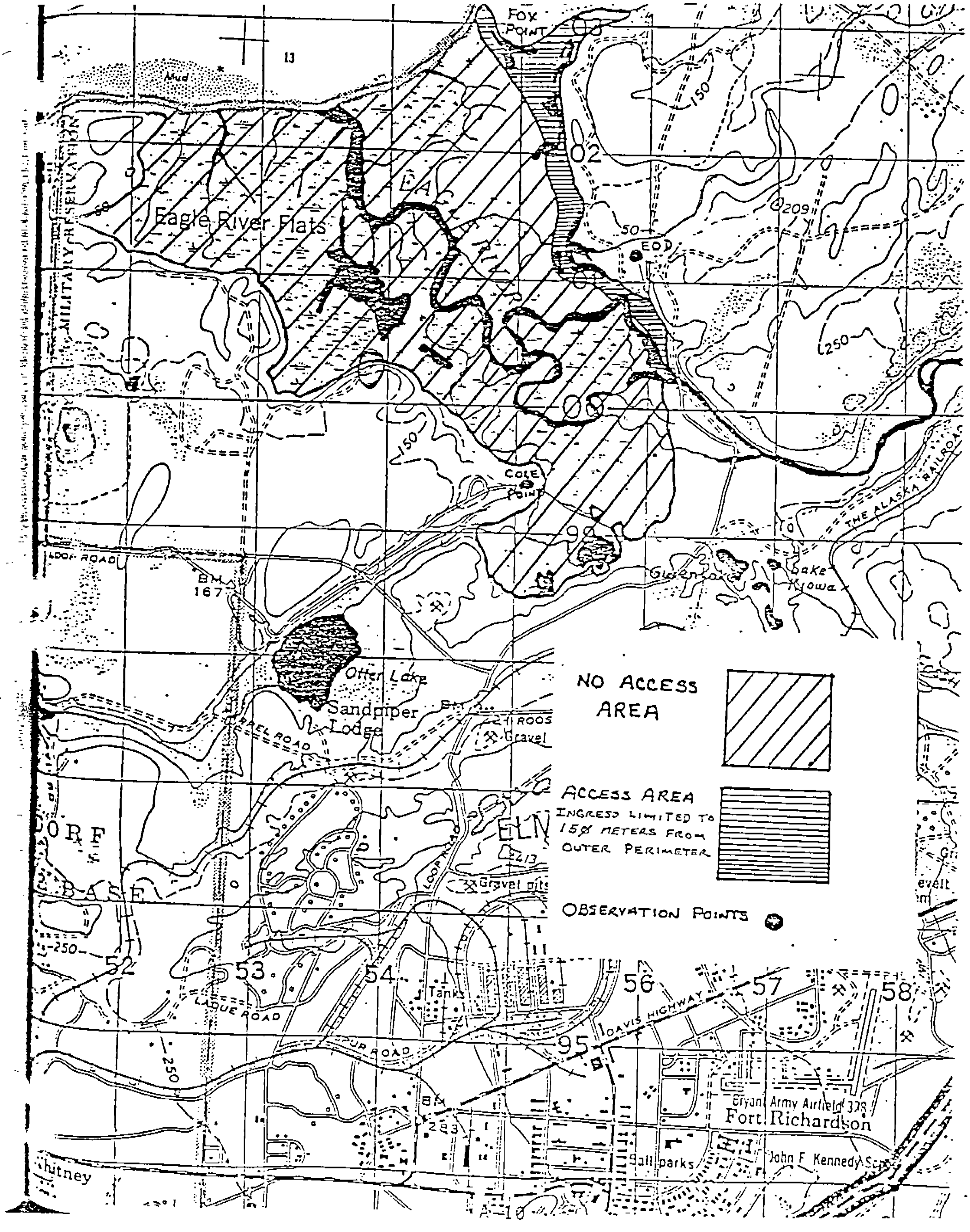
9 February 1988
DATE

For the Using Agency:

BY [signature]

Bill Lamoreaux
Southcentral Regional Supervisor
Department of Environmental
Conservation
Anchorage, Alaska

Feb. 9, 1988
DATE


FOX POINT
13
Mud
MILITARY RESERVATION
Eagle River Flats
82
EOD
50
150
209
250
COLE POINT
THE ALASKA RAILROAD
LOOP ROAD
BM 167
Green Lake
Lake Kiowa
Otter Lake
Sandpiper Lodge
Gravel
DORF
BASE
Gravel pits
52
53
54
56
57
58
LADUE ROAD
Tanks
DAVIS HIGHWAY
95
Bryant Army Airfield
Fort Richardson
Ball parks
John F. Kennedy Sch
hitney
NO ACCESS AREA
ACCESS AREA
INGRESS LIMITED TO 150 METERS FROM OUTER PERIMETER
OBSERVATION POINTS

APPENDIX B

MAR 21 1989

SUMMARY OF FINDINGS
CONTAMINANT RESIDUES-EAGLE RIVER FLATS

TRACE ELEMENTS

Introduction

Waterbird specimens were collected from Eagle River Flats (ERF) to determine if lethal trace element, heavy metal, organochlorine, and aromatic hydrocarbon concentrations were present in select tissue matrices. Fifteen specimens, representing six species, northern shoveler (*Anas clypeata*), mallard (*A. platyrhynchos*), northern pintail (*A. acuta*), green-winged teal (*A. crecca*), trumpeter swan (*Cygnus buccinator*), and bald eagle (*Haliaeetus leucocephalus*), were collected. Upon discovery, dead birds were collected and placed in plastic zip-lock bags, then double-bagged prior to shipment or storage. The majority of the specimens were sent unfrozen to the U.S. Fish and Wildlife Service's Madison National Wildlife Health Research Center for necropsy. After select specimens were examined, specific tissues were dissected and stored frozen in plastic zip-locked bags for trace element analysis or wrapped in aluminum foil prior to being placed in plastic zip-lock bags for organic analysis. Specimens not necropsied were sent to the analytical laboratory where they were then dissected for select tissues.

Trace element analysis was conducted at the University of Missouri, Environmental Trace Substances Research Center. Kidney and liver tissue were analyzed for eleven trace elements (lead, cadmium, copper, chromium, nickel, manganese, aluminum, iron, beryllium, thallium, zinc) using inductively coupled argon plasm (ICP) spectroscopy with preconcentration. Lung tissue was only analyzed for zinc using atomic absorption spectroscopy. Arsenic and selenium were determined in kidney and liver tissue using atomic absorption hydride methodologies and mercury was determined using cold vapor techniques. Refer to Appendix A for a detailed description of analytical methods.

Results

The results of the tissue analysis for trace elements are summarized in Tables 1, 2 and 3. Concentrations were determined and are expressed on a dry weight basis unless otherwise noted. No detectable levels of lead, beryllium, or thallium were reported in northern shoveler kidney and liver tissue, and mallard, northern pintail, bald eagle, and green-winged teal kidney tissue. Levels of the aforementioned elements were detected in swan kidney tissue at levels slightly above their detection limits.

Concentrations of nickel and chromium clustered slightly above their respective detection limits when detected in specimens. Arsenic levels in mallard kidney tissue ranged between the detection limit of 0.1 micrograms/gram (mcg/g) and 0.3 mcg/g, a range considered to be very low. Low levels of arsenic also occurred in bald eagle, swan, and green-winged teal

Table 1. Trace element analyses of select mallard tissue, Eagle River Flats, Alaska, 1988.

SPECIMEN	TISSUE	ELEMENT CONCENTRATION (micrograms per gram dry weight)													
		Hg	As	Se	Zn	Pb	Cu	Cr	Cd	Ni	Mn	Al	Be	Fe	Tl
1	KD	0.864	0.3	6.1	66.7	*	13.2	*	0.80	*	10.7	7.9	*	944	*
	LG				34										
2	KD	0.31	0.2	5.9	76.3	*	24.7	0.2	7.74	0.1	10.4	0.9	*	953	*
	LG				41										
3	KD	0.735	0.1	6.3	111	*	20.7	0.1	5.20	0.2	12.6	3.6	*	1070	*
	LG				43										
4	KD	0.825	0.3	4.9	88.1	*	28.0	0.3	3.53	0.3	13.1	1.7	*	591	*
	LG				38										
5	KD	0.40	0.3	4.0	90.0	*	13.2	0.2	1.6	*	10.6	0.8	*	905	*
	LG				52										
Detection Limit		.007	0.1	0.05	0.5	0.4	0.02	0.1	0.03	0.1	0.03	0.3	0.01	0.1	0.5

KD - Kidney
LG - Lung
* - less than detection limit

Table 2. Trace element analyses of select northern shoveler tissue, Eagle River Flats, Alaska, 1988.

SPECIMEN	TISSUE	Hg	As	Se	Zn	Pb	Cu	Cr	Cd	Ni	Mn	Al	Be	Fe	Tl
		ELEMENT CONCENTRATION (micrograms per gram dry weight)													
1	KD	2.2	1.2	7.9	83.8	*	21.5	0.2	13.3	*	12.1	2.6	*	804	*
	LG				36										
2	KD	4.6	0.71	5.9	59.7	*	11.2	*	2.4	*	8.54	1.2	*	1090	*
	LG				37										
3	KD	1.15	*	6.8	71.9	*	17.9	0.2	16.5	*	8.85	54.2	*	486	*
4	KD	7.81	0.1	11.9	67.4	*	14.9	*	5.2	*	11.9	4.5	*	721	*
	LV	14.6	0.2	11.0	85.3	*	50.9	0.3	1.7	*	16.1	6.2	*	5010	*
5	KD	3.2	0.29	6.8	61.4	*	14.9	*	2.1	*	11.4	12.0	*	363	*
	LV	4.7	*	5.0	75.7	*	46.5	0.2	0.66	*	13.4	7.4	*	1200	*
Detection Limit		.007	0.1	0.05	0.5	0.4	0.02	0.1	0.03	0.1	0.03	0.3	0.01	0.1	0.5

KD - Kidney
LG - Lung
LV - Liver
* - less than detection limit

Table 3. Trace element analyses of select pintail, bald eagle, swan and green-wing teal tissue, Eagle River Flats, Alaska, 1988.

ELEMENT CONCENTRATION (micrograms per gram dry weight)

SPECIMEN	TISSUE	Hg	As	Se	Zn	Pb	Cu	Cr	Cd	Ni	Mn	Al	Be	Fe	Tl
Pintail	KD	.517	*	7.8	95.8	*	15.1	0.2	1.7	*	12.9	0.6	*	848	*
	LG				41										
Bald Eagle	KD	7.4	0.3	6.9	62.5	*	7.38	0.2	2.3	*	4.73	50.7	*	1330	*
Swan	KD	0.064	*	3.6	67.4	0.5	13.2	0.5	1.7	0.3	12.7	49.5	0.01	1530	0.6
	LG				43										
	LV	0.093	*	3.0	75.6	*	78.9	0.2	0.54	0.2	11.1	4.0	*	1750	*
Green-wing teal #1	KD	0.68	0.2	7.8	62.3	*	16.9	0.7	2.4	0.5	14.1	24.0	*	750	*
Green-wing teal #2	KD	0.799	*	5.5	80.6	*	16.1	*	3.6	0.4	12.8	13.0	*	361	*
Estimated Detection Limit		.007	0.1	0.05	0.5	0.4	0.02	0.1	0.03	0.1	0.03	0.3	0.01	0.1	0.5

KD - Kidney
LG - Lung
LV - Liver
* - less than detection limit

kidney tissue and swan liver tissue. The widest range of arsenic residues occurred in northern shoveler kidney tissue (0.1 to 1.2 mcg/g); however, liver tissue concentrations narrowly ranged from nondetectable to 0.2 mcg/g.

Iron concentrations in mallard kidneys ranged between 591 and 1070 mcg/g, with a mean of 892.6 mcg/g. Northern shoveler kidney tissue had a lower mean value of 692.8 mcg Fe/g with a wider range of 363 to 1090 mcg Fe/g. Two northern shoveler liver tissues however, had a much higher iron mean value of 3105 mcg/g and a range of 1200 to 5010 mcg/g. Iron concentrations in pintail, bald eagle, green-winged teal, and swan kidney tissue ranged from 361 to 1330 mcg/g. The single swan liver tissue had an iron concentration of 1750 mcg/g.

Manganese concentrations in northern shoveler and mallard kidneys ranged narrowly between 8.54 to 12.1 mcg/g, and 10.4 to 13.1 mcg/g, respectively; less than 1 mcg/g separated their mean values of 10.56 mcg/g and 11.48 mcg/g. With the exception of bald eagle kidney tissue (4.73 mcg/g), manganese concentrations ranged between 12.7 and 14.1 mcg/g in pintail and green-winged teal kidney tissue, and swan kidney and liver tissue.

Aluminum concentrations in northern shoveler kidneys ranged widely from 1.2 to 54.2 mcg/g, with a mean concentration of 14.9 mcg/g; however, two liver samples contained only 6.2 and 7.4 mcg/g aluminum. Mallard kidney tissue had a much narrower and lower range of aluminum concentrations (0.8-7.9 mcg/g) than northern shoveler kidney tissue. The lowest determined aluminum concentration (0.6 mcg/g) occurred in a pintail kidney and was only slightly above the detection limit (0.3 mcg/g). The mean aluminum concentration in green-winged teal kidney was 18.5 mcg/g. Aluminum was twelve times greater in swan kidney tissue (49.5 mcg/g) than in swan liver tissue (4.0 mcg/g) collected from the same specimen. Aluminum concentrations in bald eagle kidney tissue (50.7 mcg/g) was similar to that found in swan kidney tissue.

The lowest concentrations of cadmium were determined in swan liver tissue (0.54 mcg/g) and an individual northern shoveler liver sample (0.66 mcg/g). The highest cadmium levels occurred in kidney tissue from two northern shovelers (16.5 and 13.3 mcg/g). The overall mean value for cadmium in green-winged teal, northern shoveler, and mallard kidney tissue was 3.0 mcg/g, 7.9 mcg/g, and 3.7 mcg/g, respectively. Cadmium concentrations in pintail, bald eagle, and swan kidney ranged narrowly between 1.7 and 2.3 mcg/g.

Copper concentrations in mallard tissue occurred in a narrow range of 13.2 to 28.0 mcg/g; the mean concentration was 19.9 mcg/g. Similarly, northern shoveler kidney tissue contained copper concentrations ranging between 11.2 to 21.5 mcg/g; however, concentrations in liver tissue ranged higher (46.5 to 50.9 mcg/g). The mean copper concentration in northern shoveler kidney tissue was 16.08 mcg/g. Pintail and green-winged teal kidney tissue had copper concentrations ranging between 15.1 and 16.9 mcg/g. The highest concentration of copper occurred in the single swan liver (78.9 mcg/g). The lowest concentration of copper occurred in bald eagle kidney tissue (7.38 mcg/g).

Zinc concentrations in mallard kidney tissue ranged from 66.7 to 111 mcg/g, with a mean concentration of 86.4 mcg/g. A narrower and lower range existed in mallard lung tissue (34 to 52 mcg Zn/g). Northern shoveler kidney zinc levels ranged between 59.7 and 83.8 mcg/g. Levels of zinc in northern shoveler lung tissue clustered around a mean concentration of 36.5 mcg/g, whereas liver tissue had a higher mean concentration of 80.5 mcg/g. Green-winged teal kidney tissue had a mean value of 71.4 mcg Zn/g. Pintail, bald eagle, and swan kidney tissue, and swan liver tissue contained zinc concentrations between 62.5 mcg/g and 95.8 mcg/g. Pintail and swan lung tissue had similar zinc levels of 41 and 43 mcg/g, respectively.

Selenium concentrations were detected in all tissue samples. Selenium levels in northern shoveler kidney tissue ranged and had a mean slightly higher (7.86 mcg/g; 6.8-11.9 mcg/g) than those determined in mallard kidney tissue (5.4 mcg/g; 4.0-6.3 mcg/g). Liver tissue from northern shovelers had a mean selenium concentration of 8.0 mcg/g. The lowest selenium concentrations occurred in swan kidney (3.6 mcg/g) and liver (3.0 mcg/g) tissue. Green-winged teal, bald eagle, and pintail kidney tissue contained selenium levels ranging between 5.5 and 7.8 mcg/g.

With the exception of northern shoveler and bald eagle kidney tissue, all mercury concentrations in mallard, pintail, swan, and green-winged teal tissues were below 1 mcg/g. Northern shoveler kidney tissue contained mercury concentrations ranging between 1.15 and 7.81 mcg/g. The highest concentration of mercury occurred in a northern shoveler liver (14.6 mcg/g); however, a second northern shoveler liver analyzed for mercury contained only 4.7 mcg/g. Bald eagle kidney tissue contained a mercury concentration (7.4 mcg/g) slightly lower than the highest mercury concentration determined in northern shoveler kidney tissue (7.81 mcg/g).

Discussion

Arsenic, a potentially toxic element to avian species, is used in the production of herbicides, insecticides, desiccants, wood preservatives, and growth stimulants for plants and animals. Background arsenic concentrations in living organisms are usually less than 1 milligram/kilogram (mg/kg) fresh weight in terrestrial flora and fauna, birds, and freshwater biota (Eisler 1988). Arsenic residues in bird liver or kidney tissue ranging between 2 to 11 mg total As/kg fresh weight are considered elevated; residues greater than 10 mg/kg are indicative of arsenic poisoning (Goede 1985). Signs of inorganic trivalent arsenite poisoning in birds (muscular incoordination, debility, slowness, jerkiness, falling hyperactivity, fluffed feathers, drooped eyelid, huddled position, unkempt appearance, loss of righting reflex, immobility, seizures) are similar to those induced by many other toxicants (Eisler 1988). Internal examination suggests that lethal effects of acute inorganic arsenic poisoning is due to the destruction of blood vessels lining the gut, which results in decreased blood pressure and subsequent shock (Nystrom 1984). Arsenic concentrations determined in the ERF specimens do not occur at levels which can be considered toxic, as the highest determined concentration of .2916 mg/kg (fresh weight conversion) falls below Goede's arsenic poisoning criteria of 10 mg/kg.

Since the selenium contamination issue surfaced in 1983 at the U.S. Fish and Wildlife Service's Kesterson National Wildlife Refuge in California, research in selenium toxicity of birds has increased. Selenium, although an essential nutrient for some plants and animals, can decrease hatching success of fertile eggs and increase embryo abnormality at elevated levels (Eisler 1985a). Definitive criteria used to identify a selenium hazard in various avian tissues is wanting; however, numerous studies have identified concentrations of selenium (and its various forms) thought to be lethal or sublethal and acute or chronic.

Heinz and Hoffman (1987) reported that mallards fed 100 mg/kg selenium as sodium selenite died within 16 to 39 days and had liver selenium concentrations in the range of 5.6 to 8.3 mg/kg fresh weight. White and Cromartie (1985) determined selenium concentrations in aquatic bird tissues collected from the Corpus Christi, Texas area and reported a range of 0.7-1.1 mg/kg fresh weight in green-winged teal kidney (control site) and a range of 1.0-1.5 mg/kg fresh weight in kidney tissue from green-winged teal inhabiting dredge material pits (contaminated site). Ohlendorf et. al. (1986) reported that selenium levels in scoters (34.4 mg/kg, dry weight) were similar to those in livers of dabbling ducks (Anas spp.) in nearby San Joaquin Valley where reproduction was severly impaired.

Selenium levels were comparatively greater in ERF green-winged teal kidney (1.4-2.3 mg/kg fresh weight conversion) than those determined by White and Cromartie (1985) but lower than liver levels determined by Heinz and Hoffman (1982) in selenium-killed mallards. The range of selenium levels in mallard kidney tissue from ERF (0.8-1.35 mg/kg fresh weight conversion) is similar to that identified for green-winged teal analyzed by White and Cromartie (1985) in their control (uncontaminated site). Ninety-three percent of the ERF specimens contained less than the 2.5 mg/kg fresh weight kidney selenium associated with reproductive problems in chickens given dietary supplements of selenium (Ort and Latshaw 1978). Based on the available literature, it appears that selenium levels in ERF specimens do not occur at levels documented to cause acute or chronic mortalities.

According to Eisler (1987), authorities on mercury agree: 1) that mercury and its compounds have no known biological function, and its presence in living organisms in undesirable and potentially hazardous; 2) forms of mercury with relatively low toxicity can be transformed into forms of very high toxicity (e.g., methylmercury) through biological and other processes; 3) mercury can be bioconcentrated in organisms and biomagnified through food chains; and 4) mercury is a mutagen, teratogen, and carcinogen, and causes embryoidal, cytochemical, and histopathological effects.

How a bird is affected by mercury toxicity depends upon the form of the element, its dose, the route of exposure, the species, sex, age, and physiological condition (Fimreite 1979). Birds poisoned by mercury show the following signs: muscular incoordination, falling, slowness, fluffed feathers, calmness, withdrawal, hyporeactivity, hypoactivity, and eyelid drooping. Stickel (1971) reports that in certain terrestrial bird species, symptoms of mercury poisoning occur when concentrations in the liver or kidney tissue approach 30 mg/kg; Ohlendorf et al. (1978) state that background levels are usually less than 1 mg/kg. In acute oral exposures, signs appeared as soon as 20 minutes post administration in mallards, and death occurred between 4 and 48 hours (Hudson et al. 1984).

Numerous studies have identified concentrations of mercury thought to be lethal or sublethal and acute or chronic. Concentrations of total mercury lethal for birds range from 2200 to 31000 micrograms/kilogram (mcg/kg) body weight (acute oral) and 4000 to 40000 mcg/kg (dietary) (Eisler 1987). Mercury concentrations in excess of 1.1 mcg/g fresh weight of tissue (liver, kidney, blood, brain, hair), should be considered as presumptive evidence of an environmental mercury problem (Eisler 1987). Finley et al. (1979) concluded from their work that concentrations of mercury in excess of 20 mg/kg fresh weight in soft tissue (undefined) should be considered extremely hazardous, as this level has been reported in wild birds known to have died of mercury poisoning.

The only ERF samples to have levels exceeding Eisler's criteria were two kidneys and two livers from northern shovelers and a bald eagle kidney. Such levels were higher than anticipated and may reflect a low-level chronic exposure. In all cases where both the kidney and liver from the same specimen were analyzed for mercury, residue levels were higher in the liver. Other tissues analyzed in these and other specimens ranged between .013 and .816 mcg/g (fresh weight conversion), below Eislers' criteria. These concentrations are comparable to low ranges reported by numerous studies.

White and Cromarite (1985) reported mercury values in waterbird livers ranging from non-detectable to 0.3 mcg/g fresh weight and stated that such levels were considered to be low, and below known-effect levels in other avian species, as determined by Fimreite (1974).

ERF specimens analyzed for mercury contained concentrations less than levels found in fish-eating waterbirds from contaminated areas studied by Dustman et al. (1972) and Fimreite (1974). Female mallards fed 3 mg/kg (dry weight) mercury (as methylmercury) in their diet had average mercury residues of 11.1 mg/kg in their livers and 14.7 mg/kg in their kidneys (Heinz 1976).

Fimreite and Karstad (1971) reported that more than 20 mg/kg of mercury in hawk livers could be lethal. Koeman et al. (1971) reported an average of 83 and 74 mg/kg of mercury in livers and kidneys, respectively, of kestrels that died as a result of eating mice containing an average of 13.3 mg/kg mercury.

Many experimental studies have illustrated that low dietary concentrations of mercury can lower reproductive success (e.g., reduced egg production, embryo survival, reduced hatchability) in certain birds (Spann et al. 1972, Wright et al. 1974, Borg et al. 1969, Fimreite 1971, Heinz 1975). Finley and Stendell (1978) reported no mortality in adult black duck breeders fed 3 mg/kg mercury; levels of mercury as high as 23, 16, 4.5, and 3.8 mg/kg (fresh weight) were recorded in liver, kidney, breast muscle, and brain tissue, respectively. However, Finley and Stendell's (1978) data did indicate that approximately 4 mg/kg (fresh weight) mercury in the brain of black duck embryos and ducklings can cause mortality. Heinz (1976) reported levels of 11.1, 14.7, 5.0, and 4.6 mg/kg mercury (fresh weight) in livers, kidneys, breast muscle, and brain, respectively, of mallard hens fed 3 mg/kg for 18 months; these mallard breeders were considered in excellent health when necropsied.

Of special note is that approximate mercury levels can be predicted in muscle, liver, and kidneys of several species of ducks when the mercury level is known in any one tissue. Finley and Stendell (1978) and several other investigators have examined the relationship between residues of mercury in various soft tissues and found significant correlations. They reported predictable mercury levels for black duck liver-kidney, liver-brain, and breast muscle-brain combinations; mean ratios of mercury levels in tissues of adult breeders were breast muscle/brain = 1.3; liver/kidney = 1.5; liver/brain = 6.2; liver/muscle = 5.2; and liver/egg = 5.1. Hesse et al. (1975) correlated mercury levels between muscle-liver, muscle-kidney, and liver-kidney tissue for five species of birds. Vermeer and Armstrong (1972a, 1972b) reported similar correlations between levels of mercury in wing-breast muscle and liver-breast muscle in each of five species of field-collected ducks.

Mercury and selenium are known to affect each others concentration in numerous tissues of a variety of fish and wildlife. The adverse or lethal effects induced by the various forms of mercury is lessened or eliminated by the protective action of selenium (Magos and Webb 1979, Heisinger et al. 1979, Eisler 1985). It is reported that selenite salts break the link between methylmercury and proteins, although the exact mechanism is not fully known (Eisler 1987). Ohlendorf et al. (1986) discovered a positive correlation between selenium and mercury in kidneys and livers of skuas and gulls and considered the correlation to reflect antagonistic interactions that reduced mercury toxicity. However, some investigators have reported that selenium results in increased mercury accumulations (Beijer and Jernelov 1978).

To conclude on mercury, because some specimens (e.g. northern shovelers, a bald eagle) have been found to have mercury residues in select tissue equal to or exceeding reportable levels of concern, there should be some concern that the reproduction and behavior of these birds could have been adversely affected by environmental mercury pollution had they survived; however, the reportable levels are not within the levels expected to cause acute or chronic mercury poisoning.

Cadmium, a relatively rare heavy metal, is a known teratogen and carcinogen, and a probable mutagen. No evidence exists which states that cadmium is biologically essential (Eisler 1985b). Sublethal effects of cadmium in birds are similar to those in other species and include growth retardation, anemia, and testicular damage (Hammons et al. 1978).

Birds, as well as mammals, are comparatively resistant to the biocidal properties of cadmium. Cadmium concentrations in vertebrate kidney or liver that exceed 10 mg/kg fresh weight or 2 mg/kg whole body fresh weight should be viewed as evidence of probable cadmium contamination. Residues of 200 mg/kg fresh weight kidney, or more than 5 mg/kg whole body fresh weight, are probably life-threatening to the organism (Eisler 1985b).

White and Cromartie (1985) reported cadmium residue levels in waterbird liver tissue and concluded that the levels were considered to be low, and below known-effect levels, as reported by White et al. (1978). In cadmium-polluted area studies, cadmium levels in common tern kidneys averaged 6.0 mg/kg fresh weight (Conners et al. 1975) and 22 to 55 mg/kg fresh weight in puffins, fulmars, and shearwaters (Nicholson and Osborn 1983); the latter study of which reported varying degrees of kidney damage in its specimens. Cadmium selectively accumulates in the kidneys where it is known to damage structure and impair renal function. White et al. (1978) and Cain et al. (1983) report that histopathological effects are first noted in birds when kidney cadmium levels approach 20 mg/kg fresh weight. King and Cromartie (1986) in their study of heavy metals in waterbird species in Galveston Bay reported a range of kidney cadmium levels of 0.1 to 16 mg/kg fresh weight and considered the mean concentrations as not presenting any significant contaminant hazard. Fleming (1981) reported cadmium residues ranging from 0.02 to 4.6 mg/kg fresh weight in canvasback kidneys. No histological effects were observed by White and Finley (1978) when they fed mallards 2 mg/kg dietary cadmium (30 day exposure, kidney residue 3.4 mg Cd/kg; 90 day exposure, kidney residue 54 mg Cd/kg), but kidney lesions resulted in mallards fed diets containing 200 mg/kg cadmium chloride (White et al. 1978).

To conclude, all determined cadmium values, fell within a range (.12-4.8 mcg/g fresh weight conversion) below the 10 mg/kg fresh weight criteria used to delineate probable cadmium contamination and the 200 mg/kg fresh weight criteria use to delineate a life-threatening situation.

Zinc and copper are required as trace elements in fish and wildlife, but become toxic when they occur in relatively high concentrations. Gay (1985) reports that in wildlife, acute effects of zinc are first manifested in diets containing 500-5000 mg Zn/kg and in oral dosages of 2-20 mg Zn/kg; acute effects of copper are first manifested by oral dosages of greater than 2000 mg Cu/kg. Gasaway and Buss (1972) reported significant adverse effects in mallard ducks fed 3,000 to 12,000 mg/kg Zn in their diet. In ducks fed zinc, the pancreas and gonads underwent reduction, legs became paralyzed, high concentrations of zinc occurred in the pancreas and kidney, and the kidneys altered color to yellowish-red; these signs, Gasaway and Buss (1972) report, may be used for diagnosing toxicosis in mallards.

Zinc concentrations (fresh weight) associated with zinc toxicosis are 483 ± 271 mg/kg in liver and 519 ± 359 mg/kg in kidney (Gasaway and Buss 1972). In an area where effluents from mining industries occurred, Laude (1977) reported high fresh weight concentrations of zinc (204 mg/kg) and copper (367 mg/kg) in common eider livers. Ohlendorf et al. (1986) reported higher mean, dry weight concentrations of copper and zinc in scaup livers (96.8 ± 7.59 mg Cu/kg; 151 ± 5.94 mg Zn/kg) than in scoters (49.8 ± 3.65 mg Cu/kg; 131 ± 4.71 mg Zn/kg) and contributed the difference to different foraging behaviors.

It is difficult to ascertain whether the zinc levels found in ERF avian lung tissue are lethal, as comparative literature is wanting and no control samples were collected and analyzed. Zinc phosphide, a rodenicide placed in burrows and lethal when inhaled, is a by-product of select munitions (i.e. HC smoke) and could be a contributing agent in ERF bird mortalities (Stroud 1988). Continued analysis of lung tissue for zinc, as it could be a tracer for zinc phosphide, may help answer this question.

Chupp and Daiki (1964) determined in waterfowl mortality studies in the thoroughly polluted Coeur d' Alene River Valley that elevated copper concentrations (1.20-1.90 mg/g) existed in swan internal organs. Furthermore, it was concluded that lethal concentrations of toxic metals could have conceivably poisoned the birds. Spectrographic analyses of whistling swan, common merganser, American widgeon, and mallard liver showed sizable concentrations of copper (5-72 mg/kg fresh weight, 5.0 mg/kg fresh weight. 19-33 mg/kg fresh weight, 35.0 mg/kg fresh weight, respectively). Lande (1977) indicated that copper concentrations of 13 mg/kg dry weight (pectoral musculature), 367 mg/kg dry weight (liver) and 43 mg/kg dry weight (kidney) do not seem to indicate harmful levels in eiders.

Custer and Mulhern (1983) determined high (24-381 mg/kg dry weight) copper concentrations in black-crowned night-herons from three Atlantic Coast colonies. In their report, Custer and Mulhern also presented (for relative comparative purposes) other reseacher's determinations of copper in a variety of avian species' livers:

Immature ospreys	141 mg/kg fresh weight
Adult ospreys	3.0 mg/kg fresh weight
Brown pelicans	18-98 mg/kg dry weight
Brown pelicans (6 wks old)	4.3-9.0 mg/kg fresh weight
Common terns	13-28 mg/kg dry weight
Lesser black-backed gulls	17 mg/kg dry weight
Greater scaup, Surf scoters	35-66 mg/kg dry weight
Canvasbacks	59 mg/kg fresh weight
Mute swans	1000 mg/kg fresh weight

Ohlendorf et al. (1986) determined copper concentrations in surf scoter (range 29-110 mg/kg dry weight) and greater scaup (range 28-159 mg/kg dry weight) livers and concluded that they were not indication of elevated levels.

Waterfowl-liver studies conducted by Parslow et al. (1982) were designed to obtain background levels of metals from an unpolluted area. The reported ranges and means (mg/kg, dry weight) are tabulated below:

5	Gadwall	25.3-190.0	100.4 ± 28.3
60	Widgeon	16.0-231.0	116.3 ± 5.76
43	Mallard	21.0-248.0	114.8 ± 4.8
32	Pintail	44.0-197.0	101.1 ± 4.8
59	Teal	15.0-167.0	82.4 ± 4.8
25	Shoveler	20.0-211.0	77.3 ± 9.6

No significant differences in copper concentrations between sexes were noted. Di Guilio and Scanlon (1984) conducted a study to elucidate relationships between food habits and tissue (i.e. liver, kidney) accumulations of heavy metals in Chesapeake Bay waterfowl. Copper concentrations varied with higher levels reported in the liver than in the kidney. The overall mean liver copper concentration was 114.7 mg/kg. White et al. (1979) observed mean liver copper concentration in Chesapeake Bay waterfowl of 252 mg/kg. According to Scott et al. (1982) normal copper concentrations in livers and kidneys of chickens are both approximately 12 mg/kg dry weight.

Comparing ERF data to the copper concentrations reported by other researchers, a similar pattern of variability results. Kidney and liver mean values all fell below those reported by Parslow et al. (1982) but were above the 12 mg/kg value reported by Scott et al. (1982), with the exception of a single bald eagle kidney sample. Therefore, it does not appear that zinc and copper concentrations found in ERF specimens are high enough to be suspected as a probable cause ~~for~~ of mortality.

Select Environmental Protection Agency-defined priority pollutants (e.g. lead, nickel, beryllium, thallium, chromium) are not suspect in contributing to the mortality of the collected ERF specimens because of their low levels (e g., less than five times their respective detection limit or non-detectable), and therefore, will not be discussed further in this report.

****
The following paragraph will be "beefed up" and rewritten when additional Fe, Al, and Mn information is received from the Interior Resources Library.

As is the case with zinc residue levels in lung tissue, information is wanting regarding the significance of iron, aluminum, and manganese residue levels in select avian tissues. Lande (1977) reported a mean value of 2904 mg/kg dry weight iron in six eider livers. He went on to state that his results did not seem to indicate harmful levels in the tissues. Only one ERF specimen exceeded this value, a northern shoveler liver. Gay (1985) reports that no scientific documentation is readily available regarding the acute effects of aluminum in wildlife. However, it is known that chronic effects can occur at concentrations between 500 and 5000 mg/kg.
****

Conclusions and Recommendations

The concentrations of select trace elements in various avian tissues collected from ERF do not appear to occur at levels which are documented to cause acute or chronic mortality. Mercury concentrations were found in select tissues equal to or exceeding reportable levels of concern; therefore, there should be some concern that the reproduction and behavior of some birds could be adversely affected. The source of mercury is not known and should not be surmized, at this time, to occur on ~~Eagle River~~ ERF Flats.

Antagonist/synergistic discussions were limited to mercury and selenium. Although their relationship does not appear to be contributing to ERF mortalities, relationships between other trace elements may prove otherwise and should be studied further.

Limited physiological, morphological, and/or behavioral descriptions manifested by trace element poisoning were provided in this report. Comparison of these descriptions to field observations of dying birds and necropsy reports are wanting and should be pursued. Such comparisons may provide some insight as to the cause of the birds death.

Two facilitate the continued assessment of probable avian mortality causes, it is recommended that:

1. the synergistic and antagonistic relationships of select trace elements (e.g., selenium, mercury) should be investigated further,

2. zinc concentrations should continue to be quantified in avian lung tissue, as a possible tracer for phosphide-type compounds,

3. an exhaustive literature search be conducted pertaining to acute, chronic, lethal, and sublethal residue levels in avian species common to ERF,

4. future contaminant investigations be conducted emphasizing the delineation of military munitions-related residues in avian tissue and their surrounding habitat, and

5. future contaminant investigations carefully categorize bird behavior in the field and compare such behavior with the symptoms of trace element poisoning and necropsy findings.

References Cited

Beijer, K., and A. Jernelov. 1978. Ecological aspects of mercury-selenium interactions in the marine environment. Environ. Health Perspec. 25:43-451.

Borg, K., H., Wanntorp, K. Erne, and E. Hanko. 1969. Alkyl mercury poisoning in terrestrial Swedish wildlife. Viltrevy. 6:301-379.

Cain, B.W., L. Sileo, J.C. Franson, and J. Moore. 1983. Effects of dietary cadmium on mallard ducklings. Environ. Res. 32:286-297.

Chupp, N.R., and P.D. Daiki 1964. Waterfowl mortality in the Coeur d' Alene River Valley, Idaho. J. Wildl. Manage. 24:4:692-701.

Connors, P.G., V.C. Anderlini, R.W. Risebrough, M. Gilbertson, and H. Hays. 1975. Investigations of heavy metals in common tern populations. Can. Field-Natur. 89:157-162.

Custer, T.W. and B.L. Mulhern. 1983. Heavy metal residues in prefledgling black-crowned night-herons from three Atlantic Coast Colonies. Bull. Environ. Contam. Toxicol. 30:178-185.

Di Giulio, R.T., and P.F. Scanlon. 1984. Heavy metals in tissues of waterfowl from the Chesapeake Bay, USA. Environ. Poll. (Series A) 35:29-48.

Dustman, E.H., L.F. Stickel, and J.B. Elder. 1972. Mercury in wild animals, Lake St. Clair, 1970. Pp. 46-52 in Environmental mercury contamination. (R. Hartung and B.D. Dinmen Eds.) Ann Arbor, Michigan: Ann Arbor Science Publishers

Eisler, R. 1985a. Selenium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.5). 57pp.

Eisler, R. 1985b. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.2). 46pp.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85 (1.10). 90pp.

Eisler, R. 1988. Arsenic hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.12). 92pp.

Fimreite, N. 1971. Effects of dietary methyl-mercury on ring-necked pheasants. Can. Wildl. Serv. Occ. Pap., No. 9.

Fimreite, N. 1974. Mercury contamination of aquatic birds in northwestern Ontario. J. Wildl. Manage. 38:120-131.

Fimreite, N. 1979. Accumulation of effects of mercury on birds. Pages 601-627 in J.O. Nriagu (ed.). The biogeochemistry of mercury in the environment. Elsevier/North-Holland Biomedical Press. New York.

Fimreite N., and L. Karstad. 1971. Effects of dietary methyl mercury on red-tailed hawks. J. Wildl. Manage. 35:293-300.

Finley, M.T., and R.C. Stendell. 1978. Survival and reproductive success of black ducks fed methyl mercury. Environ. Pollut. (16)51-64.

Finley, M.T., W.H. Stickel, and R.E. Cristensen. 1979. Mercury residues in tissues of dead and surviving birds fed methylmercury. Bull. Environm. Contam. Toxicol. 21:105-111.

Fleming, W.J. 1981. Environmental metal residues in tissues of canvasbacks. J. Wildl. Manage. 45(2): Short communications.

Gasaway, W.C., and I.O. Buss. Zinc toxicity in the mallard duck. J. Wildl. Manage. 36(4):1107-1117.

Gay, M. 1985. Personal communication. U.S. Fish and Wildlife Service. Patuxent Analytical Control Facility, Maryland.

Goede, A.A. 1985. Mercury, selenium, arsenic, and zinc in waders from the Dutch Wadden Sea. Environ. Pollut. 37A:287-309.

Hammons, A.S., J.E. Huff, H.M. Braunstein, J.S. Drury, C.R. Shriner, E.B. Lewis, B.L. Whitfield, and L.E. Towill. 1978 Reviews of the environmental effects of pollutants: IV Cadmium. U.S. Environ. Protection Agency Rep. 600/1-78-026. 251pp.

Heinz, G. 1975. Effects of methylmercury on approach and avoidance behavior of mallard ducklings. Bull. Environm. Contam. and Toxicol., 13, 554-64.

Heinz, G. 1976. Methylmercury: second-year feeding effects on mallard reproduction and duckling behavior. J. Wildl. Manage. 40(1):82-90.

Heinz, G.H. and D.J. Hoffman. 1987. Reproduction in mallards fed selenium. Environ. Tox. and Chem. 9:423-433.

Heisinger, J.F., C.D. Hansen, and J.H. Kim. 1979. Effects of selenium dioxide on the accumulation and acute toxicity of mercury chloride in goldfish. Arch. Environ. Contam. Toxicol. 8:279-283.

Hesse, L.W., R.L. Brown, and J.F. Heisinger. 1975. Mercury contamination of birds from a polluted watershed. J. Wildl. Manage. 39:299-304.

Hudson, R.H., R.K. Tucker, and M.A. Haegele. 1984. Handbook of toxicity of pesticides to wildlife. U.S. Fish Wildl. Serv. Resour. Publ. 153. 90 pp.

King, K.A., and E. Cromartie. 1986. Mercury, cadmium, lead, and selenium in three waterbird species nesting in Galveston Bay, Texas, USA. Colon. Waterbirds 9,1:90-94.

Koeman, J.H., J. Garssen-Hoekstra, E. Rels, and J.J.M. De Goij. 1971. Mededelingen Fakulteit Landbouw-Wetenschappen Gent. 36:43.

Lande, E. 1977. Heavy metal pollution in Trondheimsfjorden, Norway, and the recorded effects on the fauna and flora. Environ. Pollut. 12:187-198.

Magos, L., and M. Webb. 1979. Synergism and antagonism in the toxicology of mercury. Pages 581-599 in J.O. Nriagu (ed.) The biogeochemistry of mercury in the environment. Elsevier/North-Holland Biomedical Press, New York.

Nicholson, J.K. and K. Osborn. 1983. Kidney lesions in pelagic seabirds with high tissue levels of cadmium and mercury. J. Zool., London 200:99-118.

Nystrom, R.R. 1984. Cytological changes occurring in the liver of coturnix quail with an acute arsenic exposure. Drug Chem. Toxicol. 7:587-594.

Ohlendorf, H.M., R.W. Risebrough, and K. Vermeer. 1978. Exposure of marine birds to environmental pollutants. U.S. Fish Wildl. Serv. Res. Rep. 9. Washington, D.C.

Ohlendorf, H.M., R.W. Lowe, P.R. Kelley, and T.E. Harvey. 1986. Selenium and heavy metals in San Francisco Bay diving ducks. J. Wildl. Manage. 50(1):64-71.

Ort, J.F., and J.D. Latshaw. 1978. The toxic level of sodium selenite in the diet of laying chickens. J. Nutrition. 109:1114-1120.

Parslow, J.L.F., G.J. Thomas, and T.D. Williams. 1982. Heavy metals in the livers of waterfowl from the Ouse Washes, England. Environ. Poll. (Series A) 29:317-327.

Scott, M.L., M.C. Nesheim, and R.J. Young. 1982. Nutrition of the chicken, 3rd edition. Ithaca, NY, M.L. Scott and Associates.

Spann, J.W., R.G. Heath, J.F Kreitzer, and L.N. Locke. 1972. Ethyl mercury p-toluene sulfonanilide: Lethal and reproductive effects on pheasants. Science. N.Y., 175:328-331.

Stickel, W.H. 1971. Ecological effects of methylmercury contamination. Environ. Res. 4:31-41.

Stroud, R. 1988. Personal communication. U.S. Fish and Wildlife Service, Portland, OR. Aug. 4, 1988.

Vermeer, K., and F.A.J. Armstrong. 1972a. Correlation between mercury in wings and breast muscles in ducks. J. Wild. Manage. 36:1270-1273.

Vermeer, K., and F.A.J. Armstrong. 1972b. Mercury in Canadian prairie ducks. J. Wildl. Manage. 36:179-182.

White, D.H., and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. Environ. Res. 17:53-59.

White, D.H., R.C. Stendell, and B.M. Mulhern. 1979. Relations of wintering canvasback to environmental pollutants - Chesapeake Bay, Maryland. Wilson Bull., 91:279-287.

White, D.H., M.T. Finley, and J.F. Finell. 1978. Histopathologic effects of dietary cadmium on kidneys and testes of mallard ducks. J. Toxicol. Environ. Health 4:551-558.

White, D.H., and E. Cromarite. 1985. Bird use and heavy metal accumulation in water birds at dredge disposal impoundments, Corpus Christi, Texas. Bull. Environ. Contam. Toxicol. 34:295-300.

Wright, F.C., R.L. Younger, and J.C. Riner. 1974. Residues of mercury in tissues and eggs of chickens given oral doses of Panogen 15. Bull. Environ. Contam. and Toxicol. 13:554-564.

APPENDIX A

ANALYTICAL METHODS

U. S. FISH AND WILDLIFE SERVICE

PATUXENT ANALYTICAL CONTROL FACILITY

QUALITY ASSURANCE REPORT

RE:# 5706 REGION : 7 REGIONAL ID 88-7-040

THE ANALYSES ON THE ABOVE MENTIONED SAMPLES WERE PERFORMED AT:

THE ENVIRONMENTAL TRACE SUBSTANCES RESEARCH CENTER
ROUTE 3
COLUMBIA, MISSOURI 65201

THIS LABORATORY WAS SUBJECTED TO A RIGOROUS EVALUATION PROCESS PRIOR TO THE AWARDING OF IT'S CONTRACT. A PANEL OF FISH AND WILDLIFE SERVICE SCIENTISTS CERTIFIED IT TO BE TECHNICALLY QUALIFIED TO PERFORM THE ANALYSES REPORTED HERE. IN ADDITION WE HAVE CONTINUED TO CLOSELY MONITOR THIS LABORATORY'S PERFORMANCE AND HAVE FOUND THE PRECISION AND ACCURACY OF THEIR WORK REMAINS ACCEPTABLE. WE HAVE GREAT CONFIDENCE IN THE ACCURACY OF THESE DATA.

John F Moore 12-12-88
JOHN F. MOORE

cc 12/13/88
John Moore
Wayne Crayton
Everett Robinson-V

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

% MOISTURE

For animal tissue and sediments of sufficient size, moisture was determined by placing a weighed aliquot of the sample in a Fisher Isotemp oven and drying at 103-105 C. The dried sample was then weighed and the data entered into a computer program to generate the % moisture and final report.

Plants, and samples too small for oven dried moisture determination had the % moisture calculated from the moisture lost during the freeze-drying in the Labconco Freeze-Dryer 8. The data was entered into a computer program to generate a % moisture and final report.

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route
Columbia, Missouri
Telephone

HOMOGENIZATION

Large tissue samples, such as whole fish, were first run through a meat grinder one or more times depending on the size of the sample. An aliquot of the ground sample was weighed and frozen. For smaller tissue samples and plant samples the entire sample was weighed and then frozen. For sediments, the sample was mixed and an aliquot weighed and frozen. The frozen samples were placed in a Labconco Freeze Dryer 8 until the moisture had been removed. The dry samples were then weighed and further homogenized using a blender, or Spex Industries, Inc. Model 8000 mixer/mill with tungsten-carbide vial and balls.

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

NITRIC - PERCHOLORIC DIGESTION - (I.C.P.)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. quartz Kjeldahl flask. (Samples containing a high percent of silica and sediment samples were digested in 100 ml. teflon beakers.) For water samples, 50 ml. of sample was measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 began refluxing, samples were allowed to reflux overnight. (This decreased the chance for charring during the reaction with $HClO_4$.) After the refluxing, the heat was gradually increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. When dense white fumes from the $HClO_4$ were evident, the samples were removed from the heat and allowed to cool. Two ml. of concentrated sub-boiled HCl was added. The flasks were replaced on the heat and warmed until the containers were hot to the touch or started to boil. They were removed from the heat, and 5-10 ml. of deionized water was added. Samples were allowed to cool.. They were then diluted using deionized water in a 50 ml. volumetric flask and transferred to a clean, labeled, 2 oz. polyethylene bottle.

COLUMBIA KANSAS CITY ROLLA ST. LOUIS

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center

NITRIC - PERCHOLORIC DIGESTION - (SELENIUM)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. quartz Kjeldahl flask. (Samples containing a high percent of silica and sediment samples were digested in 100 ml. teflon breakers.) For water samples, 50 ml. of sample was measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 began refluxing, samples were allowed to reflux overnight. (This decreased the chance for charring during the reaction with $HClO_4$.) After the refluxing, the heat was gradually increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. When dense white fumes from the $HClO_4$ were evident, the samples were removed from the heat and allowed to cool. Two ml. of concentrated sub-boiled HCl was added. The flasks were replaced on the heat and warmed until the containers were hot to the touch or started to boil. They were removed from the heat, and 5-10 ml. of deionized water was added. Samples were allowed to cool. They were then diluted using deionized water in a 50 ml. volumetric flask and transferred to a clean, labeled, 2 oz. polyethylene bottle.

COLUMBIA KANSAS CITY ROLLA ST. LOUIS

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

NITRIC - PERCHOLORIC DIGESTION - (ARSENIC)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. Kjeldahl flask. (Samples containing a high percent of silica and sediment samples were digested in 100 ml. teflon beakers.) For water samples, 50 ml. of sample was measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. After this reaction, the samples were heated approximately 5 minutes, after dense white fumes from the $HClO_4$ were evident. The samples were removed from the heat and allowed to cool. Samples were diluted using deionized water in 50 ml. volumetric flasks and transferred to clean, labeled, 2 oz. polyethylene bottles.

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Ce
Ro
Columbia, Missouri 6
Telephone (314) 882-

NITRIC REFLUX DIGESTION FOR MERCURY

Approximately 0.5 g. of sample was weighed into a freshly cleaned 50 ml. round bottom flask with 24/40 ground glass neck. For waters, 10 ml. of sample was measured into the flask. Five ml. of concentrate sub-boiled HNO3 was added and the flask was placed under a 12 inch water cooled condenser with water running through the condenser. The heat was turned up to allow the HNO3 to reflux no more than 1/3 th height of the columns. Samples were allowed to reflux for two hours. Then the heat was turned off and the samples allowed to cool. The condensers were rinsed with 1% v/v HCl and the flasks removed. The samples were diluted with 1% v/v HCl in a 50 ml. volumetric flask and then transferred to a clean, labeled, 2 oz. flint glass bottle.

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

PRECONCENTRATION OF ICP - PH 6

A 30 g. sample of the digestate for I.C.P. was weighed into a 50 ml. screw top centrifuge tube. One ml. of 2000 ppm Indium and 1 ml. of 10% ammonium acetate buffer were added and the pH adjusted to 6.5 with high purity NH_4OH from Seastar. One ml. of a 10% DDTC was added and the caps screwed on and mixed by turning end over end 6 times slowly. After mixing, the tubes were centrifuged in an I.E.C. refrigerated centrifuge at 20 C for 15 minutes at 15,000 RPM. The liquid was then decanted from the precipitate and 0.3 ml. of high purity HNO_3 from Seastar was added. The Tubes were heated in a water bath at 95 C to dissolve the preicipitate and diluted to 3 ml. with deionized water.

For samples high in Caclium and Phosphate a pH of 6.0 was used to reduce the precipitation of Ca_3(PO4)2.

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

INDUCTIVELY COUPLED PLASMA (ICP)

The instrument used for ICP analysis was a Jarrell-Ash Model 1100 Mark III with 40 analytical channels, controlled by a Digital Equipment Company (DEC) 11/23+ computer with two RL02 disk drives, DEC VT100 terminal, and DEC LA120 decwriter III. The instrument was standardized with a series of seven standards containing 36 elements. After the standardization, the detection limit was determined by taking ten integrations of the zero standard; three times the standard deviation of the mean was used as the detection limit. Instrumental quality control samples were then analyzed to check the ICP operation. If the values were acceptable, the samples were then analyzed. Standards were run every 10-15 samples to check for drift. If the drift was more than 5%, the instrument was restandardized. After the analysis was completed, the data was transferred to the Perkin-Elmer LIMS 2000 computer for calculation. The final detection limit for each element was further increased by 4% of the magnitude of the spectral interferences from the other elements. The data was checked before calculation to correct for possible errors in sample number, weight, volumes and dilution. The data was calculated using the ICP calculation program written by ETSRC computer staff, which corrected for blanks, standard drift, spectral interferences, sample weight, sample volume, and dilution. After the quality control was reviewed, a final report was generated using a Hewlett-Packard laser jet printer.

COLUMBIA KANSAS CITY ROLLA ST. LOUIS
an equal opportunity institution

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center
Route 3
Columbia, Missouri 65203
Telephone (314) 882-2151

ARSENIC AND SELENIUM BY HYDRIDE

The Varian VGA-76 hydride generation accessory was mounted on either a Perkin-Elmer Model 603 AA or Model 3030 (B) AA. Electrodeless Discharge lamps (EDL) were used. The instrument and EDL settings were taken from the instrument manuals. The burner mount for a Perkin-Elmer Model 10 Hydride generator was modified slightly to hold the Varian quartz cell. The cell was aligned in the light path of the burner chamber and a very lean flame was used for heating the cell. The two stock solutions were 50% v/v sub-boiled HCl and 0.6% $NaBH_4$ in 0.5% NaOH for Selenium and concentrated sub-boiled HCL and 1% $NaBH_4$ in 0.5% NaOH for Arsenic. Samples were diluted in 10% v/v sub-boiled HCl. Standards were prepared by dilution of Fisher 1000 ppm stock in 10% v/v sub-boiled HCl in the range of 0 to 20 PPB. The instrument was standardized to read directly in PPB using S1 = 5.00 and S2 = 20.00. After standardization, the standardization was checked by reading other standards such as 2.00, 10.00 and 15.00 PPB and an instrumental quality control sample with a known value. If the standards and quality control were acceptable, the detection limit was determined by reading the zero standard 10 times and twice the standard deviation of the mean was used as the detection limit. Samples were analyzed by taking an integrated reading for 3 seconds after the plateau was reached for the sample. This occurred approximately 45 seconds after the sample tube was placed in the sample. Standardization was checked every 8-15 samples and approximately 10% of the samples were checked by the method of additions to monitor matrix effects. Matrix effects were usually not significant with the VGA-76. The data was corrected for drift of the standard curve and entered into the AA calculation program. This program corrected for blank, dilution, sample weight, sample volume and recorded the data in the LIMS database for report generation.

B-24

UNIVERSITY OF MISSOURI

Environmental Trace Substances Research Center

MERCURY - COLD VAPOR ATOMIC ABSORPTION

Equipment used for Cold Vapor Atomic Absorption include: Perkin-Elmer Model 403 AA; Perkin-Elmer Model 056 recorder; Technicon Sampler I; Technicon Pump II; a glass cell with quartz windows and capillary tube for entry and exit of the mercury vapor; and a liquid-gas separator. The samples were placed in 4 ml. sample cups at least 3/4 full. The samples were mixed with hydroxylamine for preliminary reduction, then stannous chloride for reduction to the mercury vapor. The vapor was separated from the liquid and passed through the cell mounted in the light path of the burner compartment. The peaks were recorded and the peak heights measured. The standardization was done with at least 5 standards in the range of 0 to 10 ppb. The correlation coefficient was usually 0.9999 or better and must have been at least 0.999 to have been acceptable. A standard was run every 8-10 samples to check for drift in the standardization. This was usually less than 5%. Standards were preserved with 10% v/v HNO_3, 1% v/v HCl and 0.05% w/v $K_2Cr_2O_7$. The solution concentrations were calculated and the data entered into the AA calculation program which corrected for blank, dilution, sample weight, sample volume and entered the data into the LIMS system for report generation.