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U.S. Army Environmental Hygiene Agency

FINAL REPORT
RECEIVING WATER BIOLOGICAL STUDY NO. 32-24-H1ZV-93
WATER, SEDIMENT, MACROINVERTEBRATE, AND FISH SAMPLING
EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA
12-23 JULY 1993

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DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO ATTENTION OF

EXECUTIVE SUMMARY
FINAL REPORT
RECEIVING WATER BIOLOGICAL STUDY NO. 32-24-H1ZV-93
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EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA
12-23 JULY 1993

1. PURPOSE. The purpose of conducting this study was to assist Fort Richardson and the Cold Regions Research and Engineering Laboratory (CRREL) by determining:

a. The concentration of possible contaminants in the water and sediments of the Eagle River Flats (ERF).

b. The concentration of possible contaminants migrating into the Eagle River from ERF.

c. The concentration of White Phosphorus (WP) bioaccumulating in fish.

d. If WP or other contaminants were affecting the benthic macroinvertebrates in ERF.

2. CONCLUSIONS. Of all the chemicals analyzed, WP was the only one that could be attributed to the army's activities at ERF. There was only weak evidence of WP affecting the number of macroinvertebrates per unit area, and no evidence that it affected the species present or species diversity. No WP was detected in the stickleback fish living in the ponded areas of ERF.

3. RECOMMENDATION. Use the data collected in this study to help complete the ecological and human health risk assessments.

DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO ATTENTION OF

HSHB-ME-WM

15 APR 1994

FINAL REPORT
RECEIVING WATER BIOLOGICAL STUDY NO. 32-24-H1ZV-93
WATER, SEDIMENT, MACROINVERTEBRATE, AND FISH SAMPLING
EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA
12-23 JULY 1993

1. REFERENCES. See Appendix A for a list of references.

2. AUTHORITY. Memorandum, USAEC, CETHA-TS-S, 24 February 1993, subject: Request for Technical Support.

3. PURPOSE. The purpose of conducting this study was to assist Fort Richardson and the Cold Regions Research and Engineering Laboratory (CRREL), the technical coordinating Agency for several studies at Eagle River Flats (ERF), by determining:

a. The concentration of possible contaminants in the water and sediments of the ERF.

b. The concentration of possible contaminants migrating into the Eagle River from ERF.

c. The concentration of White Phosphorus (WP) bioaccumulating in fish.

d. If WP or other contaminants were affecting the benthic macroinvertebrates in ERF.

4. BACKGROUND.

a. Because ERF is on the National Priorities List, the target analyte/target compound list of contaminants was investigated even though it has already been determined that WP poisoning is the cause of the continuing die off of waterfowl.

b. Eagle River Flats is a 865-hectare estuarine salt marsh at Fort Richardson, Alaska. The marsh is located near Anchorage, south of the Knik Arm in upper Cook Inlet. The Eagle River, subject to semi-diurnal tides as great as 35 feet, winds through the flats into the Cook Inlet. In addition to the river, permanent and semi-permanent ponds account for about 8 percent of the marsh area. Other features of the wetland include regions of barren mudflats, meadows of dense sedge grass, and stands of bulrush vegetation. In 1949, the U.S. Army began to use ERF as an impact area for artillery training. Thousands of craters resulting from munitions testing are widely distributed throughout the marsh. Despite heavy anthropogenic disturbance, ERF has continued to support large numbers of waterfowl, shorebirds, gulls, terns, and raptors, as well as several mammalian species (see Appendix B).

c. Since 1981, annual waterfowl dieoffs in excess of 1,000 birds have been reported at ERF. Waterfowl primarily use the area as a migratory stop for several weeks in the spring and fall. Artillery firing at ERF was halted after the results of a 1989 U.S. Army Environmental Center (USAEC) study linked munitions testing to waterfowl mortality. Site retirement, however, did not curb the number of duck fatalities. Currently, artillery is fired into ERF only during the winter, when overlaying ice reduces sediment disturbances caused by explosions. In 1990, a team of scientists from CRREL and Dartmouth Medical School initiated another investigation into the cause and extent of waterfowl mortality at ERF.

d. The results of mortality surveys performed during the spring 1990 indicated that certain species of dabbling waterfowl were the primary victims. Green Wing Teal, Mallard, and Northern Pintail carcasses were found most frequently. Because primarily dabbling birds were vulnerable, the task force began to look for the causative agent in the sediments of ponds used by these species. Over the course of 1990, CRREL and Dartmouth assembled data and observations which suggested that ingestion of WP particles deposited in pond sediments from smoke and incendiary projectile explosions was the cause of waterfowl mortality on ERF. It has been hypothesized, due to size similarities, that most of the phosphorus particles ingested are mistaken for food items or grit. Elsewhere, waterfowl poisoning resulting from the ingestion of spent lead shotgun pellets from sediments has been extensively studied. Recent reports suggest that ducks select lead shot due to its likeness to black waterhemp and smartweed seeds (reference 1).

e. The following evidence compiled from 1990-92 studies supports the phenomenon of WP poisoning at ERF:

(1) White phosphorus was present in concentrations above the detection limit in more than 30 percent of over 600 sediment samples analyzed from ERF.

(2) White phosphorus is persistent in anoxic environments such as the salt marsh sediments of ERF.

(3) White phosphorus is highly toxic to waterfowl at ingestion levels in the range of 2-17 mg/kg body weight.

(4) White Phosphorus was found in the gizzard contents of all 74 dabbling duck carcasses collected in ERF, yet in none of the 305 ducks shot by hunters outside of Fort Richardson.

(5) Farm reared mallards dosed with lethal amounts of compound in the lab exhibited nearly identical behavioral symptoms to those of moribund wild waterfowl at ERF (references 2 and 3).

5. OVERVIEW. Eagle River Flats is a complex ecosystem supporting a network of trophic levels. It is the first documented incidence of a U.S. Artillery training ground being contaminated with WP particles (reference 3). Though WP is heterogeneously distributed throughout the marsh, the route of waterfowl exposure is through the sediments of feeding ponds, which constitute about eight percent of the total ERF area. In two of the six ponds assessed, Area C and the Breadtruck Pond's, more than 50 percent of the sediments collected tested positive for WP (reference 3). The most recent studies indicate that annual waterfowl mortality could be in excess of 3,500 individuals, and tainted carcasses may pose a risk to avian scavengers.

6. HUMAN HEALTH ISSUES. Since moribund waterfowl have been observed to fly and otherwise appear to be healthy during the early stages of WP poisoning, it is possible for hunters to unknowingly harvest contaminated birds. Due to concern for biotransfer of WP from ducks to humans, hunting is currently banned at ERF. Moreover, in September 1991, Alaska state epidemiologist John Middaugh advised hunters not to take sick or dead ducks from any Cook Inlet hunting grounds, due to concern that affected birds were moving off the flats. On opening day of the 1991 hunting season, 305 gizzards from waterfowl shot in the Cook Inlet region were collected for white phosphorus analysis. None of the gizzards tested positive for the contaminant. Based on this result, and worst-case estimates of human health risk prepared by USAEHA's Toxicology Division in 1991, Middaugh declared that the risk to human health from ducks harvested in the Cook Inlet was "so low as to constitute no basis for public concern" (reference 2). Though ducks in areas adjacent to ERF do not appear to present a human health problem, the risk associated with waterfowl hunting on the flats has never been quantified.

7. WHITE PHOSPHORUS CHEMISTRY. White phosphorus is the most reactive of the three phosphorus allotropes (white, red, and black) and does not occur in nature. The molecular structure is a regular tetrahedron with a phosphorus atom at each apex. The compound, a transparent waxy solid, autoignites in air at 30 degrees Celsius and therefore is stored in water. Upon atmospheric combustion WP produces dense white smoke. Due to these properties, WP has been widely used by the U.S. military in incendiary and smoke screen devices (reference 4). Appendix C provides additional information on the chemical and physical properties.

8. WHITE PHOSPHORUS TOXICOLOGY. White phosphorus is acutely toxic in minute quantities to humans and wildlife. The lowest reported lethal oral dose in humans is 1.4 mg/kg (reference 5). Acute effects in humans have been noted in the liver, kidney, hematopoietic system, brain, intestines, circulatory system, and myocardium (reference 6). Tissue analyses of wildfowl carcasses found on ERF and of laboratory-treated birds have found the highest concentrations of WP in fat and skin. Since WP is highly lipid soluble there is substantial concern for bioaccumulation via ingestion of tainted waterfowl meat.

Although the known lethal dose in waterfowl is 2-17 mg/kg, it is suspected that amounts as low as 1 mg will kill some of the smaller species (reference 7). Behavioral symptoms of moribund birds on ERF include central nervous system depression, loss of muscular control and aviatory capability, and violent convulsions. Death often comes as a result of a duck becoming tangled in reeds with its head underwater.

9. ENVIRONMENTAL FATE OF WHITE PHOSPHORUS AT EAGLE RIVER FLATS.

a. White phosphorus has become integrated into ERF sediments as a result of incomplete oxidation of the compound following its release into the environment. Due to its resistance to photolysis and anaerobic biodegradation, the contaminant is stable in oxygen deficient sediments such as those found at ERF (reference 4). Although WP concentrations have persisted over time in the sediments, there is a potential for particle resuspension, transport, and redeposition. Therefore, though WP is not degraded in sediments under static conditions, there are mechanisms in the field by which the contaminant may be redistributed and perhaps partially oxidized.

b. Both laboratory and field experiments indicate that small particles of WP are readily suspended in the water column subsequent to agitation of the underlying substrate. Furthermore, in laboratory studies, measurable concentrations remained in the water column for entire 60-minute trials (reference 3). These data support the idea that WP can be transported via distributaries (drainage gullies) on ERF into the Eagle River without undergoing complete oxidation. Mechanisms for particle suspension include waterfowl activity, wind, and severe tidal movements. In the 600 plus sediment samples analyzed for WP from ERF there was some WP found in some distributary sediments indicating that WP could be making its way to the Eagle River. Additionally, it is suspected that WP is redeposited in pond sediments during carcass decomposition.

10. STUDY PLAN. To date, investigations have largely been limited to WP in the sediment of the ponded areas where the ducks are known to feed. The Eagle River and distributaries have received little attention as have other possible contaminants or other possible receptors. As mentioned earlier, however, the contamination is not confined to these areas, and non-waterfowl wildlife may be exposed and vulnerable.

a. Background on Aquatic Toxicity. Studies have shown that fish, especially salmon (an indigenous species of the region) and certain species of macroinvertebrates are highly sensitive to WP in the water (reference 8). There is not enough aquatic toxicity data to develop a criterion for WP in the water. However, available data indicate that a level equal to or less than 0.01 μg/L of WP should adequately protect aquatic organisms. A WP sediment criterion cannot be derived for lack of data and complications caused by differing amounts of WP in overlying water and the heterogeneous distribution of WP in the sediments. There have been two other WP instances where WP effects on the benthic macroinvertebrate populations were studied. One was a marine harbor where sediment concentrations above 70 μg/kg and water concentrations above 3 μg/L were associated with impact on the invertebrate community (reference 19). The other was a fresh water lake where an adverse impact on the invertebrates was indicated at 2 to 43.3 μg/kg. The water concentrations associated with the affected invertebrates ranged from 1.2 to 40.4 μg/L (reference 20).

b. Brief Description of Study. We conducted this study to determine possible WP effects on the aquatic ecosystem at ERF and if there are other contaminants of concern. Water and sediment samples were collected and analyzed from the Eagle River, its distributaries, and the ponded areas at ERF. The samples were analyzed for WP, the explosives, nutrients, target analytes, and target compounds. Benthic macroinvertebrates were sampled and analyzed for community integrity from ERF distributaries, ERF ponded areas, and a reference area on Goose Bay (flats, directly across the Knik Arm of the Cook Inlet from ERF). Fish were also collected and analyzed for WP at each sample site in the ponded areas of ERF and Goose Bay.

c. Sample Site Locations. Figure 1 shows the general location of Eagle River Flats. Figure 2 and 3 shows the sample site locations. The coordinates for the sample site locations were determined by CRREL's survey team and presented in Table 1. There were 23 sample sites, two of which had duplicate samples collected. The goal was to collect water, sediment, macroinvertebrates, and fish samples from all sample sites [14 from ponded areas on ERF and goose Bay, seven from distributaries, and two from the Eagle River (one above and one below ERF)]. The macroinvertebrate populations in the Eagle River were not sampled because of the habitat differences. Water samples were not collected from three of the distributary sites because there was incomplete flooding and therefore no discharge. The sampling scheme is outlined in Appendix D.

(1) Shallow Ponds. There were three sample sites each in the Bread Truck Area and in Area C with one sample site from Area C having a duplicate sample collected. Area A, Area C/D, Racine Island and Goose Bay (reference site) each had two sample sites. These ponded areas were sampled to compare the concentration of contaminants to the condition of the benthic macroinvertebrate populations. The study was conducted in July so the macroinvertebrates would be under maximum environmental stress from low water, high salinity, and high temperatures; thus, leaving them most vulnerable to the effects of WP.

(2) Distributaries (Gullies connecting the flats to the river through the levee). The flow rate in the Eagle River averages over 1500 ft^3/sec during July with peak flows of more than 2300 ft^3/sec. Due to the diluting effect of the massive flow rate, contaminant levels in the Eagle River may be below our detection limits. Therefore, to determine concentration of

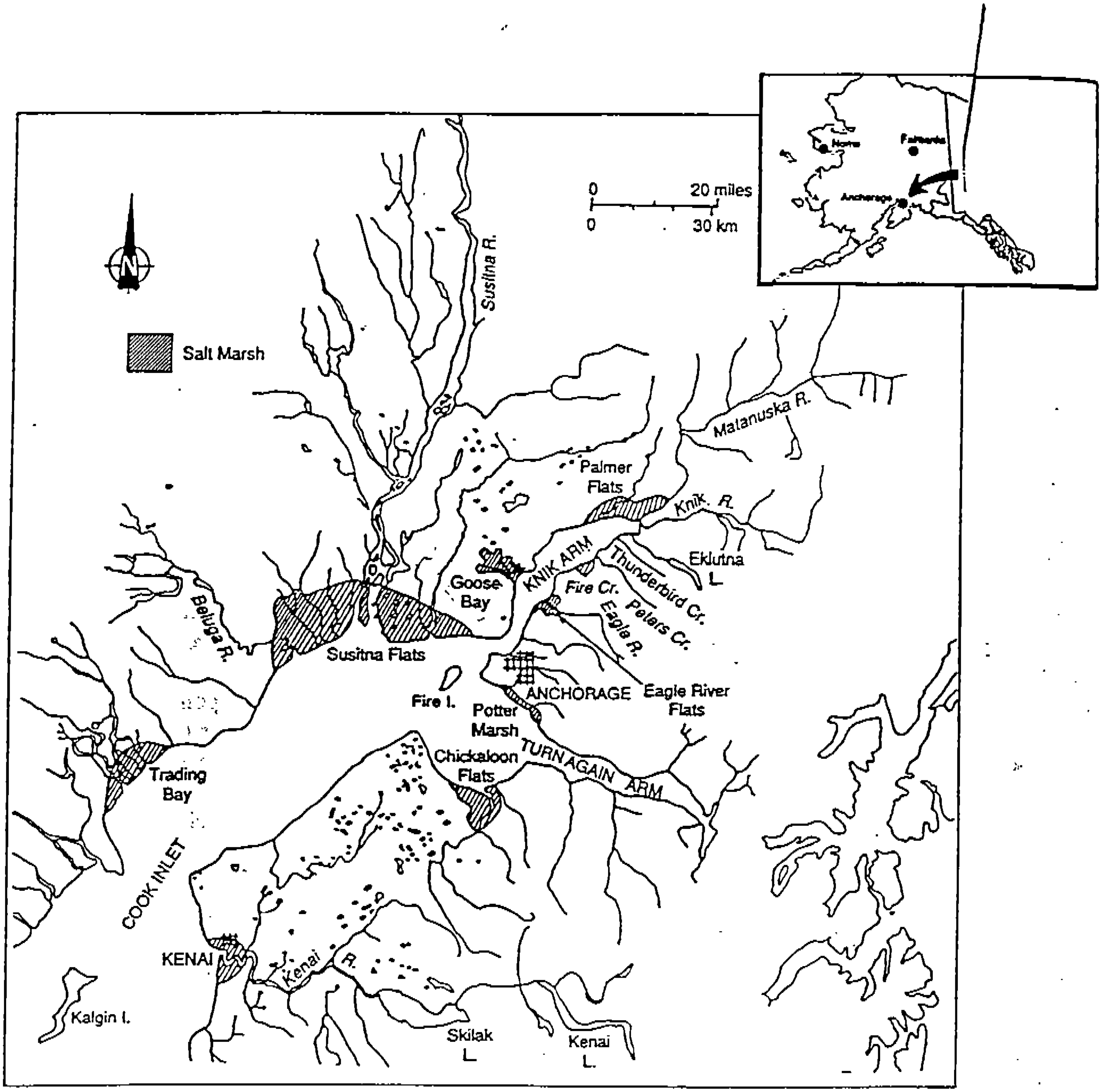

Figure 1. Upper Cook Inlet area in southcentral Alaska (inset) showing location of Eagle River Flats, Ft. Richardson, and other estuarine salt marshes used by migrating waterfowl.

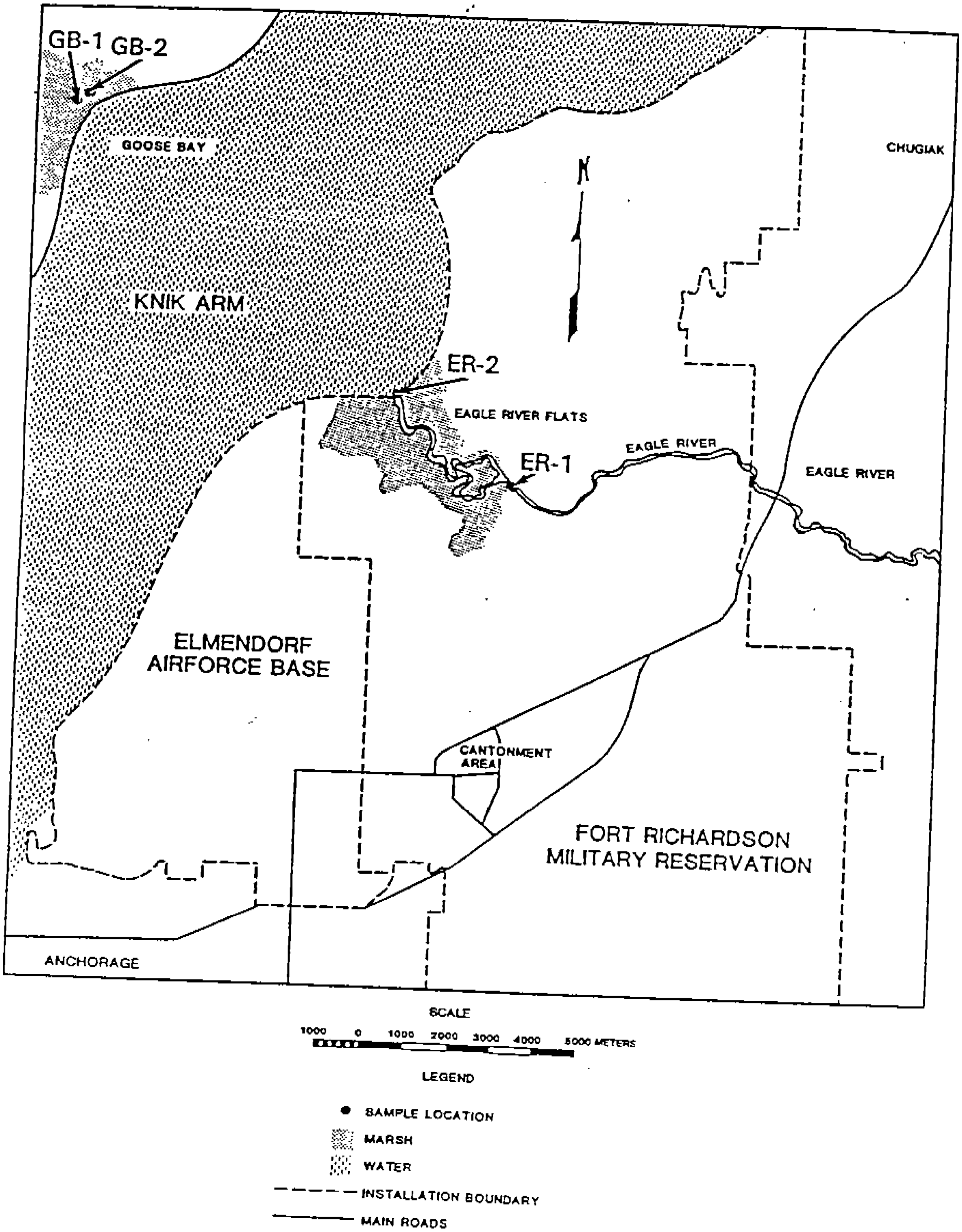

FIGURE 2. SAMPLE SITE LOCATIONS AT EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993

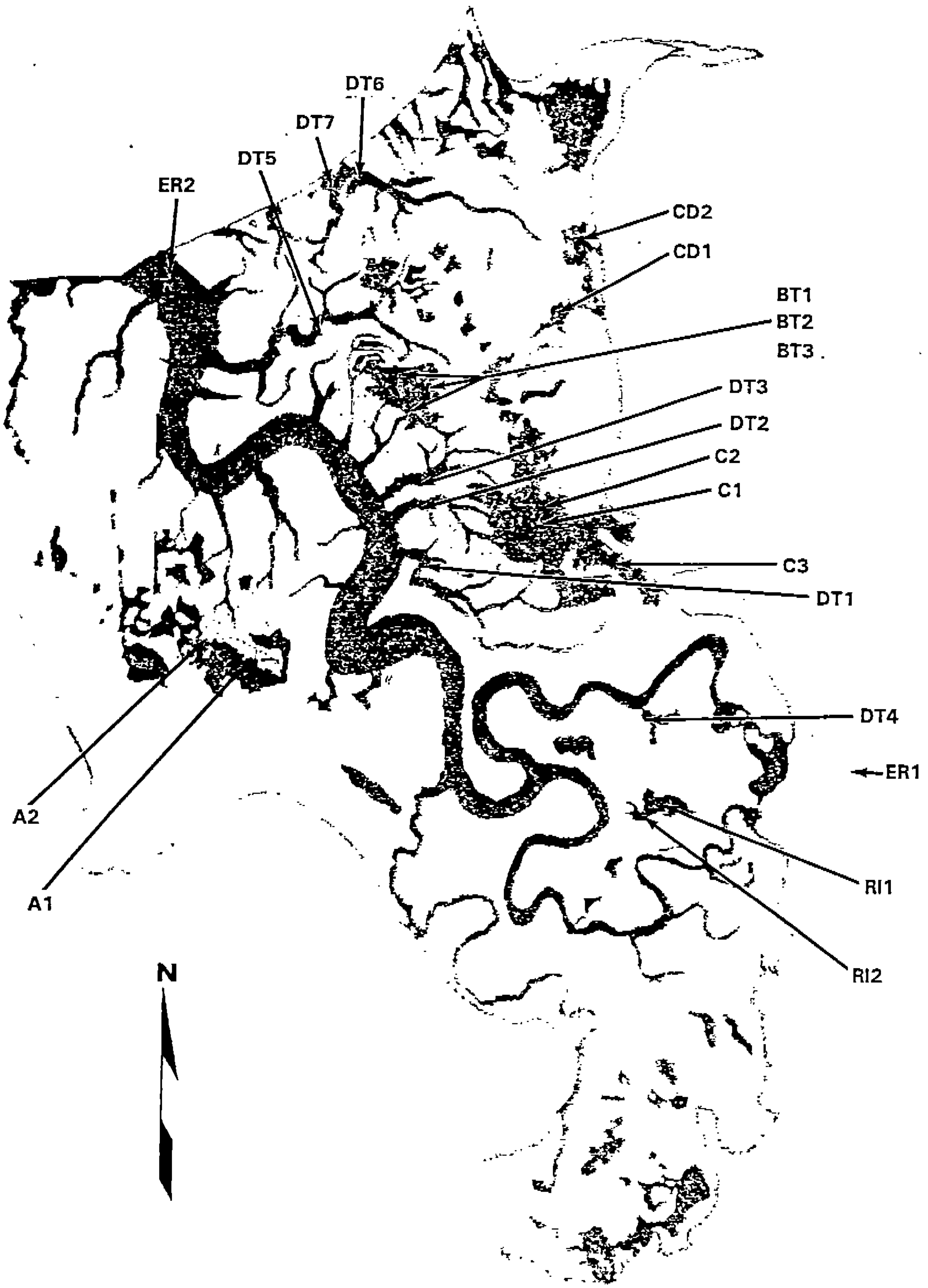

Figure 3.

Water, Sediment, and Macroinvertebrate Sample Sites
Eagle River Flats, Fort Richardson, Alaska
July 1993

TABLE 1. COORDINATES FOR SAMPLE SITE LOCATIONS, EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993

Sample Site	UTM Coordinates East	UTM Coordinates West	Date Collected Sed/Invert.	Date Collected Water
ER1	353600.00	6802300.00	7/20 NI	7/20
ER2 & DUP2	356195.00	6801203.00	7/21 NI	7/21
DT1	354570.00	6801150.00	7/16	NC
DT2	354525.00	6801325.00	7/16	NC
DT3	354500.00	6801400.00	7/16	NC
DT4	355570.00	6800600.00	7/21 NI	7/21
DT5	354351.00	6802027.00	7/16	7/21
DT6	354465.00	6802508.00	7/16	7/21
DT7	354272.00	6802376.00	7/16	7/21
A1	354000.00	6800700.00	7/19	7/19
A2	353700.00	6800975.00	7/19	7/19
CD1	355200.00	6802350.00	7/18	7/18
CD2	355325.00	6801175.00	7/18	7/18
BT1	354615.00	6801750.00	7/14	7/14
BT2	354620.00	6801675.00	7/14	7/14
BT3	354620.00	6801850.00	7/20	7/20
C1	355100.00	6801300.00	7/14	7/14
C2	355170.00	6801300.00	7/14	7/14
C3	355325.00	6801175.00	7/15	7/15
DUP1 (C3)	355325.00	6801175.00	7/21	7/21
RI1	355474.00	6800291.00	7/19	7/19
RI2	355474.00	6800252.00	7/19	7/19

NI = No Invertebrates sample at these locations due to differences in habitat.
NC = Not collected due to lack of runoff.

contaminants leaving ERF, seven distributaries were sampled before they enter the Eagle River. The samples in the distributaries were collected shortly before a low tide that followed an ERF inundating high tide. This was required to get the worst-case scenario for the amount of contaminants leaving the flats and entering the Eagle River. However, not all areas of ERF flooded completely. Therefore, water samples were collected from only those distributaries that were receiving runoff from the ponded areas.

(3) Eagle River. There were two sample sites on the Eagle River, one above ERF and one below ERF. The sample site below ERF had duplicate samples collected.

d. Analytical Procedures. Analytical methods used in this study are presented in Appendix E. Appendix F presents analytical sample collection requirements.

e. Onsite Measurements. The temperature, conductivity, salinity, dissolved oxygen, pH, and oxidation reduction potential were determined at each sample site using instrumentation calibrated daily following manufacturer's instructions.

f. Water Sampling. The water was collected directly into labeled sample containers for each of the chemical groupings. The samples requiring preservation were then preserved, and all samples were placed in ice chests and covered with ice. The dissolved metals and WP were filtered in the field using a portable pump and a high rate filter. The filter apparatus took water directly from the source to the sample container. Analytical samples were sent next-day delivery to the U.S. Army Environmental Hygiene Agency's chemical laboratory except for WP. The WP was sent to and analyzed by CRREL.

g. Sediment Sampling.

(1) The sediment sampling equipment was decontaminated between sample sites following procedures outlined below.

(a) Wash with phosphate free detergent water.

(b) Rinse with deionized water.

(c) Rinse with analytical grade acetone.

(d) Air dry.

(e) Covered with aluminum foil.

(2) Sediments were collected by scooping the top 3 to 4 inches of sediment into a stainless steel bucket and thoroughly mixing with a stainless steel spoon and scooped into the sample containers. Dredges or core tubes were not used because encountering unexploded ordinance was too high a risk. The samples were iced, packed, and shipped the same as the water samples.

h. Macroinvertebrate Sampling. Benthic macroinvertebrates (bottom dwelling aquatic insects, crustaceans, and other invertebrates) were collected in all the pond locations including the two control locations in Goose Bay. Macroinvertebrate samples were collected from distributaries where ponding occurred at low tide. Macroinvertebrate samples were not collected from the Eagle River because the above and below ERF sample sites varied substantially in habitat type. Three 1-square foot subsamples were collected at each sample site. A 1-square foot frame was used to delineate the area to be subsampled. The sediment within the frame was hand scooped into a sieve bucket that had a #30 standard mesh screen in the bottom. The sediments were washed through the screen. The organisms and detritus were then placed into a liter plastic bottle and preserved in 6-10 percent formalin with Rose Bengal dye that stains the organisms to aid in later sorting. The organisms were sorted, identified to species when possible, and counted. The diversity (H), species richness, percent contribution of dominant species, and similarity between samples were calculated according to definitions in paragraph 10h(2).

(1) Rationale for Biological Sampling. It is widely recognized that biota accurately reflect the quality of the environment in which they live. Many biological indices/indicator organisms have been used to evaluate environmental stress (references 9, 10, 11, 12, and 13). The usefulness of biota as indicators of environmental quality results from a number of biological characteristics.

(a) Ecological Importance. An ecosystem is a natural unit of living and environmental components which interact to form a stable system. A change in one component normally disturbs the balance and causes changes throughout the system.

(b) Mobility. Many organisms are either attached to the substrate or have limited mobility. When these organisms are exposed to environmental changes, e.g., pollution, they must adapt or perish. Others that can move about freely normally seek an environment suited for their survival, adapt, or perish. Thus, the organisms present in an ecosystem are dependent on physical, chemical, and biological environmental factors.

(c) Sensitivity to Pollutants. Many members of these communities are very sensitive to physical and/or chemical stresses and, depending on the nature and concentration of pollutants, are often eliminated or reduced in number. Conversely, a limited number of more tolerant species often become relatively or absolutely more abundant. The tolerance or sensitivity of some of these organisms to certain types of pollutants has been established, and these organisms can be used as indicators of either healthy or polluted conditions, e.g., certain species of mayflies indicate healthy conditions and tubifex worms indicate polluted conditions.

(d) Community Structure. Environmental impact is also reflected by changes in community structure. Communities impacted by environmental stress are typically composed of a small number of species represented by large numbers of individuals (low diversity), whereas those unimpacted have many different species with relatively few individuals in a given species (high diversity). Diversity can be quantified using a diversity formula, and resultant values are used to determine whether or not an environmental perturbation is adversely impacting upon the ecosystem and the extent of that impact. This comparative use of community diversity results in a simple and quantitative summary of pollutional impact.

(2) Data Analysis.

(a) Species Diversity. The diversity (H) was calculated according to Brillouins (reference 14) Diversity Index as modified by Patten (reference 15), incorporating Stirling's approximation for logarithms of factorials, in order to minimize the bias resulting from rare species (reference 16).

$$H = C/N\ [N(\ln N-1) + 1/2 \ln 2\pi N - \sum_{i=1}^{S} \{n_i(\ln n_i-1) + 1/2 \ln 2\pi n_i\}]$$

where:

n_i = total number of individuals in the i_{th} species
N = the total number of individuals
C = 1.442695 for conversion of natural logarithms
S = number of species

This treatment results in diversity values ranging from 0 to 3.321928 log N (reference 17).

(b) Species Richness. The total number of species present was used to help compare biological integrity between sample sites.

i. Laboratory Sediment Toxicity Study. A 30-day sediment toxicity study was conducted on the amphopod (Hyallela azteca) and the midge larva (Chironomus riparius) using ASTM methods (reference 18). A WP contaminated sediment collected from sample site RI2 was mixed with a reference sediment from Goose Bay in the following percentages; 100, 80, 60, 40, 20, and 0. The assays were conducted using five replicates of 200 mL of sediment with 800 mL of overlying water and exposing 20 organisms each. The amphopod bioassay measures survival and reproduction, and the midge bioassay measures survival and emergence.

11. RESULTS AND DISCUSSION. The analytical data are presented in Appendix I.

a. White Phosphorus. A summary of the WP analyses is presented in Table 2. There was no WP detected in either the water or sediment samples from the Eagle River or the distributaries. The WP was detected at 5 of the 12 ponded area sample sites. Where detected, WP concentrations ranged from 14.3 to 1,740,000 μg/kg in the sediments (detection limit 0.88 μg/kg), 0.013 to 0.069 μg/L total WP in the water, and 0.005 to 0.048 μg/L dissolved WP in the water (detection limit 0.01 μg/L). There was no WP detected in the fish (detection limit 10 μg/kg) collected from the ponded areas, even though WP was detected in five of the corresponding water and sediment samples.

b. Field Measurements. The dissolved oxygen was generally high, even above saturation because of aquatic plant growth. The only sample sites below 5 mg/L were RI1, and RI2 on Racine Island. Salinity/conductivity ranged from fresh water to 150 percent that of sea water. Temperature ranged from 7.7 °C in the Eagle River to 30.9 °C in the Bread Truck Area. The pH was generally above 7 but ranged from 6.6 to 9.9 standard pH units. The oxygen reduction potential (ORP) ranged from -118 to 147 in the water and -406 to 114 in the sediment. It was felt that the ORP could be an indication of the presence of WP, but the correlation was very poor. The ORP is more a measure of the potential for WP to be stored in the sediment.

c. Nonmetal Inorganic Compounds. These results were typical of what would be expected in a dynamic tidal wetland with a glacial fed river and surging 30 feet plus esturine tides that flood the wetlands on a lunar cycle when the tides exceed 31 feet above mean low tide. There are one to two cycles in the summer where tides do not exceed 31 feet. The last flooding tide was about 12 weeks before this study. Several of the ponded areas had evaporated to the extent that salinity was as much as 150 percent that of sea water.

d. Metals. Metals in water were within freshwater criteria based on site-specific hardness. Because of the large amount of metals that could be contributed by the suspended solids from the glacial flour, dissolved metals (form biologically available) was measured and used for criterion comparison. There were several metals in the sediment that were slightly higher than they were in the Goose Bay samples (reference site). Except for sodium (salinity related), all sediment metal concentrations were within the upper 95 percentile of the sediments from Goose Bay and within the level of variance seen in the duplicate samples.

TABLE 2. SUMMARY OF WP DATA, EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993

Sample Site	Water (μg/L) Dissolved WP	Water (μg/L) Total WP	Wet Weight Sediment (μg/kg) Total WP	Wet Weight Fish (μg/kg) Total WP
ER1	NA	<0.01	<0.88	NC
ER2	NA	<0.01	<0.88	NC
DUP2*	NA	<0.01	<0.88	NC
DT1	NC	NC	<0.88	NC
DT2	NC	NC	<0.88	NC
DT3	NC	NC	<0.88	NC
DT4	NA	<0.01	<0.88	NC
DT5	NA	<0.01	<0.88	NC
DT6	NA	<0.01	<0.88	NC
DT7	NA	<0.01	<0.88	NC
A1	NA	<0.01	<0.88	<10
A2	NA	<0.01	<0.88	<10
CD1	NA	<0.01	<0.88	<10
CD2	NA	<0.01	<0.88	<10
BT1	NA	<0.01	<0.88	<10
BT2	NA	<0.01	<0.88	<10
BT3	0.006	0.011	79	<10
C1	NA	<0.01	<0.88	<10
C2	0.012	0.016	1600	<10
C3	0.005	0.013	430	<10
DUP1*	0.014	0.069	205	<10
RI1	0.009	0.043	14.3	<10
RI2	0.014	0.020	1,700,000	<10
GB1	NA	<0.01	<0.88	<10
GB2	NA	<0.01	<0.88	<10

* DUP1 is a duplicate sample for C3, and DUP2 is a duplicate sample for ER2.
NA = Not Analyzed.
NC = Not Collected.

e. Volatile and Base/Neutral/Acid Extractable Organic Compounds. Except for two low level detections, one of bis(2-ethylhexyl)phthalate at DUP2 and one of methylene chloride at CD2 there were no volatile, or base/neutral/acid extractable organic compounds detected in any of the water or sediment samples. Both compounds are often laboratory contaminants. Therefore, their detection is questionable.

f. Pesticides/PCBs and Herbicides. There were no pesticides/PCBs or herbicides detected in any of the water or sediment samples.

g. Explosives. No compounds of explosives or their breakdown products were detected in any of the water or sediment samples.

h. Benthic Macroinvertebrates. The benthic macroinvertebrate data is presented in Appendix I and summarized in Table 3.

(1) The benthic macroinvertebrate populations were limited in number of species present. The maximum number of species collected at a sample site was six (GB2 and DT1). The lowest number of species collected at a sample site was two (BT2, C3, and A2). The most dominate species were the midge (Chiromomus salinarius) and the oligocheate (Nais varialis), both are tolerant organisms as are most the other species collected.

(2) Statistical analysis of the data at the 95 percent confidence level indicates that the number of species and diversity was not significantly different in WP contaminated sites. However, the number of organisms per unit area of substrate was significantly lower at the WP contaminated sites than at the uncontaminated sites within the ponded areas of ERF. This would indicate that WP could be having a biological effect. However, if WP concentrations are compared to numbers of individuals within contaminated sites, the reverse correlation is strongest. The highest WP concentration generally had the higher number of organisms. If WP was having an adverse biological effect, the variability of the biological and chemical data may have been confounding any conclusive findings.

(3) The benthic macroinvertebrate populations in the distributaries had a statistically higher mean number of species and mean diversity than uncontaminated ponded areas of ERF. This is likely due to the daily exchange of water reducing the environmental stress.

i. Sediment Toxicity Study Using WP Contaminated Sediments. The sediment toxicity tests did not agree with the results of the benthic macroinvertebrate sampling. A summary of the results is presented in Tables 4-6.

(1) All the organisms in both the amphopod (Hyallela azteca) and midge larvae (Chironomus riparius) toxicity tests died; sediments with 20 percent WP contaminated sediment were the lowest concentrations tested. The WP concentration in the 20 percent

TABLE 3. SUMMARY OF BENTHIC MACROINVERTEBRATE RESULTS, EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993

Sample Site	Number of Species	Number of Individuals	Diversity H	Sediment WP µg/kg
DT1 A	5	176	0.37	
B	4	448	0.26	
C	4	152	0.19	
Total	6	776	0.30	<0.88
DT2 A	5	44	1.53	
B	4	93	0.98	
C	3	78	1.02	
Total	5	215	1.25	<0.88
DT3 A	4	70	0.34	
B	4	79	0.61	
C	3	153	0.28	
Total	4	302	0.43	<0.88
DT5 A	3	48	1.00	
B	3	936	0.20	
C	2	309	0.45	
Total	4	1293	0.33	<0.88
DT7 A	3	724	0.05	
B	3	692	0.10	
C	3	657	0.11	
Total	4	2073	0.09	<0.88
A1 A	3	623	0.10	
B	2	507	0.07	
C	1	462	0.00	
Total	3	1592	0.07	<0.88
A2 A	1	541	0.00	
B	1	509	0.00	
C	2	1007	0.03	
Total	2	2057	0.01	<0.88

TABLE 3. SUMMARY OF BENTHIC MACROINVERTEBRATE RESULTS, EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993 (Continued)

Sample Site	Number of Species	Number of Individuals	Diversity H	Sediment WP µg/kg
CD1 A	2	29	0.17	
B	3	39	0.55	
C	2	21	0.50	
Total	4	89	0.51	<0.88
CD2 A	4	132	0.47	
B	1	126	0.00	
C	2	77	0.08	
Total	4	335	0.25	<0.88
BT1 A	4	336	0.29	
B	2	233	0.03	
C	3	526	0.05	
Total	5	1095	0.14	<0.88
BT2 A	2	383	0.04	
B	1	884	0.00	
C	2	772	0.01	
Total	2	2036	0.01	<0.88
BT3 A	3	282	0.08	
B	2	59	0.10	
C	4	116	0.54	
Total	4	457	0.26	79
C1 A	3	1373	0.03	
B	2	1606	0.02	
C	1	753	0.00	
Total	3	3732	0.02	<0.88
C2 A	2	137	0.05	
B	3	113	0.27	
C	1	420	0.00	
Total	3	670	0.08	1600

TABLE 3. SUMMARY OF BENTHIC MACROINVERTEBRATE RESULTS, EAGLE RIVER FLATS, FORT RICHARDSON, ALASKA, JULY 1993 (Continued)

Sample Site	Number of Species	Number of Individuals	Diversity H	Sediment WP μg/kg
C3 A	1	238	0.00	
B	2	32	0.16	
C	1	4	0.00	
Total	2	274	0.12	430
DUP1 A	0	0	0.00	
B	2	63	0.93	
C	3	75	0.24	
Total	3	138	0.75	205
RI1 A	1	7	0.00	
B	2	7	0.74	
C	3	8	0.95	
Total	3	22	1.03	14.3
RI2 A	5	69	1.27	
B	4	84	1.60	
C	4	89	1.46	
Total	5	242	1.78	1,740,000
GB1 A	1	1347	0.00	
B	4	88	0.74	
C	1	562	0.00	
Total	4	1997	0.07	<0.88
GB2 A	6	301	2.07	
B	5	386	1.76	
C	5	1081	0.96	
Total	6	1768	1.72	<0.88

Chironomus riparius
30–Day Survival and Reproduction Test

Sample Identity	Replicate	Survival (%)	Average Survival (%)	Significant Difference (p=.05)	Emergence (%)	Average Emergence (%)	Significant Difference (p=.05)
Control	A	95			85		
	B	90			70		
	C	80			60		
	D	90			80		
	E	100	91		70	73	
Reference	A	85			40		
	B	80			30		
	C	70			35		
	D	75			10		
	E	75	77		35	30	
20%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0	*
40%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0	*
60%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0	*
80%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0	*
100%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0	*

* Significantly less than reference sample

Hyallela azteca
30–Day Survival and Reproduction Test

Sample Identity	Replicate	Survival (%)	Average Survival (%)	Significant Difference (p=.05)	Reproduction (# of young)	Average Reproduction (# of young)	Significant Difference (p=.05)
Control	A	85			5		
	B	100			25		
	C	95			7		
	D	85			18		
	E	90	91		12	13.4	
Reference	A	80			0		
	B	70			16		
	C	65			0		
	D	60			0		
	E	75	70		9	5.0	
20%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0.0	
40%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0.0	
60%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0.0	
80%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0	0.0	
100%	A	0			0		
	B	0			0		
	C	0			0		
	D	0			0		
	E	0	0	*	0		

* Significantly less than reference sample

TABLE 6. WHITE PHOSPHORUS CONCENTRATIONS FROM SEDIMENT TOXICITY STUDY

% WP Sediment	Day 1	Day 3	Day 10	Day 23	Day 31
0%					
Sediment mg/kg	<0.001				NA
	<0.001				<0.001
20%					
Sediment mg/kg	469				50
	57				202
40%					
Sediment mg/kg	539				710
	801				172
60%					
Sediment mg/kg	1578				925
	812				855
80%					
Sediment mg/kg	1026				1959*
	977				717
100%					
Sediment mg/kg	1168				1830*
	1108				5384*
	1735				
	1783				
	1458				
0%					
Water µg/L Dis.	<0.2	<0.2	<0.2	<0.2	<0.2
Water µg/L Total	<0.2				<0.2
20%					
Water µg/L Dis.	14.7	9.70	2.10	2.73	1.32
Water µg/L Total	23.7				2.54
40%					
Water µg/L Dis.	30.4	21.8	11.9	9.59	NA
Water µg/L Total	41.1				7.00
60%					
Water µg/L Dis.	NA	25.9	12.5	19.5	4.71
Water µg/L Total	62.8				6.05

TABLE 6. WHITE PHOSPHORUS CONCENTRATIONS FROM SEDIMENT TOXICITY STUDY (Continued)

% WP Sediment	Day 1	Day 3	Day 10	Day 23	Day 31
80%					
Water µg/L Dis.	51.3	36.4	18.7	32.9	15.0
Water µg/L Total	60.7				27.2
100%					
Water µg/L Dis.	41.0	21.8	32.5	4.95	10.9
Water µg/L Total	62.2				12.3

* Caps broken off in shipment. Most of contents spilled.

sediment averaged 194,500 µg/kg. The water concentrations in the 20 percent dilution chambers were 23.7 µg/L total and 14.7 µg/L dissolved WP at the start of the test and 2.54 µg/L total and 1.32 µg/L dissolved WP at the end of the 30 day test. These water concentrations were far in excess of field samples collected over sediments with higher WP levels. A sediment concentration of 1,700,000 µg/kg Wp in the field had overlying water with 0.014 µg/L dissolved Wp and 0.020 µg/L total WP. This indicates that the toxicity test did a poor job of mimicking what was observed in the field. The WP concentrations in the water of the toxicity test, even at the end of 30 days, was 1,000 times that found in the field over equally contaminated sediments. In addition, the dissolved solids indicated that water in the ponded areas on ERF was concentrated 100-1,000 times by evaporation during 12 weeks without inundating tides. Theoretically this would have concentrated the WP as well.

(2) The toxicity tests need to be redone at lower WP concentrations to get a no observable effect level. But since organisms were living over sediments in ERF with higher concentrations than those found to be toxic in the toxicity test, it becomes obvious that the level of WP in the sediments that affect the natural aquatic organisms cannot be answered without altering this laboratory test. Renewal of the overlying water would better emulate field conditions.

(3) The literature indicates that levels less than 0.01 µg/L in the water and 2 µg/kg in the sediment would protect the aquatic organisms (reference 20). If the Army were to use these numbers, almost any detectable WP concentrations in the sediment would have to be cleaned up. More work needs to be done on the sediment concentration that causes an

aquatic problem. The lowest acute LC_{50} value I could find for the midge (Chironomus tentans) was 20 μg/L in a 120 hour toxicity test. The lowest LC_{50} for the amphopod (Gammerus facciotus) was 250 μg/L (reference 20). According to these values the amphopod should have survived our toxicity test if the water concentration of WP were the only cause of toxicity and our amphopod was equally sensitive to WP. The water concentration in our amphopod toxicity test was 23.7 μg/L.

12. CONCLUSIONS. Of all the chemicals analyzed, WP was the only one that could be attributed to the Army's activities at ERF. The data from this study indicates that it is unlikely WP cleanup levels would not be driven by effects on benthic macroinvertebrates or bioaccumulation in fish. There was weak evidence of WP affecting numbers of macroinvertebrates and no evidence that it affected what species that were present or species diversity. No WP was found in the stickleback fish living in the ponded areas of ERF even when they were collected from contaminated locations. The low levels of WP in the water of the ponded areas would be diluted far beyond the recommended safe concentration of 0.01 μg/L WP when flood tides carry this water to the Eagle River. During this study, the WP was already diluted past this concentration in the distributary waters. The discharge from the ponded areas was collected from the distributaries after the first inundating tide that followed 12 weeks of evaporation. The dissolved solids were concentrated 100-1,000 times.

13. RECOMMENDATIONS. Use the data collected in this study to help in the human health and ecological risk assessments.

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APPENDIX A

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APPENDIX B

SPECIES OBSERVED ON EAGLE RIVER FLATS

	Waterfowl
American wigeon	Anas americana
Green-winged teal	Anas crecca
Northern Pintail	Anas acuta
Mallard	Anas platyrhynchos
Northern shoveler	Anas clypeata
Canada goose	Branta canadensis
Tundra swan	Cygnus columbianus
Trumpeter swan	Cygnus buccinator
Greater white-fronted goose	Anser albifrons
Blue-winged teal	Anas discorsis
Ring-necked duck	Aythya collaris
Bufflehead	Bucephala albeola
Common merganser	Mergus merganser
Lesser scaup	Aythya affinis
Sandhill crane	Grus canadensis
	Gulls & Terns
Herring gull	Larus argentatus
Mew gull	Larus canus
Arctic tern	Sterna paradisea
	Raptors
Bald eagle	Haliaeetus leucocephalus
Common northern raven	Corvus corax
Northern harrier	Circus cyaneus
Merlin	Falco columbarius
Peregrine falcon	Falco peregrinus
Red-tailed hawk	Buteo jamaicensis
Rough-legged hawk	Buteo lagopus
Sharp-skinned hawk	Accipiter striatus
Kestrel	Falco sparverius
Northern goshawk	Accipiter gentilis

	Shorebirds
Red-necked phalarope	Phalaropus lobatus
Lesser yellowlegs	Tringa flavipes
Short-billed dowitcher	Limnodromus griseus
Pectoral sandpiper	Calidris melanotos
Common snipe	Gallinago gallinago
Wilson's phalarope	Phalaropus tricolor
Semipalmated plover	Charadruis semipalmatus
Hudsonian godwit	Limosa haemmastica
Whimbrel	Numenius phaeopus
Killdeer	Charadruis vociferus
Lesser golden plover	Pluvialis dominica
Solitary sandpiper	Tringa solitaria
Western sandpiper	Calidris mauri
	Other Birds
Violet-green swallow	Tachycineta thalassina
Rough-winged swallow	Stelgidopteryx serripennis
Tree swallow	Tachycineta bicolor
Bank swallow	Riparia riparia
Cliff swallow	Hirundo pyrrhonota
Belted kingfisher	Ceryle alcyon
Rusty blackbird	Euphagus carolinus
Savannah sparrow	Passerculus sandwichensis
Lapland longspur	Calcarius lapponicus
	Other Animals
Moose	Alces alces
Coyote	Canis latrans
Muskrat	Ondatra zibethicus
Beaver	Castor canadensis
Wood Frog	Rana sylvatica

APPENDIX C

CHEMICAL AND PHYSICAL PROPERTIES OF WHITE PHOSPHORUS

Molecular Structure[1]	P_4
Molecular Weight[1]	124 amu
Solid melting point[1]	44 °C
boiling point[1]	280 °C
Appearance[1]	Waxy Transparent Colorless (pure)
Mohs hardness[1]	0.5
Density (20 °C)[1]	1.8 g/cm^3
Vapor Pressure (20 °C)[2]	0.026 torr
Solubility in water (15 °C)[3]	2.4 mg/L
in olive oil[4]	12.5 g/L
in mineral oil	14.5 g/L
Octanol-water partition coefficient[3]	1200
Auto ignition temperature[5]	20-40 °C

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APPENDIX D

SAMPLING SCHEME, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

				Sample Site								
Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
Field Measured Characteristics												
Dissolved Oxygen	w	w	w	NA	NA	NA	w	w	w	w	w	w
Salinity	w	w	w	NA	NA	NA	w	w	w	w	w	w
Conductivity	w	w	w	NA	NA	NA	w	w	w	w	w	w
pH	w	w	w	NA	NA	NA	w	w	w	w	w	w
Temperature	w	w	w	NA	NA	NA	w	w	w	w	w	w
ORPotential	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Metals Total (water & sediment) and Dissolved (water)												
Aluminum	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Antimony	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Arsenic	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Barium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Beryllium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Cadmium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Calcium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chromium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Cobalt	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Copper	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Iron	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Lead	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Magnesium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Manganese	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Mercury	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Nickel	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Potassium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Selenium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws

See footnotes on page D-6.

Final Rpt, Receiving Water Biological Study No. 32-24-H1ZV-93, 12-23 Jul 93

Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
							Sample Site					
Metals Total (water & sediment) and Dissolved (water) (Continued)												
Sodium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Silver	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Thallium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Vanadium	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Zinc	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Nonmetals												
Alkalinity	w	w	w	NA	NA	NA	w	w	w	w	w	w
Hardness	w	w	w	NA	NA	NA	w	w	w	w	w	w
White Phosphorus	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Dissolved WP	w	w	w	NA	NA	NA	w	w	w	w	w	w
Chlorides	w	w	w	NA	NA	NA	w	w	w	w	w	w
Nitrate+Nitrite-N	w	w	w	NA	NA	NA	w	w	w	w	w	w
Ammonia-N	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Total Kjeldahl-N	w	w	w	NA	NA	NA	w	w	w	w	w	w
Total Nitrogen	s	s	s	s	s	s	s	s	s	s	s	s
Sulfates	w	w	w	NA	NA	NA	w	w	w	w	w	w
Total Sulfate	s	s	s	s	s	s	s	s	s	s	s	s
Total Phosphate-P	w	w	w	NA	NA	NA	w	w	w	w	w	w
Total Phosphorus	s	s	s	s	s	s	s	s	s	s	s	s
T-Organic Carbon	w	w	w	NA	NA	NA	w	w	w	w	w	w
T-organic Matter	s	s	s	s	s	s	s	s	s	s	s	s
T-Suspended Solids	w	w	w	NA	NA	NA	w	w	w	w	w	w
T-Dissolved Solids	w	w	w	NA	NA	NA	w	w	w	w	w	w
Explosives												
2,4,6-TNT	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4-DNT	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,6-DNT	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Nitrotoluene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,3-DNB	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,3,5-TNB	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Nitrobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
TETRYL	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
RDX	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
HMX	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws

See footnotes on page D-6.

Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
				Sample Site								
Volatile Organics												
1,1,1-Trichloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,1,2,2-Tetrachloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,1,2-Trichloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,1-Dichloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,2-Dichloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,2-Dichloroethene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,2-Dichloropropane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,2-Dichlorobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,3-Dichlorobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
1,4-Dichlorobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bromodichloromethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bromoform	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bromoethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Carbon Tetrachloride	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chlorobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chloroform	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chloromethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Ethylbenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Methylene Chloride	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Tetrachloroethylene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Toluene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Trichloroethylene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Xylene, Total Combined	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
cis-1,3-Dichloropropylene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
trans-1,3-Dichloropropene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Semivolatile Organic Compounds												
2,4,5-Trichlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4,6-Trichlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4-Dichlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4-Dimethylphenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4-Dinitrophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,4-Dinitrotoluene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2,6-Dinitrotoluene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Chloronaphthalene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Chlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws

See footnotes no page D-6.

Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
				Sample Site								
Semivolatile Organic Compounds (Continued)												
2-Methyl-4,6-Dinitrophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-methylnaphthalene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Methylphenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Nitroaniline	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
2-Nitrophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
3,3-Dichlorobenzidine	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
3-Methyl-4-Chlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
3-Nitroaniline	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Bromophenylether	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Chloroaniline	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Chlorophenylphenylether	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Methylphenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Nitroaniline	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
4-Nitrophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Acenaphthene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Acenaphthylene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Anthracene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzo(a)Anthracene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzo(a)Pyrene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzo(b)Fluoranthene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzo(g,h,i)Perylene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Benzo(k)Fluoranthene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bis(2-chloroethoxy)Methane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bis(2-chloroethyl)Ether	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bis(2-chloroisopropyl)ether	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Bis(2-ethylhexyl)Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Butylbenzyl Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chrysene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Di-n-butyl Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Di-n-octyl Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Dibenz(a,h)Anthracene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Dibenzofuran	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Diethyl Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Dimethyl Phthalate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Fluoranthene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Fluorene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Hexachlorobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Hexachlorobutadiene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Hexachlorocyclopentadiene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws

See footnotes on page D-6.

Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
				Sample Site								
Semivolatile Organic Compounds (Continued)												
Hexachloroethane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Indeno(1,2,3-c,d)Pyrene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Isophorone	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
N-Nitrosodi-n-Propylamine	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
N-Nitrosodiphenylamine	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Naphthalene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Nitrobenzene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Pentachlorophenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Phenanthrene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Phenol	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Pyrene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Pesticides/PCBs												
DDT	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
DDD	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
DDE	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Aldrin	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Dieldrin	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Endosulfan Sulfate	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Endrin	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Endrin Aldehyde	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Endrin Ketone	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Heptachlor	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Heptachlor Epoxide	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Lindane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Methoxychlor	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Toxaphene	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
alpha-Chlordane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
alpha-Endosulfan	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
beta-Benzenehexachloride	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
beta-Endosulfan	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
delta-Benzenehexachloride	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
gamma-Chlordane	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1016	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1221	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1232	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1242	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1248	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws

See footnotes on page D-6.

Parameter	ER1	ER2	DUP2	DT1	DT2	DT3	DT4	DT5	DT6	DT7	A1	A2
				Sample Site								
Pesticides/PCBs (Continued)												
PCB 1254	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
PCB 1260	ws	ws	ws	s	s	s	ws	ws	ws	ws	ws	ws
Chlorinated Herbicides												
Dalapon	w	w	w	NA	NA	NA	w	w	w	w	w	w
Dicamba	w	w	w	NA	NA	NA	w	w	w	w	w	w
Dinoseb	w	w	w	NA	NA	NA	w	w	w	w	w	w
2,4,5-Trichlorophenoxyacetic Acid	w	w	w	NA	NA	NA	w	w	w	w	w	w
2,4-Dichlorophenoxyacetic Acid	w	w	w	NA	NA	NA	w	w	w	w	w	w
4-(2,4-Dichlorophenoxy)Butyric Acid	w	w	w	NA	NA	NA	w	w	w	w	w	w
Pentichlorophenol	w	w	w	NA	NA	NA	w	w	w	w	w	w
Picloram	w	w	w	NA	NA	NA	w	w	w	w	w	w
Silvex	w	w	w	NA	NA	NA	w	w	w	w	w	w

w = Water sample collected and analyzed.
s = Sediment sample collected and analyzed.
NA = Not analyzed, associated ponded areas did not flood enough to discharge through these distributaries.

Parameter	Sample Site BT1	BT2	BT3	C1	C2	C3	DUP1	RI1	RI2	CD1	CD2	GB1	GB2
Field Measured Characteristics													
Dissolved Oxygen	w	w	w	w	w	w	w	w	w	w	w	w	w
Salinity	w	w	w	w	w	w	w	w	w	w	w	w	w
Conductivity	w	w	w	w	w	w	w	w	w	w	w	w	w
pH	w	w	w	w	w	w	w	w	w	w	w	w	w
Temperature	w	w	w	w	w	w	w	w	w	w	w	w	w
ORPotential	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Metals Total (water & sediment) and Dissolved (water)													
Aluminum	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Antimony	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Arsenic	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Barium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Beryllium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Cadmium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Calcium (Total)	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chromium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Cobalt	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Copper	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Iron	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Lead	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Magnesium (Total)	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Manganese	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Mercury	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Nickel	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Potassium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Selenium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Sodium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Silver	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Thallium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Vanadium	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Zinc	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Nonmetals													
Alkalinity	w	w	w	w	w	w	w	w	w	w	w	w	w
Hardness	w	w	w	w	w	w	w	w	w	w	w	w	w
Chlorides	w	w	w	w	w	w	w	w	w	w	w	w	w
White Phosphorus	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Dissolved WP	w	w	w	w	w	w	w	w	w	w	w	w	w

See footnotes on page D-11.

	Sample Site												
Parameter	BT1	BT2	BT3	C1	C2	C3	DUP1	RI1	RI2	CD1	CD2	GB1	GB2
Nonmetals (Continued)													
Nitrate+Nitrite-N	w	w	w	w	w	w	w	w	w	w	w	w	w
Ammonia-N	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Total Kjeldahl-N	w	w	w	w	w	w	w	w	w	w	w	w	w
Total Nitrogen	s	s	s	s	s	s	s	s	s	s	s	s	s
Sulfates	w	w	w	w	w	w	w	w	w	w	w	w	w
Total Sulfate	s	s	s	s	s	s	s	s	s	s	s	s	s
Total Phosphate-P	w	w	w	w	w	w	w	w	w	w	w	w	w
Total Phosphorus	s	s	s	s	s	s	s	s	s	s	s	s	s
T-Organic Carbon	w	w	w	w	w	w	w	w	w	w	w	w	w
T-organic Matter	s	s	s	s	s	s	s	s	s	s	s	s	s
T-Suspended Solids	w	w	w	w	w	w	w	w	w	w	w	w	w
T-Dissolved Solids	w	w	w	w	w	w	w	w	w	w	w	w	w
Explosives													
2,4,6-TNT	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4-DNT	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,6-DNT	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Nitrotoluene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,3-DNB	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,3,5-TNB	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Nitrobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
TETRYL	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
RDX	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
HMX	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Volatile Organics													
1,1,1-Trichloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,1,2,2-Tetrachloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,1,2-Trichloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,1-Dichloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,2-Dichloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,2-Dichloroethene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,2-Dichloropropane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,2-Dichlorobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,3-Dichlorobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
1,4-Dichlorobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws

See footnotes on page D-11.

Parameter	Sample Site BT1	BT2	BT3	C1	C2	C3	DUP1	RI1	RI2	CD1	CD2	GB1	GB2
Volatile Organics (Continued)													
Bromodichloromethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bromoform	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bromoethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Carbon Tetrachloride	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chlorobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chloroform	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chloromethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Ethylbenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Methylene Chloride	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Tetrachloroethylene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Toluene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Trichloroethylene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Xylene, Total Combined	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
cis-1,3-Dichloropropylene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
trans-1,3-Dichloropropene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Semivolatile (BNA) Organic Compounds													
2,4,5-Trichlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4,6-Trichlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4-Dichlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4-Dimethylphenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4-Dinitrophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,4-Dinitrotoluene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2,6-Dinitrotoluene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Chloronaphthalene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Chlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Methyl-4,6-Dinitrophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-methylnaphthalene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Methylphenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Nitroaniline	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
2-Nitrophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
3,3-Dichlorobenzidine	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
3-Methyl-4-Chlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
3-Nitroaniline	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
4-Bromophenylether	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
4-Chloroaniline	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
4-Chlorophenylphenylether	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws

See footnotes on page D-11.

	Sample Site												
Parameter	BT1	BT2	BT3	C1	C2	C3	DUP1	RI1	RI2	CD1	CD2	GB1	GB2
Semivolatile (BNA) Organic Compounds (Continued)													
4-Methylphenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
4-Nitroaniline	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
4-Nitrophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Acenaphthene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Acenaphthylene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Anthracene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzo(a)Anthracene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzo(a)Pyrene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzo(b)Fluoranthene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzo(g,h,i)Perylene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Benzo(k)Fluoranthene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bis(2-chloroethoxy)Methane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bis(2-chloroethyl)Ether	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bis(2-chloroisopropyl)ether	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Bis(2-ethylhexyl)Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Butylbenzyl Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chrysene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Di-n-butyl Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Di-n-octyl Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Dibenz(a,h)Anthracene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Dibenzofuran	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Diethyl Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Dimethyl Phthalate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Fluoranthene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Fluorene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Hexachlorobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Hexachlorobutadiene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Hexachlorocyclopentadiene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Hexachloroethane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Indeno(1,2,3-c,d)Pyrene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Isophorone	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
N-Nitrosodi-n-Propylamine	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
N-Nitrosodiphenylamine	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Naphthalene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Nitrobenzene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Pentachlorophenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Phenanthrene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Phenol	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Pyrene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws

See footnotes on page D-11.

	Sample Site												
Parameter	BT1	BT2	BT3	C1	C2	C3	DUP1	RI1	RI2	CD1	CD2	GB1	GB2
Pesticides/PCBs													
DDT	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
DDD	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
DDE	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Aldrin	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Dieldrin	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Endosulfan Sulfate	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Endrin	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Endrin Aldehyde	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Endrin Ketone	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Heptachlor	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Heptachlor Epoxide	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Lindane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Methoxychlor	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Toxaphene	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
alpha-Benzenehexachloride	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
alpha-Chlordane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
alpha-Endosulfan	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
beta-Benzenehexachloride	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
beta-Endosulfan	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
delta-Benzenehexachloride	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
gamma-Chlordane	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1016	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1221	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1232	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1242	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1248	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1254	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
PCB 1260	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws	ws
Chlorinated Herbicides													
Dalapon	w	w	w	w	w	w	w	w	w	w	w	w	w
Dicamba	w	w	w	w	w	w	w	w	w	w	w	w	w
Dinoseb	w	w	w	w	w	w	w	w	w	w	w	w	w
2,4,5-Trichlorophenoxyacetic Acid	w	w	w	w	w	w	w	w	w	w	w	w	w
2,4-Dichlorophenoxyacetic Acid	w	w	w	w	w	w	w	w	w	w	w	w	w
4-(2,4-Dichlorophenoxy)Butyric Acid	w	w	w	w	w	w	w	w	w	w	w	w	w
Pentichlorophenol	w	w	w	w	w	w	w	w	w	w	w	w	w
Picloram	w	w	w	w	w	w	w	w	w	w	w	w	w
Silvex	w	w	w	w	w	w	w	w	w	w	w	w	w

w = Water sample collected and analyzed.
s = Sediment sample collected and analyzed.

APPENDIX E

ANALYTICAL METHODS USED FOR THIS STUDY

Characteristic	Reference	Method
Water		
pH	EPA 360.1*	Electrochemical
Conductivity	EPA 121.1*	Specific Conductance, µmhos at 25 °C
Dissolved Oxygen	EPA 360.1*	Electrochemical membrane
Temperature	EPA 170.1*	Thermometric
Total Dissolved Solids	EPA 120.1*	Gravimetric, dried at 103-105 °C
Total Suspended Solids	EPA 160.2*	Gravimetric, dried at 103-105 °C
Alkalinity	EPA 310.1*	Titration to pH 4.5
Hardness	SM 2340 B†	Calculated, Atomic Absorption
Ammonia-Nitrogen	EPA 350.1*	Automated Phenate Following Distillation
Nitrate+Nitrite-Nitrogen	EPA 353.2*	Automated Cadmium Reduction
Total Kjeldahl-Nitrogen	EPA 351.1*	Automated Phenate
Total Phosphate-Phosphorus	EPA 365.2*	Spectrophotometric, Ascorbic Acid
Sulfates	EPA 375.4*	Barium Sulfate, Turbidimetric
Mercury	EPA 245.1*	Manual Cold Vapor Technique
Metals	EPA 200*	Atomic Absorption, Direct Aspiration or Furnace Technique or ICP
Explosives	AEHA‡	Gas/Liquid Chromatography

See footnotes on page E-3.

Characteristic	Reference	Method
Water (Continued)		
White Phosphorus	USATHAMA§	Gas Chromatography After Extraction With Isooctane
A/B/N Extractable Organics	EPA 625**	Gas Chromatography/Mass Spectrophotography
Volatile Organics	EPA 624**	Gas Chromatography/Mass
Pesticides	EPA 507 & 508**	Gas Chromatography
Sediments		
Total Organic Matter	CS p. 475‡‡	Volatilization at 700 °C
Total Nitrogen	MSA 31-7.1§§	Salicylic Acid, H_2SO_4, Distillation, Titration
Ammonia-Nitrogen	SM 417B†	KCl/MgO Distillation, Titration
A/B/N Extractable Organics	EPA 8270***	Gas Chromatography/Mass Spectrophotography
Volatile Organics	EPA 8260***	Gas Chromatography/Mass Spectrophotography
Pesticides/PCBs	EPA 8080***	Gas Chromatography
Total Phosphate Phosphorus	SM 424C&F†	Perchloric Acid Digestion, Ascorbic Acid Color Determination
Mercury	EPA 245.1 *	Manual Cold Vapor Technique After Digestion
Metals	EPA 200*	Atomic Absorption, Direct Aspiration or Furnace Technique or ICP After Digestion

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See footnotes on page E-3.

Characteristic	Reference	Method
Sediments (Continued)		
Explosives	EPA 8330***	Gas/Liquid Chromatography After Extraction
White Phosphorus	USATHAMA§	Gas Chromatography After Extraction With Isooctane

* EPA 600/4-79-020, Methods for Chemicals Analysis of Water and Waste, revised March 1983.

\+ American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 17th ed, 1989.

‡ USAEHA, Method No. 87.3 and 97.1.

§ USATHAMA (1990) US Amy Toxic and Hazardous Materials Agency Installation Restoration Quality Assurance Program, Aberdeen Proving Ground, Maryland.

** EPA 600/4-82-057, July 1982, Test Methods for Organic Chemical Analysis of municipal and Industrial Wastewater.

++ Official Methods of Analysis, Section 29.012 (E, 29.014 and 29.015), Association of Official Analytical Chemists, 1975 following AEHA/OECD/PAB SOP No. 37.1.

‡‡ Bear, Firman ed., Chemistry of the Soil, Van Nostrand Reinhold Co., New York, 1964.

§§ American Society of Agronomy, Methods of Soil Analysis, Madison Wisconsin, 1982.

*** EPA, Methods for Evaluation of Solid Wastes, SW-846, 3d ed., January 1990.

APPENDIX F

ANALYTICAL SAMPLING REQUIREMENTS

Characteristic	Matrix	Container	Preservative
Metals, total	water	1 L cubitainer	HNO_3 to pH<2
Metals, dissolved*	water	1 L cubitainer	HNO_3 to pH<2
Metals, total	sediment	250 mL glass, WM	cool, 4 °C
Alkalinity	water	250 mL plastic	cool, 4 °C
Hardness	water	with total metals	HNO_3 to pH<2
Chlorides	water	250 mL plastic	cool, 4 °C
White Phosphorus	water	1000 mL glass	cool, 4 °C
WP, dissolved*	water	1000 mL glass	cool, 4 °C
White Phosphorus	sediment	500 mL glass, WM	cool, 4 °C
Nutrients+	water	1 L cubitainer	4 °C, H_2SO_4 to pH<2
Nutrients+	sediment	1 L glass, WM	cool, 4 °C
Sulfates	water	250 mL plastic	cool, 4 °C
Sulfate	sediment	250 mL glass, WM	cool, 4 °C
Total Organic Carbon	water	250 mL plastic	4 °C, H_2SO_4 to pH<2
Total Organic Matter	sediment	250 mL glass, WM	cool, 4 °C
Total Suspended Solids	water	1 L cubitainer	cool, 4 °C
Total Dissolved Solids	water	250 mL plastic	cool, 4 °C
Explosives	water	2-1 L glass	cool, 4 °C
Explosives	sediment	250 mL glass, WM	cool, 4 °C
Volatiles Organics	water	3-40 mL glass	cool, 4 °C
Volatiles Organics	sediment	250 mL glass, WM	cool, 4 °C
Semivolatile Organics	water	2-1 L glass	cool, 4 °C
Semivolatile Organics	sediment	500 mL glass, WM	cool, 4 °C
Pesticides	water	3-1 L glass	cool, 4 °C
Pesticides	sediment	1 L glass, WM	cool, 4 °C

* Filter before preserving in field using a portable high rate filter.

\+ Nitrate+Nitrite-N, Ammonia-N, Total Kjeldahl Nitrogen, and Total Phosphate-P in water and Total Nitrogen and Total Phosphate Phosphorus in sediments.

APPENDIX G

PERSONNEL INVOLVED

USAEHA Project Officer:	Carl A. Bouwkamp Aquatic Biologist Water Quality Engineering Division
Study Team:	Richard E. Griffith Wildlife Biologist Entomological Sciences Division
	Irene L. Sacilotto Environmental Scientist Directorate of Laboratory Services
	Stacy A. Mosko, 2LT Sanitary Engineer Water Quality Engineering Division

APPENDIX H

ANALYTICAL RESULTS

TABLE H-1. PHYSICAL AND CHEMICAL RESULTS FROM WATER SAMPLING (mg/L unless otherwise designated), EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

	Sample Site										
Parameter	ER1	ER2	DUP2*	DT4	DT5	DT6	DT7	A1	A2	CD1	CD2
Field Measured Characteristics											
Date	7/20	7/21	7/21	7/21	7/21	7/21	7/21	7/19	7/19	7/18	7/18
Time	1300	1410	1430	1450	1130	1340	1235	1225	1130	1030	1200
Dissolved Oxygen	12.9	13.4	13.5	11.6	10.9	11.3	11.0	12.9	14.6	11.2	5.4
Salinity PPT	0.09	0.16	0.07	0.92	5.3	5.7	6.2	24.0	22.0	0.28	0.92
Cond (mohs/cm)	0.078	0.305	0.177	1.740	9.13	10.1	1.22	37.6	42.5	7.1	1.82
pH standard units	8.2	7.6	7.2	6.6	7.0	7.4	7.3	8.6	8.2	9.2	7.2
Temperature °C	7.7	9.8	9.8	12.8	15.3	15.2	15.9	22.5	20.8	20.3	20.3
ORPotential	147	100	114	48	28	71	65	-16	53	52	69
Nonmetals											
Alkalinity	28	31	21	63	57	59	58	130	180	88	130
Hardness	49	111	91	204	1002	1189	1155	4056	4436	126	253
WP (µg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved WP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorides (g/L)	<0.001	0.011	0.024	0.38	2.9	2.8	3.1	13.0	15.0	0.15	0.46
Nitrate+Nitrite-N	0.05	0.06	0.06	<0.01	0.08	0.10	0.09	0.04	0.10	<0.01	<0.01
Ammonia-N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Kjeldahl-N	0.46	0.65	0.70	0.67	1.0	2.0	0.98	0.95	1.9	0.47	0.80
Sulfates	2.5	3.2	12	83	470	440	520	1400	1500	19	56
Total Phosphate-P	0.44	0.62	0.83	0.62	0.61	2.2	0.19	0.04	0.10	0.02	0.03
T-Organic Carbon	8.7	NA	17	3.6	8.2	4.9	2.0	6.6	2.1	2.3	2.6
T-Susp. Solids	230	520	650	440	620	3300	130	6.3	13.0	<1.0	6.5
T-Dis. Solids	86	160	65	920	5300	5700	6200	24000	22000	280	920
Explosives µg/L											
2,4,6-TNT	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
2,4-DNT	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
2,6-DNT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2-Nitrotoluene	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
1,3-DNB	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090
1,3,5-TNB	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nitrobenzene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
TETRYL	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
RDX	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
HMX	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0

* Duplicate sample for ER2. There was about half an hour between samples causing a slight change in salinity and related parameters.

TABLE H-2. METALS IN WATER (mg/L unless otherwise designated), EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Parameter	ER1	ER2	DUP2*	DT4	DT5	DT6	DT7	A1	A2	CD1	CD2
					Sample Site						
Metals (T=total, D=dissolved)											
T-Aluminum	6.2	11	12	6.3	9.1	31	2.4	<0.25	<0.25	<0.25	<0.25
D-Aluminum	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
T-Antimony	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
D-Antimony	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
T-Arsenic	0.0055	0.0096	0.013	0.0080	0.013	0.034	0.0043	0.0038	0.0037	<0.0011	0.0015
D-Arsenic	<0.0011	<0.0011	<0.0011	<0.0011	0.0017	0.0017	0.0018	0.0042	0.0034	<0.0011	0.0014
T-Barium	0.076	0.12	0.13	0.085	0.11	0.29	0.055	0.21	0.32	0.0044	0.0091
D-Barium	0.0068	0.0063	0.0059	0.021	0.038	0.036	0.038	0.22	0.32	0.0054	0.010
T-Beryllium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
D-Beryllium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Cadmium	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038
D-Cadmium	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038
T-Calcium	12	15	17	29	88	97	100	240	260	21	39
T-Chromium	0.013	<0.011	0.025	0.014	0.020	0.070	<0.011	<0.011	<0.011	<0.011	<0.011
D-Chromium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Cobalt	0.0063	0.010	0.013	0.0068	0.0092	0.036	<0.0055	<0.0055	<0.0055	<0.0055	<0.0055
D-Cobalt	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056
T-Copper	0.017	0.029	0.038	0.031	0.059	0.14	0.047	0.15	0.17	0.012	0.0063
D-Copper	0.0048	<0.0030	<0.0030	0.0086	0.032	0.034	0.038	0.15	0.17	0.0066	0.0085
T-Iron	15	26	29	16	22	86	5.4	0.57	0.78	<0.28	<0.28
D-Iron	0.17	<0.11	<0.11	0.43	0.37	0.42	0.46	0.99	0.97	0.23	0.30
T-Lead	0.0060	0.012	0.0099	0.0062	0.0068	0.029	0.0020	0.0030	0.0022	0.0045	<0.0015
D-Lead	<0.0015	<0.0015	<0.0015	<0.0015	0.0032	<0.0015	0.0018	0.0021	0.0028	<0.0015	0.0018
T-Magnesium	4.6	18	12	32	190	230	220	840	920	18	38
T-Manganese	0.28	0.45	0.54	0.37	0.52	1.6	0.24	<0.055	<0.055	<0.055	<0.055
D-Manganese	<0.056	<0.056	<0.056	0.086	0.15	0.12	0.15	<0.056	<0.056	<0.056	<0.056
T-Mercury	<0.0002	<0.0002	0.00024	<0.0002	0.00023	<0.0002	0.00023	<0.00023	<0.0002	<0.0002	<0.0002
D-Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
T-Nickel	<0.055	<0.055	0.058	<0.055	<0.055	0.35	<0.055	<0.055	<0.055	<0.055	<0.055
D-Nickel	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055
T-Potassium	4.4	2.1	6.2	15	65	73	77	260	280	6.9	12
D-Potassium	1.2	1.3	2.1	12	59	63	71	240	270	5.1	12
T-Selenium	<0.0011	<0.0011	<0.0011	<0.0011	0.0012	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
D-Selenium	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
T-Silver	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	0.044	<0.0015	<0.0015
D-Silver	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	0.0047	0.0029	0.096	<0.0015	<0.0015
T-Sodium	0.61	26	27	230	1500	1600	1800	7700	8500	77	190
D-Sodium	1.3	30	30	230	1400	1600	1700	7400	8300	75	250
T-Thallium	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
D-Thallium	<0.0022	0.0028	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
T-Vanadium	0.016	0.029	0.035	0.022	0.028	0.097	<0.011	<0.011	<0.011	<0.011	<0.011
D-Vanadium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Zinc	0.037	0.060	0.075	0.047	0.065	0.20	0.029	0.053	0.059	0.012	<0.011
D-Zinc	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	0.012	0.040	0.048	<0.011	<0.011

* Duplicate sample for ER2. There was about half an hour between samples causing a slight change in salinity and related parameters.

TABLE H-3. PHYSICAL AND CHEMICAL RESULTS FROM WATER SAMPLING, (mg/L unless otherwise designated) EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Parameter	Sample Site										
	BT1	BT2	BT3	C1	C2	C3	DUP1*	RI1	RI2	GB1	GB2
Field Measured Characteristics											
Date	7/14	7/14	7/20	7/14	7/14	7/15	7/21	7/19	7/19	7/17	7/17
Time	1630	1530	1105	1200	1030	1130	0930	1510	1610	1230	1030
Dissolved Oxygen	13.6	16.8	7.8	13.2	11.5	9.8	8.9	1.4	4.5	13.8	13.4
Salinity (PPT)	37.000	21.000	46.000	24.000	27.000	2.800	1.400	10.000	13.000	22.000	44.000
Cond. (mohm/cm)	54.400	36.200	65.900	37.700	41.900	5.300	5.110	17.600	22.100	34.300	60.600
pH (Stand. units)	8.1	8.0	8.6	8.3	8.4	7.7	6.9	6.6	8.0	8.8	8.2
Temperature °C	30.9	30.2	17.9	24.1	22.3	21.1	20.5	20.4	24.0	25.5	25.0
ORPotential	-35	8	-118	68	0	63	102	NA	NA	39	86
Nonmetals											
Alkalinity	280	340	260	150	130	210	140	290	220	230	160
Hardness	5463	3005	6748	3915	4443	405	500	1658	2097	3387	7733
White Phosphorus	<0.01	<0.01	0.011	<0.01	0.016	0.013	0.069	0.043	0.020	NA	<0.01
Dissolved WP	NA	NA	0.006	NA	0.012	0.005	0.014	0.009	0.014	NA	NA
Chlorides (g/L)	21.000	10.000	12.000	12.000	14.000	1.400	1.000	4.500	8.100	12.000	26.000
Nitrate+Nitrite-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia-N	0.41	0.42	NA	0.25	0.42	0.30	NA	NA	NA	0.24	0.32
Total Kjeldahl-N	0.94	2.6	1.5	2.3	4.0	1.0	0.88	1.5	2.7	1.5	1.5
Sulfates	2000	920	2300	1100	1300	140	98	480	680	1000	3500
Total Phosphate-P	0.44	0.22	0.05	0.10	0.20	0.05	0.04	0.09	0.11	0.08	0.23
T-Organic Carbon	27	15	45	10	14	5.8	6.7	9.1	12	12	26
T-Susp. Solids	63	14	100	23	63	5	3.2	11	16	6.0	42
T-Dis. Solids	37000	21000	46000	24000	27000	2800	1400	10000	13000	22000	44000
Explosives (µg/L)											
2,4,6-TNT	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.0
2,4-DNT	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.0
2,6-DNT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0
2-Nitrotoluene	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.0
1,3-DNB	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.0
1,3,5-TNB	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.0
2-Nitrobenzene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.0
TETRYL	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
RDX	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.3
HMX	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0

* Duplicate sample for C3. It was not collected the same day causing a slight change in salinity and related parameters.

TABLE H-4. METALS IN WATER (mg/L unless otherwise designated), EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Parameter	BT1	BT2	BT3	C1	C2	C3	DUP1*	RI1	RI2	GB1	GB2
					Sample Site						
Metals (mg/L) (T=total, D=dissolved)											
T-Aluminum	<0.25	0.69	<0.25	0.26	0.92	<0.25	<0.25	<0.25	0.46	<0.25	0.36
D-Aluminum	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
T-Antimony	0.0062	<0.003	0.0071	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.0053
D-Antimony	0.0031	<0.003	0.0041	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
T-Arsenic	0.032	0.027	0.12	0.0038	0.0080	<0.0011	0.0028	0.0088	0.014	0.053	0.0079
D-Arsenic	0.041	0.027	0.11	0.0040	0.0081	<0.0011	0.0027	0.0042	0.012	0.051	0.0067
T-Barium	0.24	0.18	0.17	0.33	0.40	0.026	0.077	0.087	0.0044	0.0091	0.0067
D-Barium	0.24	0.18	0.16	0.35	0.40	0.040	0.029	0.073	0.082	0.13	0.31
T-Beryllium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
D-Beryllium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Cadmium	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038
D-Cadmium	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038	<0.0038
T-Calcium	210	180	230	200	230	50	57	120	98	120	460
T-Chromium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
D-Chromium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Cobalt	<0.0055	<0.0055	<0.055	<0.0055	<0.0055	<0.0055	<0.0055	<0.0055	<0.0055	<0.0055	<0.0055
D-Cobalt	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056	<0.0056
T-Copper	0.23	0.13	0.28	0.15	0.16	0.015	0.016	0.064	0.085	0.13	0.25
D-Copper	0.23	0.13	0.27	0.15	0.16	0.022	0.015	0.062	0.081	0.13	0.26
T-Iron	<0.28	1.3	0.32	0.47	1.3	<0.28	0.32	0.42	1.1	<0.28	0.94
D-Iron	0.88	0.78	0.93	0.90	0.88	0.37	0.30	0.57	0.46	0.59	1.8
T-Lead	0.0083	0.0028	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
D-Lead	<0.0015	<0.0015	<0.0015	0.0017	0.0024	<0.0015	0.0019	0.0026	0.0017	0.0019	0.027
T-Magnesium	1200	730	1500	830	940	68	87	330	450	750	1600
T-Manganese	0.17	0.45	2.8	0.056	0.15	<0.055	0.12	0.46	0.34	0.26	0.31
D-Manganese	0.19	0.42	2.5	<0.056	0.13	0.072	0.088	0.29	0.23	0.22	0.16
T-Mercury	<0.0002	0.00023	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
D-Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
T-Nickel	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055
D-Nickel	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055
T-Potassium	370	220	530	250	270	22	27	120	160	230	500
D-Potassium	340	210	520	240	250	29	24	120	150	210	400
T-Selenium	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
D-Selenium	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
T-Silver	<0.0015	<0.0015	0.0029	<0.0015	<0.0015	<0.0015	<0.0015	0.0036	0.0022	<0.0015	<0.0015
D-Silver	0.0022	<0.0015	0.0030	<0.0015	<0.0015	<0.0015	<0.0015	0.0043	0.0024	<0.0015	<0.0015
T-Sodium	11000	5900	14000	6200	7200	490	690	2800	3800	6400	13000
D-Sodium	11000	6200	14000	7400	8100	790	630	3100	4100	6700	13000
T-Thallium	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
D-Thallium	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
T-Vanadium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
D-Vanadium	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
T-Zinc	0.077	0.047	0.090	0.047	0.058	<0.011	<0.011	0.024	0.032	0.044	0.10
D-Zinc	0.065	0.035	0.083	0.042	0.047	<0.011	<0.011	0.022	0.022	0.037	0.098

* Duplicate sample for C3. It was not collected the same day causing a slight change in salinity and related parameters.

TABLE H-5. VOLATILE ORGANIC COMPOUNDS IN WATER, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Compound	Detection Limit $\mu g/L$*
1,1,1-Trichloroethane	5
1,1,2,2-Tetrachloroethane	5
1,1,2-Trichloroethane	5
1,1-Dichloroethane	5
1,1-Dichloroethene	5
1,2-Dichloroethane	5
1,2-Dichloroethene	5
1,2-Dichloropropane	5
1,2,4-Trichlorobenzene	10
1,2-Dichlorobenzene	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
2-Chloroethyl Vinyl Ether	10
Acrolein	100
Acrylonitrile	100
Benzene	5
Bromodichloromethane	5
Bromoform	5
Bromoethane	10
Carbon Tetrachloride	5
Chlorobenzene	5
Chloroethane	5
Chloroform	5
Chloromethane	5
Dibromochloromethane	5
Ethylbenzene	5
Methylene Chloride	5
Tetrachloroethylene	5
Toluene	5
Trichloroethylene	5
Trichlorofluoromethane	5
Vinyl Chloride	10
Xylene, Total Combined	5
cis-1,3-Dichloropropylene	5
trans-1,3-Dichloropropene	5

* No volatiles were detected in any of the following water samples above these detection limits; ER1, ER2, DUP2, DT4, DT5, DT6, DT7, A1, A2, CD1, CD2, BT1, BT2, BT3, C1, C2, C3, DUP1, RI1, RI2, GB1, and GB2.

TABLE H-6. SEMIVOLATILE ORGANIC COMPOUNDS IN WATER, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Compound	Detection Limit $\mu g/L$
2,4,5-Trichlorophenol	10
2,4,6-Trichlorophenol	10
2,4-Dichlorophenol	10
2,4-Dimethylphenol	10
2,4-Dinitrophenol	25
2,4-Dinitrotoluene	10
2,6-Dinitrotoluene	10
2-Chloronaphthalene	10
2-Chlorophenol	10
2-methylnaphthalene	10
2-Methylphenol	10
2-Nitroaniline	10
2-Nitrophenol	10
3,3-Dichlorobenzidine	20
3-Nitroaniline	10
4,6-Dinitro-2-Methylphenol	25
4-Bromophenylphenylether	10
4-Chloroaniline	10
4-Chloro-3-Methylphenol	10
4-Chlorophenylphenylether	10
4-Methylphenol	10
4-Nitroaniline	10
4-Nitrophenol	25
Acenaphthene	10
Acenaphthylene	10
Anthracene	10
Benzo (a) Anthracene	10
Benzo (a) Pyrene	10
Benzo (b) Fluoranthene	10
Benzo(g,h,i)Perylene	10
Benzo (k) Fluoranthene	10
Benzoic Acid	50
Benzyl Alcohol	20
Bis (2-chloroethoxy) Methane	10
Bis (2-chloroethyl) Ether	10

* See footnote on page H-8.

TABLE H-6. SEMIVOLATILE ORGANIC COMPOUNDS IN WATER, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993 (Continued)

Compound	Detection Limit μg/L*
Bis (2-ethylhexyl) Phthalate	10
Butylbenzyl Phthalate	10
Chrysene	10
Di-n-butyl Phthalate	10
Di-n-octyl Phthalate	10
Dibenz (a,h) Anthracene	10
Dibenzofuran	10
Diethyl Phthalate	10
Dimethyl Phthalate	10
Fluoranthene	10
Fluorene	10
Hexachlorobenzene	10
Hexachlorobutadiene	10
Hexachlorocyclopentadiene	10
Hexachloroethane	10
Indeno (1,2,3-c,d) Pyrene	10
Isophorone	10
N-Nitrosodi-n-Propylamine	10
N-Nitrosodiphenylamine	10
Naphthalene	10
Nitrobenzene	10
Pentachlorophenol	25
Phenanthrene	10
Phenol	10
Pyrene	10

* No semivolatiles were detected in any of the following water samples above these detection limits; ER1, ER2, DUP2, DT4, DT5, DT6, DT7, A1, A2, CD1, CD2, BT1, BT2, BT3, C1, C2, C3, DUP1, RI1, RI2, GB1 and GB2.

TABLE H-7. PESTICIDES/PCB's IN WATER, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Compound	Detection Limit μg/L*
alpha-Benzenehexachloride	0.05
beta-Benzenehexachloride	0.05
delta-Benzenehexachloride	0.06
Lindane	0.05
o,p'-DDD	0.06
p,p'-DDD	0.06
o,p'-DDE	0.06
p,p'-DDE	0.06
o,p'-DDT	0.10
p,p'-DDT	0.10
Aldrin	0.05
Chlordane (technical)	0.40
Cis-Chlordane	0.06
Trans-Chlordane	0.06
Gamma-Chlordene	0.06
Chlorobenzilate	0.05
Chloroneb	0.20
Chlorothalonil	0.06
Dacthal	0.06
Dieldrin	0.06
Endosulfan I	0.10
Endosulfan II	0.20
Endosulfan Cyclic Sulfate	0.30
Endrin	0.04
Endrin Aldehyde	0.10
Etridiazole	0.06
Hexachlorobenzene (HCB)	0.02
Heptachlor	0.05
Heptachlor Epoxide	0.05
Hexachlorocyclopentadiene (HCCPD)	0.05
1-Hydroxychlordene	0.06
Methoxychlor	0.40
Mirex	0.10
Trans-Nonachlor	0.06
Oxychlordane	0.05

* See footnote on page H-10.

TABLE H-7. PESTICIDES/PCB's IN WATER, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993 (Continued)

Compound	Detection Limit $\mu g/L$*
Cis-Permethrin	1.00
Trans-Permethrin	1.00
PCB 1016	0.80
PCB 1221	0.80
PCB 1232	0.80
PCB 1242	0.80
PCB 1248	0.80
PCB 1254	0.80
PCB 1260	0.80
Propachlor	0.50
Toxaphene	1.00
Trifluralin	0.06
Chlorinated Herbicides	
Dalapon	1.50
Dicamba	0.10
Dinoseb	0.20
2,4,5-Trichlorophenoxyacetic Acid	0.10
2,4-Dichlorophenoxyacetic Acid	0.20
4-(2,4-Dichlorophenoxy)Butyric Acid	0.80
Pentachlorophenol	0.10
Picloram	0.15
Silvex	0.10

* There were no pesticides/PCBs detected in any of the following water samples above these detection limits; ER1, ER2, DUP2, DT4, DT5, DT6, DT7, A1, A2, CD1, CD2, BT1, BT2, BT3, C1, C2, C3, DUP1, RI1, RI2, GB1, and GB2.

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993

Characteristic	ER1	ER2	DUP2	Sample Site DT1	DT2	DT3	DT4	DT5
Nonmetals								
% Moisture	18	26	25	34	46	43	33	46
Ammonia-N	0.7	1.1	3.2	4.2	13	10	10	10
Total Nitrogen	360	300	290	530	560	593	490	540
Total Sulfate	130	150	250	320	620	662	75	560
WP (μ/kg wet)	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88
Phosphate-P	690	620	780	720	830	821	890	820
% Organic Matter	2.7	2.4	2.4	3.5	4.1	4.1	3.5	4.2
ORPotential	98	100	NA	NA	NA	NA	NA	-117
Explosives								
HMX	<2	<2	<2	<2	<2	<2	<2	<2
RDX	<1	<1	<1	<1	<1	<1	<1	<1
1,3,5-TNB	<0.3	<0.3	<0.3	<3	<3	<3	<0.3	<0.3
1,3-DNB	<3	<3	<3	<0.3	<0.3	<0.3	<3	<3
NB	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.4
2,4,6-TNT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.4
2,6-DNT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.4
2,4-DNT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.4
o-NT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.4
Metals								
Aluminum	13000	8800	9500	16000	20000	21000	16000	20000
Antimony	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Arsenic	8.4	9.6	9.6	15	19	18	16	20
Barium	40	68	80	130	160	150	150	140
Beryllium	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	<1.0
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calcium	3500	5600	6000	6100	6900	6700	6300	5900
Chromium	19	13	13	27	39	38	26	34
Cobalt	9.6	8.1	8.8	14	19	19	14	19
Copper	5.6	6.5	8.5	30	43	38	28	40
Iron	31000	20000	21000	35000	44000	45000	34000	42000
Lead	6.5	5.0	5.3	9.1	13	13	9.6	13
Magnesium	9300	7100	7600	11000	14000	14000	11000	14000
Manganese	470	340	360	640	1100	970	710	900

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993 (Continued)

Characteristic	ER1	ER2	DUP2	Sample Site DT1	DT2	DT3	DT4	DT5
Metals (Continued)								
Mercury	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	<0.10
Nickel	210	110	160	440	480	450	240	300
Potassium	690	1600	1700	2600	3400	3200	2600	3000
Selenium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Silver	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Sodium	87	720	820	1900	4000	4700	850	2700
Thallium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium	23	16	18	37	54	48	37	44
Zinc	56	44	51	110	120	120	83	100

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993 (Continued)

Characteristic	DT6	DT7	A1	A2	Sample Site CD1	CD2	BT1	BT2	BT3
Nonmetals									
% Moisture	34	39	54	48	60	58	52	55	49
Ammonia-N	2.9	9.4	8.6	12	21	40	86	80	34
Total Nitrogen	420	980	1900	1400	2300	1800	1500	1600	1311
Total Sulfates	480	670	1200	960	2200	3200	770	1200	619
WP (μg/kg wet)	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	79
Phosphate-P	950	860	1400	820	1200	690	850	780	887
% Organic Matter	3.2	4.1	7.1	6.1	9.0	6.6	6.3	6.9	6.8
ORPotential	NA	-152	-336	-210	-189	-387	-406	-405	-355
Explosives									
HMX	<2	<2	<2	<2	<2	<2	<2	<2	<2
RDX	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,3,5-TNB	<0.3	<0.3	<0.4	<1	<0.4	<0.3	*	<1	<0.3
1,3-DNB	<0.4	<3	<3	<3	<0.4	<0.3	*	<1	<3
NB	<1	<0.3	<0.4	<1	<0.4	<0.3	*	<1	<0.3
2,4,6-TNT	<1	<0.3	<0.4	<1	<0.4	<0.3	*	<1	<0.3
2,6-DNT	<1	<0.3	<0.4	<1	<0.4	<0.3	*	<1	<0.3
2,4-DNT	<1	<0.3	<0.4	<1	<0.4	<0.3	*	<1	<0.3
o-NT	<1	<3	<0.4	<1	<4	<3	*	<1	<0.3
Metals									
Aluminum	14000	17000	17000	16000	19000	21000	19000	19000	16000
Antimony	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Arsenic	14	23	16	16	14	10	9.7	6.0	11
Barium	110	130	130	130	130	140	150	140	120
Beryllium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calcium	6500	5900	5800	5300	3400	8900	8400	6500	6400
Chromium	29	22	32	30	33	39	35	34	28
Cobalt	20	13	16	16	16	16	16	15	15
Copper	41	23	36	33	30	36	41	35	32
Iron	30000	39000	38000	37000	40000	44000	40000	39000	35000
Lead	9.0	13	12	12	12	14	15	12	11

See footnote on page H-14.

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993 (Continued)

	Sample Site								
Characteristic	DT6	DT7	A1	A2	CD1	CD2	BT1	BT2	BT3
Metals (Continued)									
Magnesium	10000	13000	12000	13000	12000	14000	14000	14000	12000
Manganese	880	580	660	600	480	550	740	570	600
Mercury	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nickel	330	320	280	260	560	540	600	1100	250
Potassium	2600	3000	2300	3000	3000	4200	4100	4100	3500
Selenium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Silver	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Sodium	1600	2700	5600	6100	2700	7800	10000	13000	7900
Thallium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium	44	30	43	42	44	51	45	44	39
Zinc	100	69	99	100	94	110	150	110	92

* Matrix interference prohibited accurate quantitation of this sample.

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993 (Continued)

Characteristic	Sample Site							
	C1	C2	C3	DUP1	RI1	RI2	GB1	GB2
<u>Nonmetals</u>								
% Moisture	42	38	56	59	54	50	48	30
Ammonia-N	25	21	42	71	15	23	17	15
Total Nitrogen	709	720	2700	2800	1335	850	660	430
Total Sulfates	728	2400	1100	1300	776	1300	1200	1500
WP (μg/kg wet)	<0.88	1.6E3	430	205	14.3	1.74E6	<0.88	<0.88
Phosphate-P	729	730	750	780	850	2700	750	940
	5.0	4.7	8.7	9.3	6.1	4.1	5.8	3.5
ORPotential	-166	-405	-296	-333	NA	NA	-361	-206
<u>Explosives</u>								
HMX	<2	<2	<2	<2	<2	<2	<2	<2
RDX	<1	<1	<1	<1	<1	<1	<1	<1
1,3,5-TNB	<1	<1	<1	<0.3	<1	<1	<3	<3
1,3-DNB	<1	<1	<1	<3	<4	<3	<0.4	<0.4
NB	<1	<1	<1	<0.3	<1	<1	<0.4	<0.4
2,4,6-TNT	<1	<1	<1	<0.3	<1	<1	<0.4	<0.4
2,6-DNT	<1	<1	<1	<0.3	<1	<1	<0.4	<0.4
2,4-DNT	<1	<1	<1	<0.3	<1	<1	<0.4	<0.4
o-NT	<3	<3	<3	<0.3	<1	<1	<3	<3
<u>Metals</u>								
Aluminum	19000	20000	21000	20000	17000	17000	18000	13000
Antimony	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Arsenic	17	18	14	14	9.3	14	15	13
Barium	160	160	150	130	130	140	140	110
Beryllium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calcium	5500	7300	5300	4800	4800	4600	7400	6600
Chromium	33	34	37	36	32	35	42	21
Cobalt	18	18	16	15	17	17	18	12
Copper	39	38	47	44	38	52	39	21
Iron	43000	43000	46000	41000	39000	40000	39000	27000
Lead	13	13	16	15	12	13	12	7.9
Magnesium	13000	14000	14000	13000	12000	12000	14000	9900
Manganese	800	890	530	520	620	690	710	510
Mercury	0.14	<0.10	0.11	0.52	<0.10	0.11	<0.10	<0.10

TABLE H-8. RESULTS OF SEDIMENT ANALYSIS (mg/kg dry weight), EAGLE RIVER FLATS, AK, JULY 1993 (Continued)

Characteristic	Sample Site C1	C2	C3	DUP1	RI1	RI2	GB1	GB2
Metals (Continued)								
Nickel	800	720	660	280	250	250	280	250
Potassium	3900	4000	4100	3500	3500	3400	3600	2700
Selenium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Silver	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Sodium	11000	9800	9500	3100	4200	3900	6000	5600
Thallium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium	46	47	49	49	46	45	45	28
Zinc	120	130	130	160	100	110	100	86

FLATS, FORT RICHARDSON, AK, JULY 1993

Parameter	Detection Limit as Received μg/kg*
1,1,1-Trichloroethane	5
1,1,2,2-Tetrachloroethane	5
1,1,2-Trichloroethane	5
1,1-Dichloroethane	5
1,1-Dichloroethene	5
1,2-Dichloroethane	5
1,2-Dichloroethene	5
1,2-Dichloropropane	5
1,2,4-Trichlorobenzene	10
1,2-Dichlorobenzene	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
2-Chloroethyl Vinyl Ether	10
Acrolein	100
Acrylonitrile	100
Benzene	5
Bromodichloromethane	5
Bromoform	5
Bromoethane	10
Carbon Tetrachloride	5
Chlorobenzene	5
Chloroethane	5
Chloroform	5
Chloromethane	5
Dibromochloromethane	5
Ethylbenzene	5
Methylene Chloride	5
Tetrachloroethylene	5
Toluene	5
Trichloroethylene	5
Trichlorofluoromethane	5
Vinyl Chloride	10
Xylene, Total Combined	5
cis-1,3-Dichloropropylene	5
trans-1,3-Dichloropropene	5

* No volatile organic compounds were detected at these wet weight detection limits except methylene chloride at 6 μg/Kg wet weight at CD2. For conversion to dry weight use the following percent moistures; ER1 (12.7), ER2 (23.6), DUP2 (26.1), DT1 (36.5), DT2 (45.4), DT3 (44), DT4 (34.7), DT5 (43), DT6 (34.6), DT7 (41.5), A1 (56.7), A2 (47.6), BT1 (56), BT2 (54.9), BT3 (52.1), C1 (44.2), C2 (39.7), C3 (56), RI1 (60.7), RI2 (54.5), CD1 (61.1), CD2 (59.1), GB1 (45.3), and GB2 (31.8).

TABLE H-10. SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENTS, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Compound	Detection Limit μg/kg wet weight*
2,4,5-Trichlorophenol	330
2,4,6-Trichlorophenol	330
2,4-Dichlorophenol	330
2,4-Dimethylphenol	330
2,4-Dinitrophenol	830
2,4-Dinitrotoluene	330
2,6-Dinitrotoluene	330
2-Chloronaphthalene	330
2-Chlorophenol	330
2-methylnaphthalene	330
2-Methylphenol	330
2-Nitroaniline	330
2-Nitrophenol	330
3,3-Dichlorobenzidine	670
3-Nitroaniline	330
4,6-Dinitro-2-Methylphenol	330
4-Bromophenylphenylether	330
4-Chloroaniline	330
4-Chloro-3-Methylphenol	330
4-Chlorophenylphenylether	330
4-Methylphenol	330
4-Nitroaniline	330
4-Nitrophenol	830
Acenaphthene	330
Acenaphthylene	330
Anthracene	330
Benzo (a) Anthracene	330
Benzo (a) Pyrene	330
Benzo (b) Fluoranthene	330
Benzo(g,h,i)Perylene	330
Benzo (k) Fluoranthene	330
Benzoic Acid	1700
Benzyl Alcohol	670
Bis (2-chloroethoxy) Methane	330

See footnote on page H-19.

TABLE H-10. SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENTS, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993 (Continued)

Compound	Detection Limit μg/kg wet weight*
Bis (2-chloroethyl) Ether	330
Bis (2-ethylhexyl) Phthalate	330
Butylbenzyl Phthalate	330
Chrysene	330
Di-n-butyl Phthalate	330
Di-n-octyl Phthalate	330
Dibenz (a,h) Anthracene	330
Dibenzofuran	330
Diethyl Phthalate	330
Dimethyl Phthalate	330
Fluoranthene	330
Fluorene	330
Hexachlorobenzene	330
Hexachlorobutadiene	330
Hexachlorocyclopentadiene	330
Hexachloroethane	330
Indeno (1,2,3-c,d) Pyrene	330
Isophorone	330
N-Nitrosodi-n-Propylamine	330
N-Nitrosodiphenylamine	330
Naphthalene	330
Nitrobenzene	330
Pentachlorophenol	830
Phenanthrene	330
Phenol	330
Pyrene	330

* There were no semivolatile organic compounds detected at these wet weight detection limits except Bis(2-ethylhexyl) Phthalate at 360 μg/kg wet weight at DUP2. For conversion to dry weight use the following percent moistures; ER1 (12.7), ER2 (23.6), DUP2 (26.1), DT1 (36.5), DT2 (45.4), DT3 (44), DT4 (34.7), DT6 (43), DT7 (34.6), DT8 (41.5), A1 (56.7), A2 (47.6), BT1 (56), BT2 (54.9), BT3 (52.1), C1 (44.2), C2 (39.7), C3 (56), RI1 (60.7), RI2 (54.5), CD1 (61.1), CD2 (59.1), GB1 (45.3), and GB2 (31.8).

TABLE H-11. PESTICIDES IN SEDIMENT, EAGLE RIVER FLATS, FORT RICHARDSON, AK, JULY 1993

Pesticides/PCBs	Detection Limits mg/kg wet weight*
alpha-Benzenehexachloride	0.1
beta-Benzenehexachloride	0.1
delta-Benzenehexachloride	0.1
Lindane	0.1
DDD	0.01
DDE	0.01
DDT	0.01
Aldrin	0.1
Chlordane	0.5
Dieldrin	0.01
Endosulfan I	0.01
Endosulfan II	0.01
Endosulfan Sulfate	0.03
Endrin	0.01
Endrin Aldehyde	0.10
Heptachlor	0.1
Heptachlor Epoxide	0.01
Methoxychlor	0.05
PCB 1016	0.2
PCB 1221	0.2
PCB 1232	0.2
PCB 1242	0.2
PCB 1248	0.2
PCB 1254	0.2
PCB 1260	0.2
Toxaphene	2.00

* There were no pesticides detected in any of the sediment samples using these wet weight detection limits. To convert to dry weight use the following percent moistures; ER1 (26.8), ER2 (31.6), DUP2 (26.1), DT1 (34.7), DT2 (44.9), DT3 (44), DT4 (37.6), DT5 (48), DT6 (33.2), DT7 (40.8), A1 (56.3), A2 (47.3), BT1 (57.6), BT2 (62.3), BT3 (49.4), C1 (50.2), C2 (43.7), C3 (75.2), RI1 (67.8), RI2 (49.6), CD1 (63.9), CD2 (58.8), GB1 (47), and GB2 (30.5).

APPENDIX I

BENTHIC MACROINVERTEBRATES

Benthic Macroinvertebrate Samples from
Fort Richardson, Alaska
Collected 20 July, 1993

TAXONOMIC LISTING

Species	Site		
	A-1-A	A-1-B	A-1-C
CRUSTACEA			
Amphipoda			
Gammarus lacustris	1		
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	615	502	462
Parachironomus sp.	7	5	

Species	Site		
	A-2-A	A-2-B	A-2-C
CRUSTACEA			
Amphipoda			
Gammarus lacustris			3
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	541	509	1004

Species	Site C-1-A	C-1-B	C-1-C*
CRUSTACEA			
Amphipoda			
Gammarus lacustris	4	4	
INSECTA			
Odonata			
Coenagriidae sp.	1		
Diptera			
Chironomidae			
Chironomus salinarius	1368	1602	753
Parachironomus sp.		4	

Species	Site C-2-A	C-2-B	C-2-C*
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis		3	
CRUSTACEA			
Amphipoda			
Gammarus lacustris	1	2	
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	136	108	420
Chironomus plumosus			
Muscidae			
Limnophora sp.		1	

* There were two bottles labled C-1-C and no bottle labled C-2-C. One of the C-1-C bottles was assigned to C-2-C based on content but may be incorrectly assigned.

Species	Site C-3-A	C-3-B	C-3-C
GASTROPODA			
Physidae			
Physella gyrina		1	4
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	238	31	

Species	Site Dup-1-A	Dup-1-B	Dup-1-C
GASTROPODA			
Physidae			
Physella gyrina			1
ANNELIDA	N		
Oligochaeta	O		
Naididae	N		
Nais variablis	E	37	72
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius		26	2

Species	DT-1-A	DT-1-B	DT-1-C
CRUSTACEA			
Amphipoda			
Gammarus lacustris	5	3	1
Isopoda			
Cirolana sp.		9	
Munna sp.	2		2
Decapoda			
Crago nigrocauda	2	4	1
INSECTA			
Diptera			
Ceratopogonidae			
Culicoides sp. 2	1		
Chironomidae			
Chironomus salinarius	166	432	148

Species	DT-2-A	DT-2-B	DT-2-C
CRUSTACEA			
Amphipoda			
Gammarus lacustris	15	17	27
Isopoda			
Cirolana sp.	1		
Munna sp.	1	5	
Decapoda			
Crago nigrocauda	7	1	2
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	20	70	49

Species	DT-3-A	DT-3-B	DT-3-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	66	70	146
CRUSTACEA			
Amphipoda			
Gammarus lacustris	1	2	3
Decapoda			
Crago nigrocauda	1	3	4
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	2	4	

Species	Site DT-5-A	DT-5-B	DT-5-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	29	908	279
CRUSTACEA			
Decapoda			
Crago nigrocauda		1	
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	18	27	30
Muscidae			
Limnophora sp.	1		

Species	Site DT-7-A	DT-7-B	DT-7-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	720	683	647
CRUSTACEA			
Amphipoda			
Gammarus lacustris	1		1
Decapoda			
Crago nigrocauda		1	
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	3	8	9

Species	Site CD-1-A	CD-1-B	CD-1-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis		4	3
CRUSTACEA			
Amphipoda			
Gammarus lacustris	1		
INSECTA			
Odonata			
Coenagriidae sp.		1	
Diptera			
Chironomidae			
Cryptochironomus digitatus	28	34	18

Species	Site CD-2-A	Site CD-2-B	Site CD-2-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	7		
INSECTA			
Diptera			
Chironomidae			
Chironomus plumosus	121	126	76
Cryptochironomus digitatus	3		
Tanytarsus sp.	1		1
Ephydridae			
Ephydra sp.			
Empidae			
Rhamphamyia sp.			
Muscidae			
Limnophora sp.			

Species	GB-1-A	Site GB-1-B	GB-1-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis		2	
CRUSTACEA			
Amphipoda			
Gammarus lacustris		12	
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	1347	73	562
Empidae			
Rhamphamyia sp.		1	

Species	GB-2-A	Site GB-2-B	GB-2-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	79	42	873
INSECTA			
Coleoptera			
Limnebiidae			
Hydranea sp.	2		
Diptera			
Ceratopogonidae			
Culicoides sp. 2	98	225	54
Chironomidae			
Chironomus salinarius	77	47	129
Ephydridae			
Ephydra sp.	14	46	8
Muscidae			
Limnophora sp.	31	26	17

Species	Site RI-1-A	RI-1-B	RI-1-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	7	3	2
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius		4	5
Tanytarsus sp.			1

Species	Site RI-2-A	RI-2-B	RI-2-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	45	5	53
CRUSTACEA			
Isopoda			
Liga sp.	1		
INSECTA			
Diptera			
Ceratopogonidae			
Culicoides sp. 1	1	12	5
Culicoides sp. 2	15	34	14
Chironomidae			
Chironomus salinarius	7	33	17

Species	BT-1-A	Site BT-1-B	BT-1-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	14		2
CRUSTACEA			
Amphipoda			
Gammarus lacustris		1	
INSECTA			
Diptera			
Ceratopogonidae			
Culicoides sp. 2	1		1
Chironomidae			
Chironomus salinarius	320	232	523
Empidae			
Rhamphamyia sp.	1		

Species	BT-2-A	Site BT-2-B	BT-2-C
ANNELIDA			
Oligochaeta			
Naididae			
Nais variablis	2		1
CRUSTACEA			
Amphipoda			
INSECTA			
Diptera			
Chironomidae			
Chironomus salinarius	381	884	771

Species	BT-3-A	Site BT-3-B	BT-3-C
CRUSTACEA			
Amphipoda			
Gammarus lacustris		1	1
INSECTA			
Diptera			
Ceratopogonidae			
Culicoides sp. 2	2		1
Chironomidae			
Chironomus salinarius	279	58	103
Empidae			
Rhamphamyia sp.	1		11

Ecological and Taxonomic Notes

Physella gyrina -- This widespread and abundant snail is one of the most resistant species to pollution of all the mollusks. (2)

Nais variablis -- This species is one of the most commonly occuring naidids in North American freshwater environments. (4)

Gammarus lacustris -- This species is found actoss the entire northern tier of North America. It is a detritus processor. (5)

Cirolana sp. -- Members of this genus are found n a wide variety of habitats but are most commonly observed on rock faces or in shell beds. (1)

Munna sp. -- Members of this genus are minute and usually occur in low salinity marshes. (3)

Liga sp. -- Members of this genus are very common on the west coast. They are usually found running on the surfaces of rocks in all available habitats. (1)

Crago nigrocauda -- This species occurs from Alaska to Mexico and is often found on mud flats. (1)

Coenagriidae sp. -- The two specimens in this family of damselflies were much too small to identify. In addition both specimens were damaged and missing essential body parts for identification. (8)

Hydranea sp. -- Members of this widespread genus of small water beetles are frequently found clinging to detritus at the margins of pools. (6)

Culicoides sp. 1 and *Culicoides* sp. 2 -- This very large genus of biting flies is found is a very wide variety of habitats from clean sand to mud flats to tree holes. Species level identification of the larvae is not possible at this time. (6)

Chironomus salinarius - This is a very large species (for a chironomid). The larvae are collector gatherers on the substrate. (7)

Chironomus plumosus -- This common species is tolerant of low oxegen levels. (7)

Cryptochironomus digitatus -- The very distinctive hypostomial plate makes this species unmistakable. Little is known about its habitat preference. (7)

Parachironomus sp. -- a large genus of poor taxinomic status. (7)

Tanytarsus Sp. - This is a very large genus and many of the larvae are not associated. (7)

Ephydra sp. -- Larvae if this genus are generally found in algal mats and are quite resistant to saline, mineral or thermal contamination. (6)

Rhamphamyia sp. -- This very large genus of dance flies is found at the margins of ponds and pools. (6)

Limnophora sp. -- Larvae of this genus are predators and are usually burrowers. (6)

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