USACHPPM

U.S. Army Center for Health Promotion and Preventive Medicine

CONSERVARE SALUTEM

FINAL REPORT
TIER I SCREENING RISK ASSESSMENT
OF AQUATIC ECOSYSTEMS
NO. 39-EJ-1393-97
TWIN CITIES ARMY AMMUNITION PLANT
NEW BRIGHTON, MINNESOTA
OCTOBER 1992 - JULY 1993

Published: 27 October 1997

Readiness Thru Health

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) lineage can be traced back over a half century to the Army Industrial Hygiene Laboratory which was established at the beginning of World War II under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health with a staff of three and an annual budget not to exceed three thousand dollars. Its mission was to conduct occupational health surveys of Army-operated industrial plants, arsenals, and depots. These surveys were aimed at identifying and eliminating occupational health hazards within the Department of Defense's (DOD) industrial production base and proved to be extremely beneficial to the Nation's war effort.

Most recently, the organization has been nationally and internationally known as the U.S. Army Environmental Hygiene Agency (AEHA) and is located on the Edgewood area of Aberdeen Proving Ground, Maryland. Its mission had been expanded to support the worldwide preventive medicine programs of the Army, DOD and other Federal agencies through consultations, supportive services, investigations and training.

On 1 August 1994, the organization was officially redesignated the U.S. Army Center for Health Promotion and Preventive Medicine and is affectionately referred to as the CHPPM. As always, our mission focus is centered upon the Army Imperatives to that we are optimizing soldier effectiveness by minimizing health risk. The CHPPM's mission is to provide worldwide scientific expertise and services in the areas of:

- Clinical and field preventive medicine
- Environmental and occupational health
- Health promotion and wellness
- Epidemiology and disease surveillance
- Related laboratory services

The Center's quest has always been one of customer satisfaction, technical excellence and continuous quality improvement. Our vision is to be a world-class center of excellence for enhancing military readiness by integrating health promotion and preventive medicine into America's Army. To achieve that end, CHPPM holds everfast to its core values which are steeped in our rich heritage:

- Integrity is our foundation
- Excellence is our standard
- Customer satisfaction is our focus
- Our people are our most valuable resource
- Continuous quality improvement is our pathway

Once again, the organization stands on the threshold of even greater challenges and responsibilities. The CHPPM structure has been reengineered to include General Officer leadership in order to support the Army of the future. The professional disciplines represented at the Center have been expanded to include a wide array of medical, scientific, engineering, and administrative support personnel.

As the CHPPM moves into the next century, we are an organization fiercely proud of our history, yet equally excited about the future. The Center is destined to continue its development as a world-class organization with expanded preventive health care services provided to the Army, DOD, other Federal agencies, the Nation, and the world community.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:

November 12, 1997

SRF-5J

Mr. Martin R. McCleery
Remedial Project Manager
Twin Cities Army Ammunition Plant
4700 Highway 10, Suite A
Arden Hills, Minnesota 55112-3928

Subject: **Consistency Test for the Tier I Screening Risk Assessment of Aquatic Ecosystems, Twin Cities Army Ammunition Plant, Final Draft, prepared by the U.S. Army Center for Health Promotion and Preventive Medicine, June 1997**

Dear Mr. McCleery:

You are hereby advised that the U.S. Environmental Protection Agency has determined that, in accordance with Chapter XIV of the Federal Facility Agreement, the subject document, Tier I Screening Risk Assessment of Aquatic Ecosystems, passes the Consistency Test.

If you have any questions, or require additional information, please call me at (312) 353-5577.

Sincerely,

Tom Barounis

Tom Barounis
Remedial Project Manager

Enclosure

cc: Dagmar Romano, MPCA

Minnesota Pollution Control Agency

November 4, 1997

Mr. Martin McCleery
Remedial Project Manager
Twin Cities Army Ammunition Plant
4700 Highway 10, Suite A
Arden Hills, Minnesota 55112-3928

RE: Consistency Test for the Tier I Screening Risk Assessment of Aquatic Ecosystems, Twin Cities Army Ammunition Plant, Final Draft. Prepared by U.S. Army Center for Health Promotion and Preventive Medicine, June 1997

Dear Mr. McCleery:

Staff at the Minnesota Pollution Control Agency (MPCA) have reviewed the above-referenced document. MPCA staff comments to the report, submitted on August 20, 1997, were adequately responded to in correspondence from Army dated October 24, 1997. You are hereby advised that, in accordance with Chapter XIV of the Federal Facility Agreement, the Tier I Screening Risk Assessment of Aquatic Ecosystems passes the Consistency Test.

If there are questions or you require additional information, please contact me at (612) 296-7776.

Sincerely,

Dagmar Romano

Dagmar Romano
Project Manager
Response Unit I
Site Response Section
Ground Water and Solid Waste Division

DR:ch

cc: Tom Barounis, U.S. Environmental Protection Agency

FINAL REPORT
EXECUTIVE SUMMARY
TIER I SCREENING RISK ASSESSMENT OF AQUATIC ECOSYSTEMS
NO. 39-EJ-1393-97
TWIN CITIES ARMY AMMUNITION PLANT
NEW BRIGHTON, MINNESOTA
OCTOBER 1992 - JULY 1993

1. **PURPOSE.** The purpose of this report is to identify chemicals of concern in surface waters and sediment at, or near, several source areas, to evaluate their potential to cause adverse ecological impact, and to identify missing information and other data gaps. Results and conclusions from this Tier I screening risk analysis serve two purposes. First, a limited number of contaminants are identified which might have the potential for causing adverse impact within habitats of concern. Second, missing information and data gaps are identified. Recommendations in this report will focus further investigation, where warranted, in order to better evaluate potential risks to the aquatic environment.

These investigations are proceeding under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act and the National Contingency Plan. This effort is one part of the remedial investigation/feasibility study process at TCAAP. One of the sites evaluated (Round Lake) is managed by the U. S. Fish and Wildlife Service as a management unit of the Minnesota Valley National Wildlife Refuge.

2. **CONCLUSIONS.** This investigation has been able to narrow down the chemicals and areas considered to contain the most potential for ecological risk based on expected individual species responses, benthic community evaluations, and other supporting data. This report also outlines the data gaps which can potentially hinder risk-based management decisions. It should be noted that this assessment screens for the *potential* for adverse impacts; therefore, the report does not document that impacts are definitively occurring now, or will occur in the future.

2.1 Round Lake. Though Round Lake appears to be typical of a natural eutrophic pond environment, chemical impacts could be occurring. Barium and zinc in the surface waters may be able to cause toxic effects in the water column. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

The substances thought to be contributing the most to this potential risk in sediment are limited to the metals: aluminum, cadmium, chromium, copper, silver, vanadium, and zinc. Aquatic mammals, wading birds, benthic organisms, and amphibians of the system are predicted to be impacted by the contamination.

The northern portion of the lake appears to pose more risk to benthic organisms based on the screening risk model. However, the benthic evaluation indicates that this might not be the case. These benthic evaluations indicate that the southern end, near the lake's outfall, is more impacted in terms of biodiversity.

A limited bioavailability investigation of sediment metals shows that there might be sufficient acid volatile sulfide in the sediments to bind cadmium, copper, mercury, and zinc. Because acid volatile sulfide levels in sediments are dynamic and vary seasonally and only a few samples were collected during one season, this data does not provide conclusive evidence that these metals are biologically unavailable.

2.2 Sunfish Lake. Sunfish Lake sediments show signs of organic overenrichment and might also be suffering from chemical impacts, though these chemical stresses are relatively less than those potentially occurring within Round Lake. Aluminum, barium, and zinc in the surface waters may be able to cause toxic effects in the water column. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

The substances thought to be contributing the most to these risks in the sediment are: aluminum, chromium, copper, lead, vanadium, and zinc. Benthic macroinvertebrates, amphibians, wading birds, and waterfowl are potentially at risk. Though numerous muskrat homes and other mammalian tracks and dens have been observed, aquatic mammals are predicted to be experiencing the highest chemical risks at Sunfish Lake.

A limited bioavailability investigation for sediment metals shows that there is a potential for adequate acid volatile sulfide in the sediments to bind much of the zinc, copper, lead, and cadmium, however only two samples were collected during one season.

2.3 Marsden Lake. Marsden Lake has not been adequately characterized for chemical contamination, nor for its specific ecology. Based upon the available data, the most significant potential for risks are due to detections of pesticides and zinc in the sediments. Aluminum, barium, and zinc in surface water have the potential to cause toxicity. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

2.4 Rice Creek. Rice Creek is impacted by organic pollution before it enters TCAAP. Though some chemical impact risks have been predicted by this assessment, the benthic macroinvertebrate survey provides evidence that the creek is not adversely affected by TCAAP operations. In the surface water, bariummay have the potential for causing toxicity. Zinc does not pose a hazard to aquatic organisms. Though levels of zinc which exceed water quality standards were detected during the OU-2 Feasibility Study, additional sampling during the OU-2 FS (June 1993) and the annual monitoring programs of 1994 and 1995 at five Rice Creek stations indicate that water concentrations of zinc do not exceed the standard.

The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

2.5 Area B Wetlands. The Area B Wetlands have not been adequately characterized for contaminant presence nor for ecology. Based upon the available data for Area B3, the most significant potential for risks are due to detections of pesticides in the sediments. Aluminum, barium, manganese, and zinc in surface water have the potential to cause toxicity. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

Aluminum and vanadium in the sediments may potentially impact aquatic mammals, in addition to the pesticides. This site provides some of the best TCAAP habitat for amphibian species, but insufficient toxicity information exists to screen the contaminants for their ability to be toxic to these species throughout their life-cycle without performing toxicity testing.

The sediments and surface water at Areas B1 and B2 have not been characterized. The shallow and deep soils, and groundwater at Areas B1 and B2 were characterized during the Operable Unit 2 Feasibility Study; however, contamination of the surrounding soils and groundwater was not found.

2.6 Site G Pond. Pond G is relatively small compared to the other aquatic habitats associated with TCAAP and contamination here will not likely contribute to overall ecological impact at the installation. Based upon only one sample at one location, all ecological receptors are expected to exhibit unacceptable risks when exposed to Pond G. In surface water, aluminum, barium, manganese, and zinc may be consistently toxic. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes. In the sediments, copper, lead, zinc, PCB 1254, and p,p-DDT metabolites are likely to be causing toxic conditions for sediment organisms.

2.7 Data Gaps and Limitations. This ecological risk assessment is a screening risk assessment in that it does not definitively assess ecological risks but rather defines the potential for adverse effects to occur. In some instances, the calculated potential risks may be attributed to background. Relatively low levels ($\leq$1 ppm) of pesticides that are ubiquitous in the environment are responsible for much of the potential risk at Marsden Lake and Area B. Since there is no history of pesticide disposal practices at TCAAP, it is likely that these pesticide concentrations are due to normal application, and do not exceed local background concentrations. This risk assessment has not been able to adequately assess the risks from sediment contamination of pesticides because of inadequate analytical detection limits, however, sediment organic carbon data collected by the MPCA shows that even the detected pesticides are not likely to be bioavailable. In addition, a lack of benthic toxicological data exists for aluminum and vanadium to perform a full toxicity screen.

Any estimated risks posed by aluminum and zinc in surface water are uncertain. Supplemental surface water data collected during the OU-2 Feasibility Study in 1993 and annual monitoring of Round Lake, Marsden Lake, and Rice Creek in 1994 and 1995 indicates that the zinc detections during October 1992 are suspect. This is important because it is these October 1992 data which are forcing the high risk modeling estimates from zinc at several sites.

The Area B wetlands and Marsden Lake are not fully characterized. Risks were characterized based on available data. However, adequate risk evaluations of these two wetland areas cannot be performed at this time due to limited data. Large data gaps exist for screening amphibian risks since toxicological data for many contaminants of concern are not available.

Exposures to environmental contaminants via dietary consumption were modeled for the receptors of concern. In a number of studies, the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) has found that food web modeling produces conservative estimates of exposure and, thus, risk. Risks associated with prey consumption need to be viewed with this in mind. Food web modeling, however, does focus future work on receptors most likely at risk, so that the diets of these organisms can be sampled with a minimum of unnecessary field and laboratory costs.

The potential for contaminants presently in the deep sediments at Round Lake (deeper than 1 foot below the surface) to become biologically available in the future has not been critically examined. This situation invokes a limitation of this assessment to provide information to assist in the management of the lake over the long term.

Many of the sites and water bodies at TCAAP contain critical, threatened, or endangered habitats. The benefits of all proposed remedial activities should be evaluated against the destruction of critical habitat.

3. RECOMMENDATIONS. The following investigations are recommended to close data gaps and carry out a more focused evaluation of potential ecological risks in a Tier II risk assessment.

3.1 Round Lake. For the sediments, perform sediment toxicity tests at the southern end of the lake, a bioavailability evaluation at the northern end, and collect concurrent benthic community diversity data during both studies. Design the toxicity tests to determine if the benthic impacts in the southern portion of the lake are related to toxicity. Design the bioavailablity study to evaluate the remaining contaminants of concern in sediment: aluminum, cadmium, chromium, copper, silver, vanadium, and zinc. Two Tier II studies are currently underway at USACHPPM which address these remaining sediment contamination issues.

For surface waters, collect water samples from several locations in the lake every quarter for one year. The purpose of this data collection is to provide the necessary data to determine if barium, cadmium, copper, mercury, silver, and zinc concentrations consistently exceed their water quality benchmarks.

Review the compatible use directives of the U.S. Fish and Wildlife Service as they pertian to their management of the lake as a unit in the Minnesota Valley National Wildlife Refuge and determine if they will impact the risk assessments.

3.2 Sunfish Lake. For the sediments, perform a bioavailability evaluation and collect concurrent benthic community diversity data. Design this to evaluate the remaining contaminants of concern in sediment: chromium, copper, lead, and zinc. A Tier II study is currently underway at USACHPPM which begins to address the remaining sediment contamination issues at Sunfish Lake.

For surface waters, collect water samples from several locations in the lake every quarter for one year. The purpose of this data collection is to provide the necessary data to determine if aluminum, barium, cadmium, copper, mercury, silver, and zinc concentrations consistently exceed their water quality benchmarks.

3.3 Marsden Lake. Perform additional sediment and surface water sampling at areas suspected to be impacting the lake in order to better characterize the nature and extent of any TCAAP waste contamination. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a

COC, perform a screening risk evaluation similar to the one performed in this report.

3.4 Rice Creek. For the sediments, no further action is needed. For surface waters, collect water samples from three locations in the creek every quarter for one year. The locations should include one upstream, one downstream, and one in between. Design this monitoring to determine if aluminum, barium, cadmium, copper, silver, and mercury concentrations consistently exceed their water quality benchmarks.

3.5 Area B Wetlands. Perform sediment and surface water sampling at Areas B1 and B2 in order to better characterize the nature and extent of any TCAAP waste contamination. Sample several locations in each area pothole wetland. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a COC, perform a screening risk evaluation similar to the one performed in this report.

Perform toxicity tests using amphibian species on Area B3 sediments and surface waters to close the data gap associated with the prediction of risks to amphibians. Perform toxicity tests using aquatic biota on Area B3 surface waters to determine if aluminum, barium, cadmium, copper, mercury, silver, and zinc are producing toxic effects.

3.6 Site G Pond. Perform additional sediment and surface water sampling at several locations in order to better characterize the nature and extent of any TCAAP waste contamination. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a COC, perform a screening risk evaluation similar to the one performed in this report.

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TIER I SCREENING RISK ASSESSMENT OF AQUATIC ECOSYSTEMS
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1. PURPOSE. The purpose of this report is to identify chemicals of concern in surface waters and sediment at, or near, several source areas, to evaluate their potential to cause adverse ecological impact, and to identify missing information and other data gaps. Results and conclusions from this Tier I screening risk analysis serve two purposes. First, a limited number of contaminants are identified which might have the potential for causing adverse impact within habitats of concern. Second, missing information and data gaps are identified. Recommendations in this report will focus further investigation, where warranted, in order to better evaluate potential risks to the aquatic environment.

These investigations are proceeding under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act and the National Contingency Plan. This effort is one part of the remedial investigation/feasibility study process at TCAAP. One of the sites evaluated (Round Lake) is managed by the U. S. Fish and Wildlife Service as a management unit of the Minnesota Valley National Wildlife Refuge.

2. BACKGROUND. The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) formerly the U.S. Army Environmental Hygiene Agency (USAEHA), has been tasked to generate the ecological risk assessments (ERAs) at TCAAP under agreement with the U.S. Army Environmental Center (USAEC) and the U.S. Army Materiel Command (USAMC). The Terrestrial ERA has already been completed by this Center (USAEHA, 1991). The risk assessment presented herein evaluates the aquatic systems associated with the TCAAP.

Contaminants identified in previous TCAAP investigations (i.e., Operable Unit 2 Feasibility Study) have the potential, but are now not known to, cause adverse chemically-induced effects in these habitats. These previous investigations considered these sites as a part of the Operable Unit 2. However, these sites and this risk assessment, though a part of the TCAAP remedial investigation/feasibility study process, was administratively separated from the other operable units at TCAAP. The TCAAP areas under consideration in this ERA are Round Lake, Rice Creek, Sunfish Lake, the Area B pothole wetlands, Marsden Lake, and the Site G Pond. These areas are shown in Figure 1. Brief descriptions of each site's history and general ecology begin with section 2.2. Characteristics of geology and hydrology are not included; these topics are covered in the Remedial Investigation and Feasibility Study (RI/FS) reports.

2.1 ERA Framework. This ERA addresses the potential impacts posed by source area-derived contaminants to the ecological habitats related to TCAAP in the *absence* of any remedial action. This ERA was conducted using available site and scientific data in order to make comparisons of TCAAP contamination levels to established criteria, literature toxicity references, and modeled exposure assumptions.

Ecological risk assessment is defined as a *process* that evaluates the likelihood that adverse ecological effects are occurring, or may occur, as a result of exposure to one or more stressors (USEPA 1992). As defined by the USEPA, a stressor is any physical, chemical, or biological entity that can induce an adverse ecological response. Adverse responses can range from sublethal chronic effects in an individual organism to a loss of ecosystem function. A risk does not exist unless: (1) the stressor has the ability to cause one or more adverse effects, and (2) it co-occurs with or contacts an ecological component long enough and at a sufficient intensity to elicit the identified adverse effect. The ERA process revolves around a structural framework which organizes the evaluation of the appropriate data and considerations. This structure is outlined below.

- I *Problem Formulation*: As the first phase, this step establishes the goals, breadth, and focus of the assessment. Assessment endpoints are identified here.

- II *Characterization of Exposure*: This step evaluates the interaction of the stressor with the ecological component, qualifies the magnitude of exposure, and quantifies the spatial and temporal distributions of exposure for the scenarios developed during problem formulation.

- III *Characterization of Ecological Effects*: The toxicological and ecological relationships between the stressors and the assessment and/or measurement endpoints identified in the problem formulation phase are analyzed at this stage.

- IV *Risk Characterization*: As the final phase of the assessment, this step estimates and describes the likelihood of adverse effects occurring as a result of exposures to stressors.

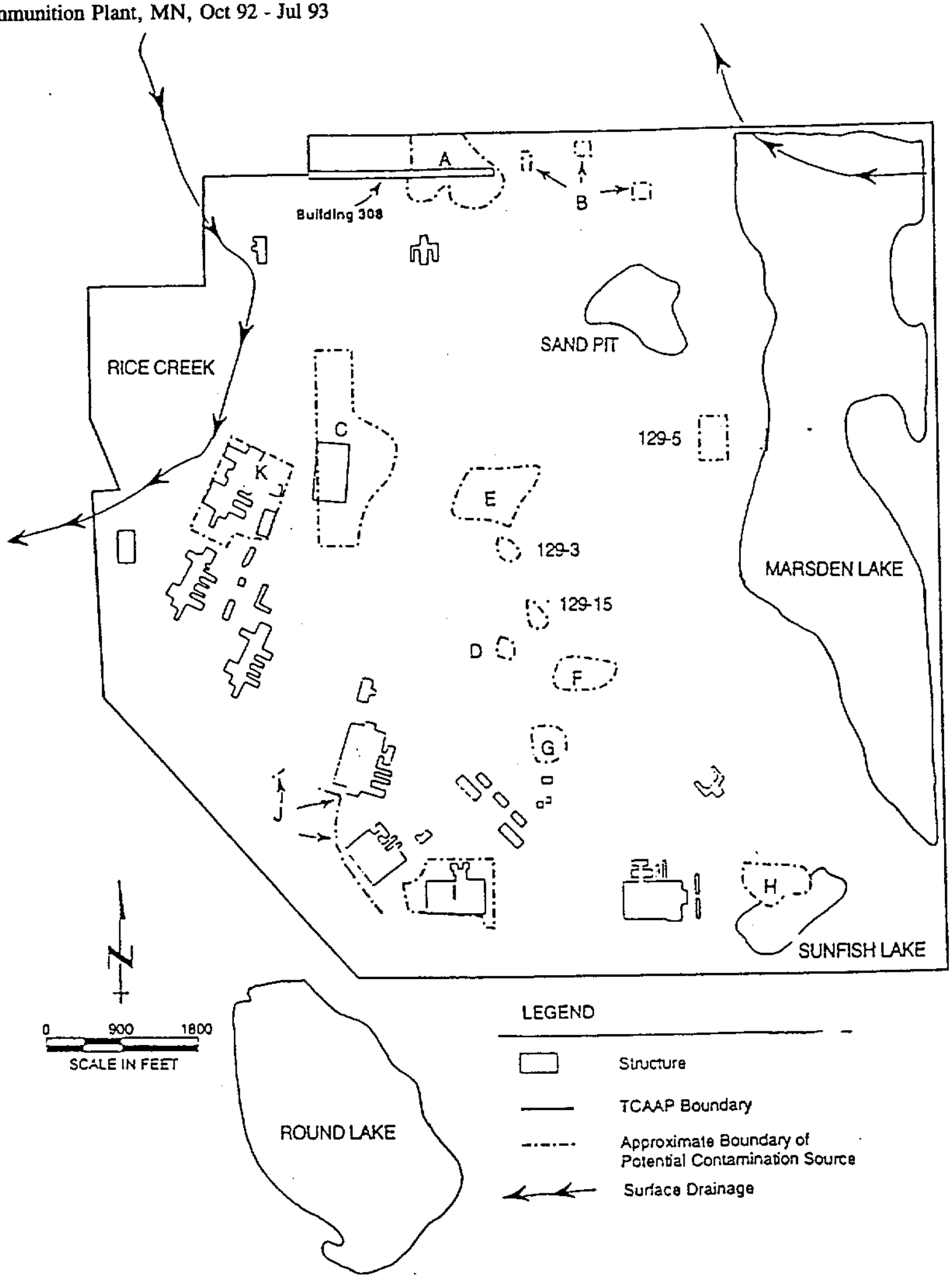

Figure 1. Twin Cities Army Ammunition Plant. This map taken from the Operable Unit 2 Feasibility Study.

Unlike human health risk assessments, ERAs should focus on the effects of contaminants on populations or communities of organisms, and not on individuals. It should be stressed that even if potential risks to individuals of a population are identified during an ERA, these risks must be evaluated within a larger context to determine if these risks are ecologically significant. Risks to a small portion of an otherwise healthy animal or plant population may not be ecologically significant. For example, if it is determined that a risk from exposure to a contaminant exists for a portion of a species population, but further field studies (to validate the estimated risks) reveal a thriving population, then that modeled risk to the individual should not generally be considered significant. However, if the species is endangered or threatened, then risks to individuals must be considered.

2.2 History and Ecology of Round Lake. Round Lake is located off the installation to the southwest, across Highway 10 and Highway 96. This lake is currently managed by the U.S. Fish and Wildlife Service (USFWS) as a management unit of the Minnesota Valley National Wildlife Refuge. This lake is rather large (approximately 50 hectares) relative to the installation lakes.

The deepest part of Round Lake is located in the south central portion of the lake and is estimated to be approximately 15 to 26 feet deep. A palustrine emergent wetland has developed around the edge of the lake. This wetland is dominated by cattail (*Typha sp.*). A small stand of willow (*Salix sp.*) exists along the northern shore. Mammals known to utilize Round Lake are red fox, muskrat, and mink. The wetland areas are also used by a number of typical marsh birds, with Red-winged Blackbirds (*Agelaius phoeniceus*) and the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) being dominant. Waterfowl can potentially utilize Round Lake as a foraging, nesting, or resting area. However, large numbers of various species of waterfowl were not observed during the field investigation. A few Canada Geese (*Branta canadensis*) and one Common Loon (*Gavia immer*) were seen.

Waterfowl species rearing broods on the lake in recent years include Canada geese, Mallards, Blue-winged Teal, and Wood Ducks. Large concentrations of Ringed-neck Ducks and Lesser Scaup use Round Lake as a resting and feeding area during their spring and fall migrations. Round Lake also has confirmed use by Black Terns and Common Loons.

Historic sources of pollutants to Round Lake include activities at part of Site I of the TCAAP facility. Round Lake may also have received contamination by unknown sources which are out of the Army's control. Part of the Site I facility has been used to produce artillery shell forgings. The production forges were cooled by water which was discharged to floor drains, along with water used in general cleanup operations. The floor drains in this part of the building were connected to the storm sewer, rather than the sanitary sewer. The forging equipment used large quantities of hydraulic fluid containing high percentages of PCBs. Leakage of this equipment, lubricants used in the forging process, and other contaminants consequently had a pathway into the storm sewer. The storm sewer discharged into a ditch which feeds into Round Lake through a sewer outfall at the intersection of Highways 96 and 10. During 1942-1943, approximately 1.9 million liters (500,000 gallons) per day were discharged from this building 502 and building 501 into the lake. In 1944, forges were added to both buildings and daily discharges increased and remained high until the end of the war. The storm sewer was altered in 1953 in response to complaints about grease and oil pollution in Round Lake, and water from some of the floor drains was subsequently sent to the sanitary sewer. For about 1 year before this conversion, Round Lake may have received about 3.8 million liters (1 million gallons) of waste water per day from building 502. Some cyanide wastes were still discharged through to the floor drains through 1967. In 1969, the tenant of the building noticed that many of the floor drains were still connected to the storm sewer. This situation has since been remedied.

A landfill was identified on the northern shore of Round Lake in 1991. Area residents were contacted during the field investigation. The landfill was constructed by the brother of one of the residents and is reportedly composed of rubble fill.

2.3 History and Ecology of Sunfish Lake. Sunfish Lake is a shallow 5.7-hectare lake in the southeast corner of the installation. Sunfish Lake drains through Marsden Lake, which in turn drains off-post in at least three different directions. The outfall of the lake is dominated by cattail (*Typha sp.*) and sedges (*Carex sp.*). Water draining from Sunfish Lake flows into Marsden Lake. Sunfish Lake is used by a number of waterfowl species including Canadian Geese (*Branta canadensis*) and Mallard (*Anas platyrhynchos*). Pied-billed Grebes (*Podilymbus podiceps*) and a Great Blue Heron (*Ardea herodias*) were seen during the field investigation. Sunfish Lake is used by the Minnesota Department of Natural Resources (DNR) to rear walleye (*Stizostedion vitreum vitreum*) and muskellunge (*Esox masquinongy*). Sunfish Lake has received copper sulfate treatments in the past to control algal growth. It has been suspected that Sunfish Lake experiences "freeze-through" with resulting winter die-off of fish populations. However, some relatively large muskellunge and walleye have been captured from Sunfish Lake during fish fry harvesting, indicating that 100 percent winter kill is not occurring. Red fox, muskrat, and mink are known to utilize Sunfish Lake. Active mink dens are suspected to be present in the landfill slope northeast of Site H. Other mustelid dens are thought to be present, yet they have not been confirmed.

Sunfish Lake is fed with water entering from a ditch on the east side of the lake. During the 1940s, a northern bay of Sunfish Lake was filled. Site H now occupies this filled area. The eastern portion of subsite H1 was used as a burning area for class A combustible waste (paper, wood, cardboard, etc.) from 1940 to 1946. In the 1960s, solvent contaminated corn cobs were burned in this area. The southwest corner of Site H may have been used for burial and dumping of industrial sludge, paint residue, incineration ash, and solvents. Metal debris, including small caliber shells, is scattered on the shore of Sunfish Lake at Site H and on the bottom of Sunfish Lake at Site H. The most likely source of contamination for Sunfish Lake is Site H, including the metal debris scattered on the bottom of Sunfish Lake.

2.4 History and Ecology of Marsden Lake. Marsden Lake is a major feature of TCAAP. It is a marsh of about 89 hectares (including open water) located along the eastern edge of the installation. Marsden Lake is a large, permanently flooded palustrine emergent wetland, occupying the eastern quarter of the installation. The vegetation of Marsden Lake is dominated by cattail (*Typha sp.*). Floating mats of emergent vegetation have been noted in this wetland. Marsden Lake is used by a number of waterfowl species including Canadian Geese (*Branta canadensis*) and Mallard (*Anas platyrhynchos*). Common Loons (*Gavia immer*) were heard but not seen during the field investigation. Numerous reptile and amphibian species utilize Marsden Lake including the snapping turtle (*Chelydra serpentina*), the painted turtle (*Chrysemis picta*), frogs (*Hyla versicolor*, *Pseudacris triseriata,* and *Rana pipiens*), and the toad (*Bufo americanus*). The most notable herptile utilizing Marsden Lake is the Blandings turtle (*Emydoidea blandingi*), a species of concern since its population is declining nationwide. Numerous Blandings turtles were seen in Marsden Lake during a survey of TCAAP for these turtles in 1989. A number of muskrat (*Ondatra zibethicus*) lodges are located in Marsden Lake, which probably help curtail the encroachment of the cattail mat. Other mammals, such as the red fox and mink, are known to use this lake. In previous years, the Minnesota Department of Natural Resources has released Trumpeter swans into Marsden Lake.

Marsden Lake is fed with water originating in Sunfish Lake. It also receives large amounts of runoff from Lexington Avenue, which runs along the entire length of Marsden Lake. Marsden Lake may also be receiving runoff from site 129-5 and a grenade range located in the central portion of the eastern shore of the lake. All of the above water and runoff sources are potential sources of contamination for Marsden Lake.

2.5 History and Ecology of Rice Creek. Rice Creek is a tributary of the Mississippi River, which flows through the northwest corner of the plant. TCAAP accounts for approximately 2 percent of Rice Creek's 474-square-kilometer basin and is near the downstream end of the creek. It generally has a sandy bottom and its banks are covered by grasses. A broad leaved deciduous scrub-shrub wetland is located along the western bank of the creek. This wetland is suspected to be permanently flooded, however, year-round observations on the hydrology of this wetland have not been made. The wetland contains a number of small oxbow lakes, which are used by amphibians for breeding. Various waterfowl species, Belted Kingfishers (*Megaceryle alcyon*), groundhogs (*Marmota monax)*, cottontail rabbits (*Sylvilagus floridanus*), and red fox (*Vulpes vulpes*) have been observed using the area immediately adjacent to Rice Creek. Rice Creek is protected as a source of drinking water by the State of Minnesota.

Rice creek potentially receives groundwater from the perched unit 1 aquifer under site K, and may be receiving VOCs from this source. The outfall of this potential contamination source is between sampling locations RCKSE04 and RCKSE05.

2.6 History and Ecology of the Area B Wetlands. The Area B Wetlands are a series of prairie potholes centered around Site B. Site B consists of three separate subsites totaling about 0.9 hectares. Several abandoned farmsteads are present in this area. There is little relief in the area. There are numerous clumps of trees, especially around the abandoned farmsteads. There is no documentation of hazardous substance disposal at this site, although it is possible that small amounts of sewage sludge were dumped before 1966. The southwestern corner of Site B3 is part of a larger landfill area. During this field study, chunks of asphalt were visible in the fill face. Site B3 is adjacent to the area cited in Linck's study as important habitat for Blandings Turtle. The area is dominated with emergent vegetation, *Typha* species being the most prevalent. Muskrat and red fox are also known to use this area.

2.7 History and Ecology of the Site G Pond. Site G covers about 1.7 hectares at the base of the kame, about 200 meters south of Site F. This site functioned as a general purpose dump from World War II until late 1976. Some of its contents include material from demolished buildings, urethane foam, floor sweepings, scrap metal grindings, and ashes from scrap paper burning cages. Most of the site is now an artificial plateau characterized by a fairly high and steep face with protruding debris. This plateau has been covered with a clay cap. Just off of the fill areas to the north and south are bands of trees; otherwise, the area is lightly vegetated with grasses and forbs. Immediately to the northeast of the site boundary is a small (0.1 hectare) pond which receives drainage from the site. This pond is used by wildlife in the vicinity, as it is some distance to any other natural year-round body of standing water. The man-made gravel pit water body on the other side of the kame does attract bird species, though a lack of access and inadequate cover prevent other species from using this water source.

3. PROBLEM FORMULATION. As was described above, the first phase of the ERA establishes the goals, breadth, and focus of the assessment. This section identifies the TCAAP-related stressors, identifies the conditions surrounding the interaction of these stressors on the environment, and establishes the assessment and measurement endpoints to be studied.

3.1 Chemical Stressors. Information collected from studies conducted between October 1992 to July 1993 identified potential TCAAP contaminants within the surface water, sediments, and wetlands including metals, polychlorinated biphenyls (PCBs), pesticides, and two volatile organic compounds. These stressors are not evenly distributed among sites, nor are they uniform in distribution within the sites.

3.2 Ecological Components. The ecological components potentially impacted and addressed in this report are formed around the aquatic habitats in and around TCAAP. The ERA methods utilized herein attempt to estimate risks to fish, benthic macroinvertebrates, amphibians, waterfowl, wading birds, and aquatic mammals. These components are present at TCAAP in lake, pond, marsh, stream, and prairie pothole wetland habitats.

3.3 Endpoints. This ERA describes the potential risks to assessment endpoints. These assessment endpoints are the resources that are valuable to the TCAAP stakeholders. The goal of this ERA is to demonstrate whether a potential for adverse toxicological impacts exists for the following assessment endpoints: water quality, which ensures the health of aquatic organisms; sediment quality, which ensures the health of benthic organisms; and healthy populations of riparian fauna (e.g., avians, mammals, and amphibians).

Measurement endpoints are *measurable* characteristics that are related to the valued assessment endpoints chosen. When possible, the characteristics chosen to be measured have been limited to adverse toxicological endpoints which have relevance to populations of organisms, i.e., reduced reproductive capabilities, decreased lifespan, and growth inhibition. To measure the potential toxicological impacts to receptors, four methods will be utilized. These measurement endpoints are:

- Hazard indices are presented which rank risks for aquatic organisms. These indices were derived by comparing water quality benchmarks, including the Minnesota Ambient Water Quality Standards (AWQS), to the water contaminant concentration data.

- Hazard indices are presented which rank risks for benthic macroinvertebrates and similar sediment organisms. These indices were derived by comparing sediment quality benchmarks to sediment contaminant concentration data.

- Hazard indices are presented which rank risks for specific riparian receptors, i.e., Mallards, Great Blue Herons, and Muskrats. These indices were derived by comparing modeled contaminant ingestion doses for each receptor, through expected fate and transfer pathways, to toxicological reference values (TRVs).

- Hazard indices are presented which rank risks for amphibians. These indices were derived by two methods: (1) comparison of literature TRVs to contaminant levels detected in the surface water and (2) comparisons of sediment contaminant concentration data to toxicologically based sediment criteria.

Though this screening method concentrates on the risk of individual organism responses for the higher organisms (e.g., amphibians, wading birds, waterfowl, and aquatic mammals), this method has been deemed appropriate for screening for the potential for population-level impacts.

4. SAMPLING AND ANALYSIS. This section outlines the field sampling activities performed by Montgomery Watson, Inc. and details the resulting data evaluations. The methodologies utilized to discriminate between site-related contaminants and natural background conditions are outlined. The results of the contaminant screening for surface water and sediment are given for each site. Finally, the limitations of the current site data for the evaluations of ecological risk are outlined.

4.1 Sampling. The analytical data used in this report has been collected during several field efforts. These efforts began with the Operable Unit 2 Feasibility Study (OU-2 FS) in October 1992 and extending through July 1993. The majority of this data was collected for the purposes of the ongoing RI/FS. The sediment data set for describing natural background constituent levels was not collected during these efforts; rather, they were provided by the USFWS. Additional data was obtained from the MPCA and the 1994 and 1995 Annual Monitoring Reports (references 5 and 6).

4.1.1 Background Sediment. In order to determine if substances identified in the aquatic ecosystems at TCAAP were elevated to a level of concern, aquatic ecosystems considered unaffected by TCAAP activities were provided by the USFWS. These background areas are important to determine which substances identified are contaminants and which are naturally occurring. These background conditions are also necessary to determine cleanup concentrations if necessary. Louisville Swamp, Chaska Lake, Rice Lake, Grass Lake, Fisher Lake, Gravel Pit, Black Dog Lake, Pond C, Blue Lake, and Long Meadow Lake--all located in the Minnesota Valley National Wildlife Refuge--were chosen by the USFWS as background sediment sample locations. The Minnesota Pollution Control Agency and the USFWS eliminated Black Dog Lake, Pond C, and Blue Lake as background locations because they receive moderate amounts of urban/highway storm water runoff. The background sediment metal concentrations used are the product of a sampling investigation in 1985 by the USFWS and are reported in $\mu g/g$ dry weight.

Refer to Table 1 for the presentation of the data set and the background screening concentrations used in the assessment to select contaminants of concern. The background sediment concentrations are calculated using the methodology recommended by the MPCA during the 8 October 1996 Ecological Risk Assessment Update Meeting at TCAAP. The algorithm follows:

$$[background] = \bar{x} + (t_{95\%} \cdot SD)$$

where, x-bar is the mean background substance concentration, $t_{95\%}$ is the t-value based upon the degrees of freedom and the 95% confidence interval, and SD is the standard deviation of the background sample set.

4.1.2 Site Sediment. As part of the OU-2 FS, Montgomery Watson, Inc. took sediment samples at Round Lake, Sunfish Lake, Marsden Lake, Rice Creek, Area B Wetlands, and Pond G in March 1993. Montgomery Watson analyzed these samples for Target Analyte List (TAL) metals, silver, lead, mercury, cyanide, Target Compound List (TCL) volatile organic compounds (VOCs), TCL semi-volatile organic compounds (SVOCs), halogenated VOCs, aromatic VOCs, TCL organochlorine pesticides (OCPs) PCBs, herbicides, rotenone, arsenic, and selenium. Samples were taken at 1-foot intervals from 0 to 6 feet in Round Lake and the surficial sediments were sampled in all other areas. It has been assumed that none of the biological groups of concern will come in contact with sediment at depths greater than 1 foot. Therefore, only sediment samples taken at a depth of 0 to 1 feet were evaluated for possible toxic effects. A summary of these results appears in Appendix B. Data collected by the Minnesota Pollution Control Agency (MPCA) has been used as well. The percentage of total organic carbon (TOC) in sediment was based on their results (Table B-17). Also, the MPCA collected sediment data at the Area B wetlands.

4.1.3 Site Surface Water. Montgomery Watson, Inc. also took surface water samples in Round Lake, Sunfish Lake, Marsden Lake, Rice Creek, Area B Wetlands, and Pond G in March 1993 (Appendix B). Montgomery Watson analyzed these samples for TAL metals, mercury, zinc, cyanide, hexavalent chromium, nitrate/nitrate as nitrogen, ortho-phosphate as phosphorus, total phosphate as phosphorus, TCL VOCs, TCL SVOCs, halogenated VOCs, aromatic VOCs, TCL OCPs/PCBs, herbicides, anions, and rotenone.

Table 1. Selected Background Sediment Samples and Calculated Screening Values

	Louisville Swamp		Chaska Lake		Rice Lake West		Grass Lake			Fisher Lake	Gravel Pit	Long Meadow Lake				Statistics and Screening Value		
Substance	001	003	005	007	009	012	014	017	020	026	051	053	056	059	063	mean	SD	[value]
aluminum	8190	4650	7880	7160	7990	6760	6370	6820	7620	5440	13400	6860	6200	6180	5300	7121	2018	10674
arsenic	<5.0	<4.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	10.0	<6.0	<5.0	<5.0	<5.0	<5.0	—	—	5.0 †
barium	150	161	153	138	204	209	133	161	151	270	201	119	129	101	113	160	44.6	238
boron	2.0	2.0	<1.0	2.0	2.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	<1.0	2.0	2.0	<1.0	—	—	2.0 †
beryllium	0.63	0.36	0.62	0.60	0.60	0.55	0.53	1.60	0.61	0.54	0.94	0.76	0.77	0.91	0.95	0.73	0.29	1.2
cadmium	0.70	0.40	0.60	0.60	0.40	1.00	0.70	0.50	0.09	1.20	0.40	0.60	0.40	0.50	0.50	0.60	0.30	1.0
chromium	16.0	10.0	15.0	14.0	15.0	18.0	13.0	13.0	17.0	13.0	31.0	15.0	13.0	13.0	15.0	15.0	4.7	24.0
copper	20.0	14.0	20.0	19.0	20.0	21.0	19.0	20.0	21.0	20.0	38.1	19.0	16.0	18.0	18.0	20.0	5.3	30.0
iron	16200	10400	15900	14500	17600	15800	15200	15400	16800	41000	23600	16000	14300	13300	15300	17420	7077	29882
lead	15.0	14.0	16.0	15.0	17.0	15.0	16.0	18.0	19.0	23.0	20.0	34.0	25.0	33.0	27.0	20.0	6.6	32.0
magnesium	10500	12200	12600	12500	9840	10200	10800	9130	9100	6780	13700	10700	10700	7820	7880	10297	1952	13734
manganese	1190	2930	922	958	1210	1130	751	991	707	1000	1070	600	781	411	1050	1047	567	2046
nickel	20.0	15.0	21.0	21.0	20.0	20.0	21.0	19.0	21.0	16.0	31.0	19.0	16.0	17.0	15.0	19.0	3.9	26.0
selenium	<7.0	<6.0	<7.0	<7.0	<8.0	<7.0	<7.0	<7.0	<7.0	<10.0	<9.0	<7.0	<7.0	<6.0	<7.0	—	—	10.0 †
silver	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.5	0.9	<0.30	<0.2	<0.2	<0.2	<0.2	—	—	0.2 †
vanadium	5.9	5.4	7.2	6.8	7.6	7.0	8.5	8.0	10.0	9.4	18.1	12.0	9.7	13.0	7.4	9.1	3.3	15.0
zinc	82.0	57.3	72.5	69.4	69.4	69.1	62.8	64.7	69.8	69.3	129.0	71.8	60.3	66.1	62.2	72.0	17.0	101
total PCBs	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	—	—	0.05 †

All values are expressed as $\mu g/g$ dry weight.
The "[value]" denotes the screening concentration value.
† Screening value selected based upon professional judgment and consideration of the detection limits.

At Sunfish Lake two surface water samples were analyzed for total hardness. Sample location SFL101SW had a total hardness of 52 mg/l as CaCO3 and sample location SFL102SW had a total hardness of 57 mg/l as CaCO3. Samples SFL101SW and SFL102SW, taken at the same locations, were adjusted accordingly. Other samples were assigned an average hardness of 55 mg/l, which was consistent with hardness levels recommended by the MPCA for state water quality standards.

At Marsden Lake two surface water samples were analyzed for total hardness. Sample location ML101SW had a total hardness of 62 mg/l as CaCO3 and sample location ML102SW had a total hardness of 77 mg/l as CaCO3. Samples taken at these locations were adjusted according to the hardness levels obtained; samples taken at other locations on the lake were adjusted to an average of 70 mg/l as CaCO3, a figure that was also recommended by the MPCA for state water quality standards.

At Rice Creek two water samples were analyzed for hardness. Sample locations RCK101S and RCK102S had consistent readings of 158 mg/l and 159 mg/l as CaCO3, respectively. Water samples taken from Rice Creek were adjusted for an average hardness of 160 mg/l as CaCO3 for simplification of the hardness adjustment equations.

Two very different readings for hardness were obtained from Round Lake. RL101SW was taken near a storm water outfall and had a total hardness of 338 mg/l as CaCO3, probably due to sediments entering the lake at the outfall. Constituents from this sample were adjusted for an average total hardness of 340 mg/l. RL102SW, taken further from the inlet, had a total hardness of 94 mg/l as CaCO3. All other samples taken from Round Lake were adjusted for an average hardness of 95 mg/l, a figure that was consistent with adjustments recommended by the MPCA for state water quality standards.

4.2 Selection of Chemicals of Concern.

4.2.1 Determination of Contaminants in Sediment. In order to be considered a sediment contaminant of concern (COC), the concentration of the constituent in the sediment should be higher than it is in background sediments. The concentration of metals and PCBs in the background sediment that was used to screen chemicals was described in an earlier section and shown in Table 1. As recommended by the regulatory parties in December 1994, the site COCs were evaluated on an exposure range basis, which resulted in a sample point-by-sample point environmental risk evaluation.

A COC was defined by set of selection criteria. Specific COCs have been assigned to each site (Table 2). First, if a substance was not detected at the detection limit is was not considered a COC. Second, if any of the site sediment concentrations was greater than the background screening value, then the substance was selected as a COC. If all site concentrations are below the screening value, then it is not considered a COC. Third, if a substance is a nutrient, then it was eliminated from consideration as a COC. This includes calcium, potassium, sodium, and others. Fourth, if no background screening value is available, and concentrations were detected above the detection limit, then the substance is considered a COC.

Table 2. Selected Chemicals of Concern in Sediment

Round Lake	Sunfish Lake	Rice Creek	Marsden Lake	Pond G	Area B wetlands
aluminum	aluminum	cobalt	aluminum	aluminum	aluminum
cadmium	barium	vanadium	barium	chromium	arsenic
chromium	cadmium		cobalt	cobalt	barium
cobalt	chromium		copper	copper	beryllium
copper	cobalt		lead	lead	chromium
lead	copper		vanadium	vanadium	cobalt
nickel	lead		zinc	zinc	copper
silver	nickel				mercury
vanadium	silver				nickel
zinc	vanadium				vanadium
	zinc				zinc
p,p-DDD	acetone		p,p-DDD	PCB 1254	p,p-DDD
p,p-DDE	methylethyl ketone		p,p-DDE	p,p-DDD	p,p-DDE
p,p-DDT			p,p-DDT	p,p-DDE	p,p-DDT
				p,p-DDT	

4.2.2 Determination of Contaminants in Surface Water. The selection process for determining contaminants of concern in waters is less restrictive than for sediments, primarily because background screening values were not available. In order to be considered a surface water COC, the constituent must be detected above the detection limit and not be a nutritive substance. Refer to Table 3 for the list of surface water COCs.

4.3 Data Analysis. Refer to Figures 2 through 7b for sampling locations and site maps.

4.3.1 Round Lake. Seventeen sediment samples were taken from Round Lake at a depth of 0-1 feet and analyzed for possible contamination. Refer to Appendix B for the concentrations of contaminants at Round Lake. The northern portion of the lake located just south of the urban runoff inflow has the most contaminated sediment. The southern portion of

Table 3. Selected Chemicals of Concern in Surface Water

Round Lake	Sunfish Lake	Rice Creek	Marsden Lake	Pond G	Area B Wetlands
aluminum	aluminum	aluminum	aluminum	aluminum	aluminum
barium	barium	barium	barium	barium	barium
lead	lead	lead	lead	magnesium	lead
magnesium	magnesium	magnesium	magnesium	manganese	magnesium
manganese	manganese	manganese	manganese	zinc	manganese
mercury	silver	silver	nickel		zinc
zinc	zinc	zinc	zinc		
	heptachlor epoxide	heptachlor epoxide			

the lake just above the outflow has the least contaminated sediment. Sample site locations RL05SE and RL09SE are the two hot spots. Zinc is the most widely spread COC, found at 16 sample locations throughout Round Lake. Vanadium is the next most common COC present in Round Lake. DDT contamination was identified at RL09SE.

A total of 24 surface water samples was taken from 20 different locations at Round Lake during October 1992. The majority of the samples were taken at the north section of the lake located south of the urban run off inflow since this section was considered the most contaminated area of the lake. Surface water samples were also taken throughout the lake to ensure that contamination was not present in other areas as well.

The primary COC in surface water samples for Round Lake was zinc. Elevated levels of zinc were found at each sample location and typically ranged between 400-600 μg/L. The highest level, 815 μg/L, was found at sample location RL13SW. Slightly elevated levels of lead (3.85 μg/L) were found at one location, RL02SW. Mercury was found at two locations; RL07SW had a reading of 2.1 μg/L and RL14SW had a reading of 1.17 μg/L. Slightly elevated levels of aluminum were found at some of the sampling locations, with the highest level (154 μg/L) detected at RL13SW.

4.3.2 Sunfish Lake . Ten surficial sediment samples were taken from Sunfish Lake. For concentrations of substances found at each sample site in Sunfish Lake, see Appendix B. The area with the most COCs is in the northwestern area of the lake adjacent to the old landfill. Chromium, copper, lead, vanadium, and zinc are significant contaminating metals. Sediment samples (SFL08SE, SFL09SE, and SFL10SE) were also taken from the outflow stream that leads into Marsden Lake. A road crosses this stream.

Three unknown chemicals were discovered in Sunfish Lake sediments. These were discovered at SFL03SE, SFL08SE, and SFL10SE. They were identified as unknowns 069 (400μg/g), 091 (0.05μg/g), and 092 (0.04μg/g), respectively. These unknown chemicals were not labeled as tentatively identified compounds (TICs) because their analysis outcomes did not meet the necessary criteria. These substances were labeled as "unknowns" because no match was found in the mass spectral library. The substances would have been labeled TICs if they were at least 10% of the response of the mearest internal standard and were matched against the library (Smith 1994). We presume that the lab examined the 30 largest peaks in the volatile run for TICs and the 30 largest peaks in each extractable run that fit the criteria. Because these substances did not satisfy this criteria for being selected as TICs, they are not considered further in this risk assessment.

A total of 10 surface water samples was taken by Montgomery Watson, Inc. from Sunfish Lake in October 1992. Aluminum and zinc were the primary COCs and elevated levels were detected in all samples. The highest detected level for aluminum (1070 μg/L) and zinc (329 μg/L) were detected in sample SFL10SW. Heptachlor epoxide (HPCLE) was a detected at two locations — SFL06SW had detected levels of 0.013 μg/L and SFL07SW had detected levels of 0.0105 μg/L. Slightly elevated levels of lead were detected at three locations, SFL08SW, SFL09SW, and SFL10SW; the highest detected level was 2.5 μg/L in sample SFL10SW. Elevated levels of silver, 24 μg/L, were detected in sample SFL06SWA indicating a possible hot spot; silver was below detection limits in all other samples.

4.3.3 Rice Creek. Ten sediment samples were collected from Rice Creek. All sediment samples were taken within the TCAAP boundary. Sediment samples RCK08SE-RCK10SE were taken from Rice Creek as it flowed off base. Only two COCs were identified in the Rice Creek sediment samples. Cobalt was the only COC identified in Rice Creek while flowing on TCAAP property (RCK06SE.b). Cobalt and vanadium were both found in Rice Creek after it flowed off the TCAAP facility, however vanadium only slightly exceeds the screeing value. Appendix B contains a complete list of substances identified at each sediment sample location along Rice Creek.

A total of 10 surface water samples was taken by Montgomery Watson, Inc. from various locations along Rice Creek during October 1992 and two samples were collected in June 1993. Samples RCK01-05SW were taken at locations along Rice Creek within the TCAAP boundaries. Samples RCK06-10SW followed Rice Creek as it flowed off-site. According to the 1992 data set, aluminum and zinc are the primary COCs. Slightly elevated levels of zinc were detected in all samples, while slightly elevated levels for aluminum were detected in approximately half of the samples. The highest detected level for aluminum, 190 μg/L, was detected in sample RCK10SW while the highest level for zinc, 535 μg/L, was detected in sample RCK08SWB. Beta-benzene hexachloride and heptachlor epoxide were a concern at one location (RCK01SW) where detection levels were 0.0074 μg/L and 0.0067 μg/L, respectively. Beta-benzene hexachloride and heptachlor epoxide were below detection limits at all other sampling locations indicating that these contaminants should not be a concern for water flowing off TCAAP property.

4.3.4 Area B Wetlands. Three sediment samples were collected and analyzed from the Area B Wetlands by Montgomery Watson, Inc. (OU-2 FS), while three additional samples were later collected and analyzed by MPCA. All three OU-2 FS samples were taken from subsite area B3. Each sample location contained a different number of COCs. Sample location B02SE is the Area B hot spot. Appendix B lists the concentrations of substances identified in the Area B Wetlands.

4.3.5 Site G Pond. Four soil/sediment samples were taken from the Pond G area. Samples G01SE, G02SE, and G04SE were taken along the edge of the landfill next to Pond G. Sample G03SE is the only true sediment sample taken at Pond G and is the only sample location used in the risk assessment. Eleven COCs were identified in the G03SE sediment sample. For a complete list of substances identified in Pond G and their concentrations, see Appendix B. In addition to metal contamination at Pond G, PCBs and DDT and its metabolites were also identified as COCs.

4.3.6 Marsden Lake. Only four sediment samples were taken in Marsden Lake. All three of four sediment samples were taken along the western shore of the marsh. Ten different COCs were identified at these locations. Each sample location contained at least two COCs. The primary COCs in Marsden Lake are p,p-DDD and vanadium. All substances identified at each sample location and their concentrations can be found in Appendix B. DDT or one of its metabolites were identified in all sediment samples. Sample ML01SE was identified as the Marsden Lake hot spot because it contained the highest number of COCs (eight), however, this sample was collected in the southern-most section of the Lake, near the channel connecting it to Sunfish Lake.

A total of five surface water samples was taken by Montgomery Watson, Inc. from Marsden Lake during October 1992. The primary COC was zinc, which was found in elevated levels at all sampling locations. The highest level was 712 μg/L found at ML01SW. Elevated levels of aluminum and lead were detected at three sampling locations. Sample ML01SW appears to be a hot spot in Marsden Lake and a potential cause for concern. Elevated levels of aluminum (28300 μg/L) and lead (102 μg/L). Sample ML01SW also had elevated levels of cobalt (75 μg/L), lead (102 μg/L), and the highest concentration of zinc (712 μg/L).

4.4 Data Limitations. The collected data from each site and habitat that has been evaluated contains some specific limitations. In addition to limitations of the collected data, uncertainties exist based on what data has *not* been collected. The significant uncertainties are outlined here.

Vanadium was identified in all aquatic ecosystems studied. Through the process of identifying COCs above, it was categorized as such in at least one sample from each site. However, no available sediment ecotoxicology studies on vanadium have been identified.

During lab analysis of Sunfish Lake sediments, three unknowns were recognized. These unknowns were dropped from further analysis because they could not be categorized as TICs.

Sediment sample ML03SE was taken from an area with a site type of "surf." Those samples with a site type of "lake" were taken from an area with standing water present year round. Sample ML03SE was taken from an area with standing water present only in times of high water.

Three of the four Marsden Lake sediment samples were taken along the western shore. No samples were taken near the grenade range or along the eastern shore (the area that primarily receives off-post urban/highway runoff). In addition, most of the COCs were collectively identified at location ML01 (in the southern-most portion of the lake and in open water). Therefore, the extent of contamination is not known and all subsequent analysis may not accurately reflect the amount of risk that might exist.

Ten sediment samples were taken from the areas of Rice Creek on TCAAP and just downstream of the TCAAP boundary. No sediment samples were taken from Rice Creek just prior to entering the TCAAP facility. However, sample location RCK01 is located just within the TCAAP fence and no TCAAP source area can be realistically contributing to the increased levels of contamination found at this location.

Also, the Rice Creek sediment samples were compared to background lake sediment not stream/creek sediment. This approach is not necessarily appropriate, but due to the lack of a reference stream evaluation, this technique has been used.

The Area B Wetlands are divided into three sub-sites. All three OU-2 FS sediment samples taken from Area B were located in subsite B3. Therefore, only broad generalizations can be made about risk in subsites B1 and B2 since no sub-site specific data was obtained. The

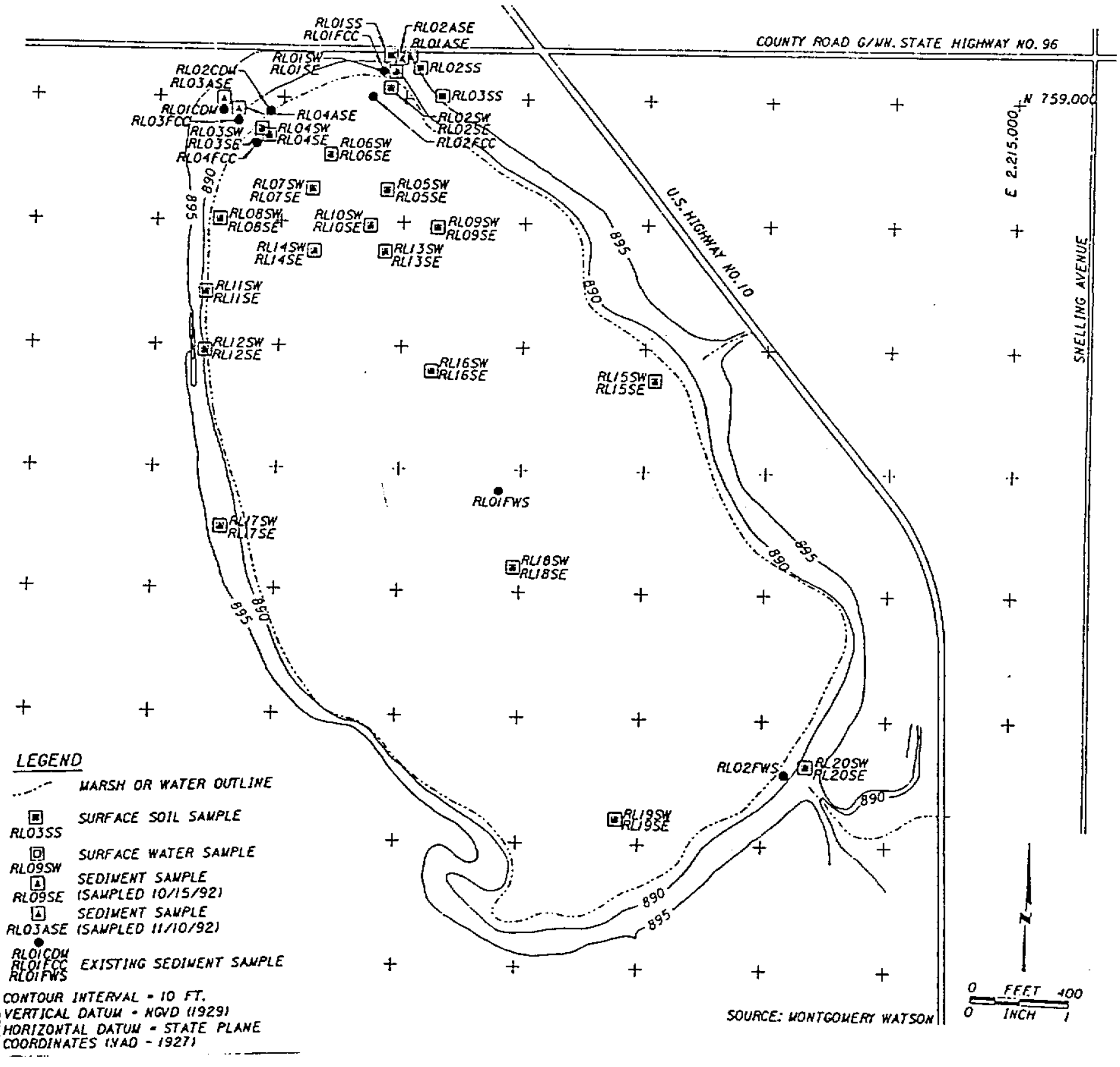

Figure 2. Round Lake sampling locations.

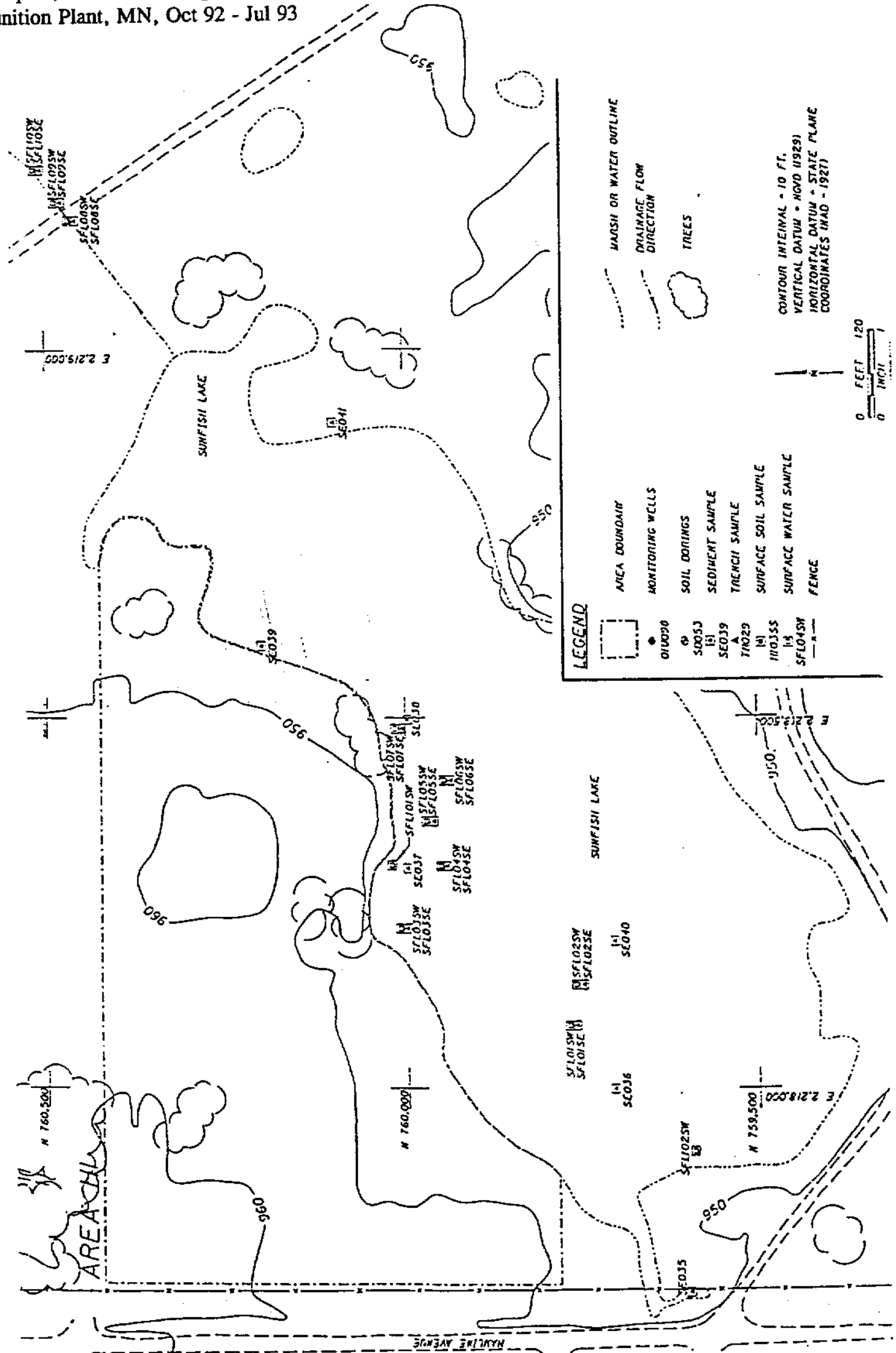

Figure 3. Sunfish Lake sample locations.

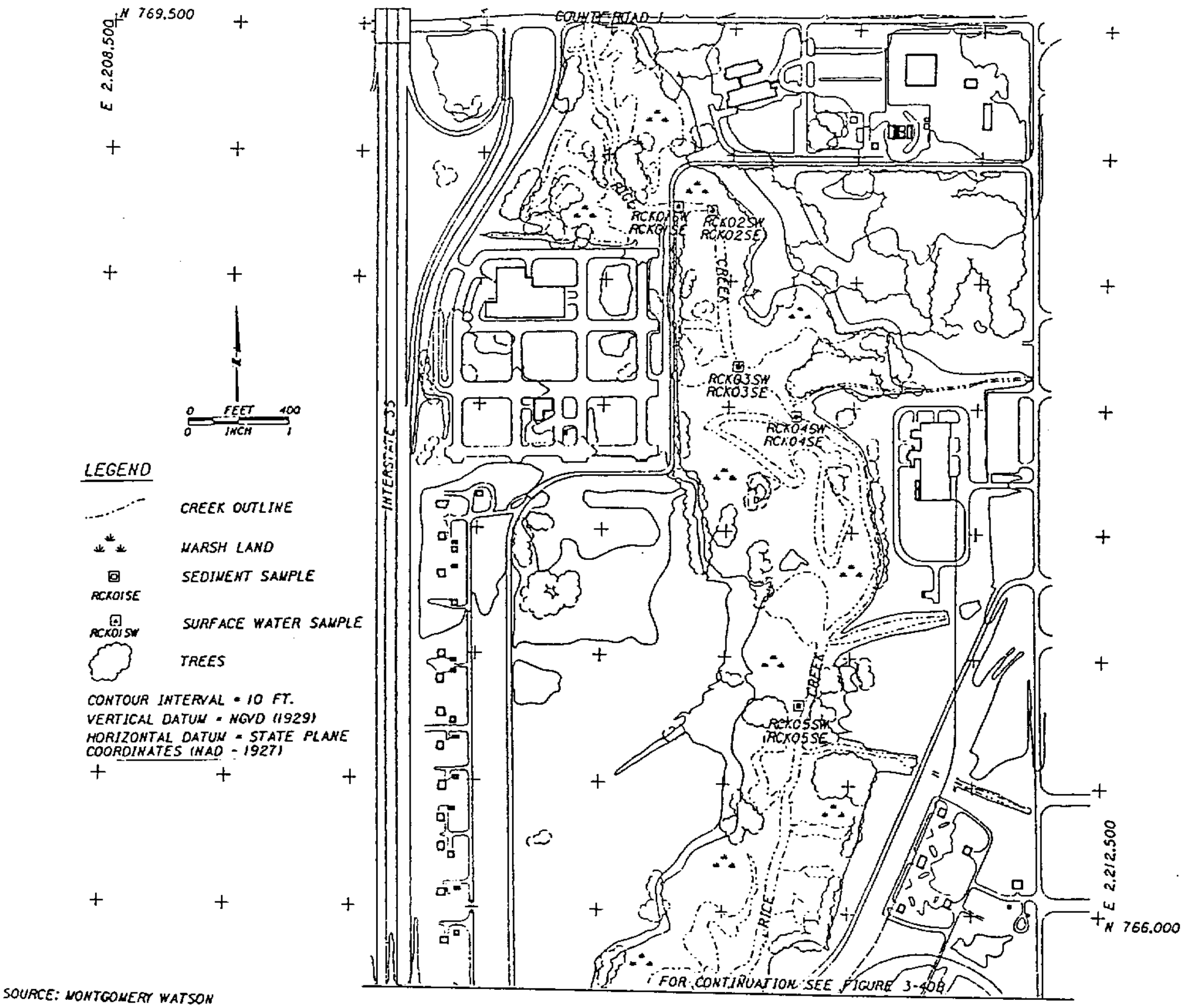

Figure 4a. Rice Creek sample locations.

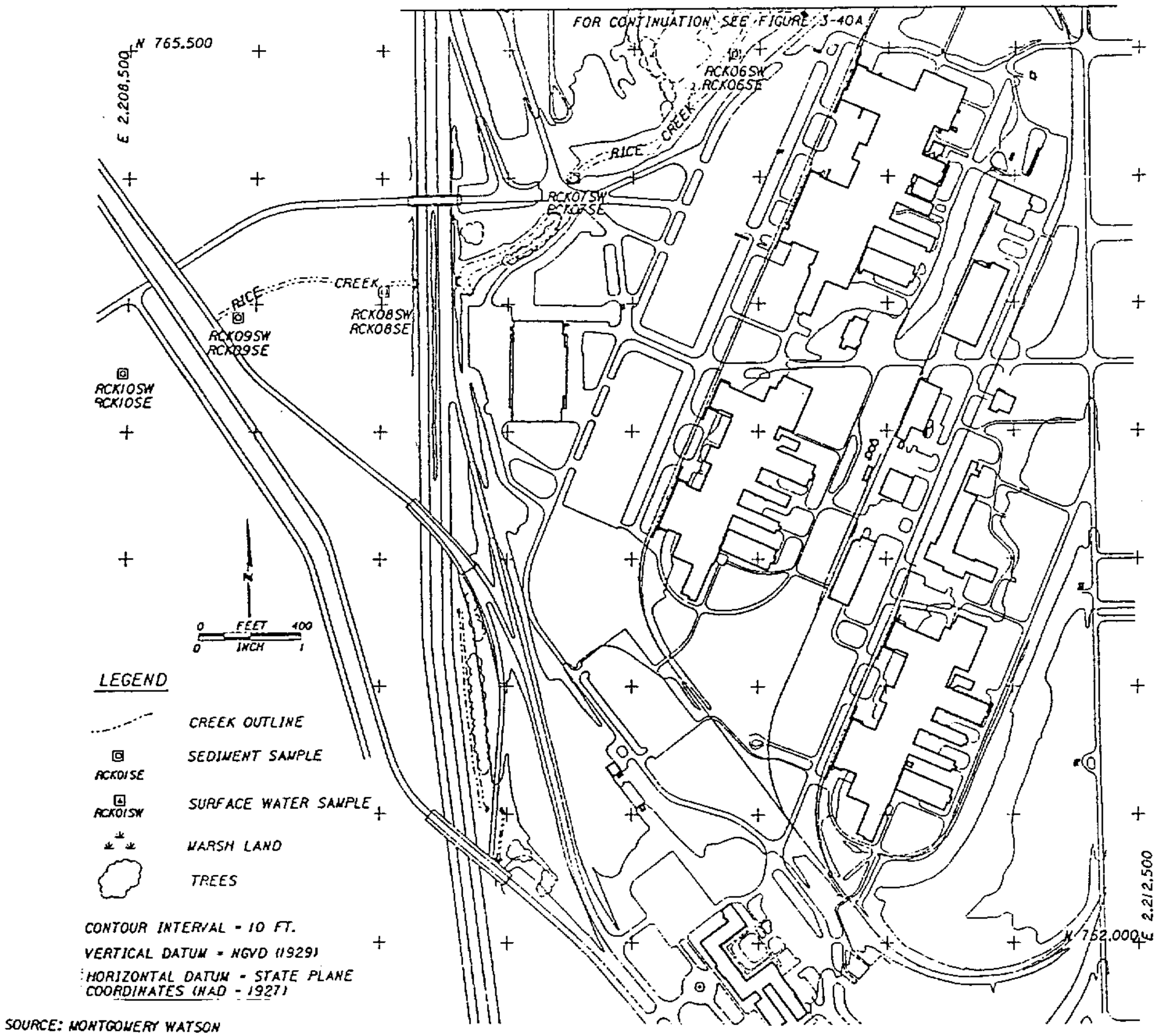

Figure 4b. Rice Creek sampling locations.

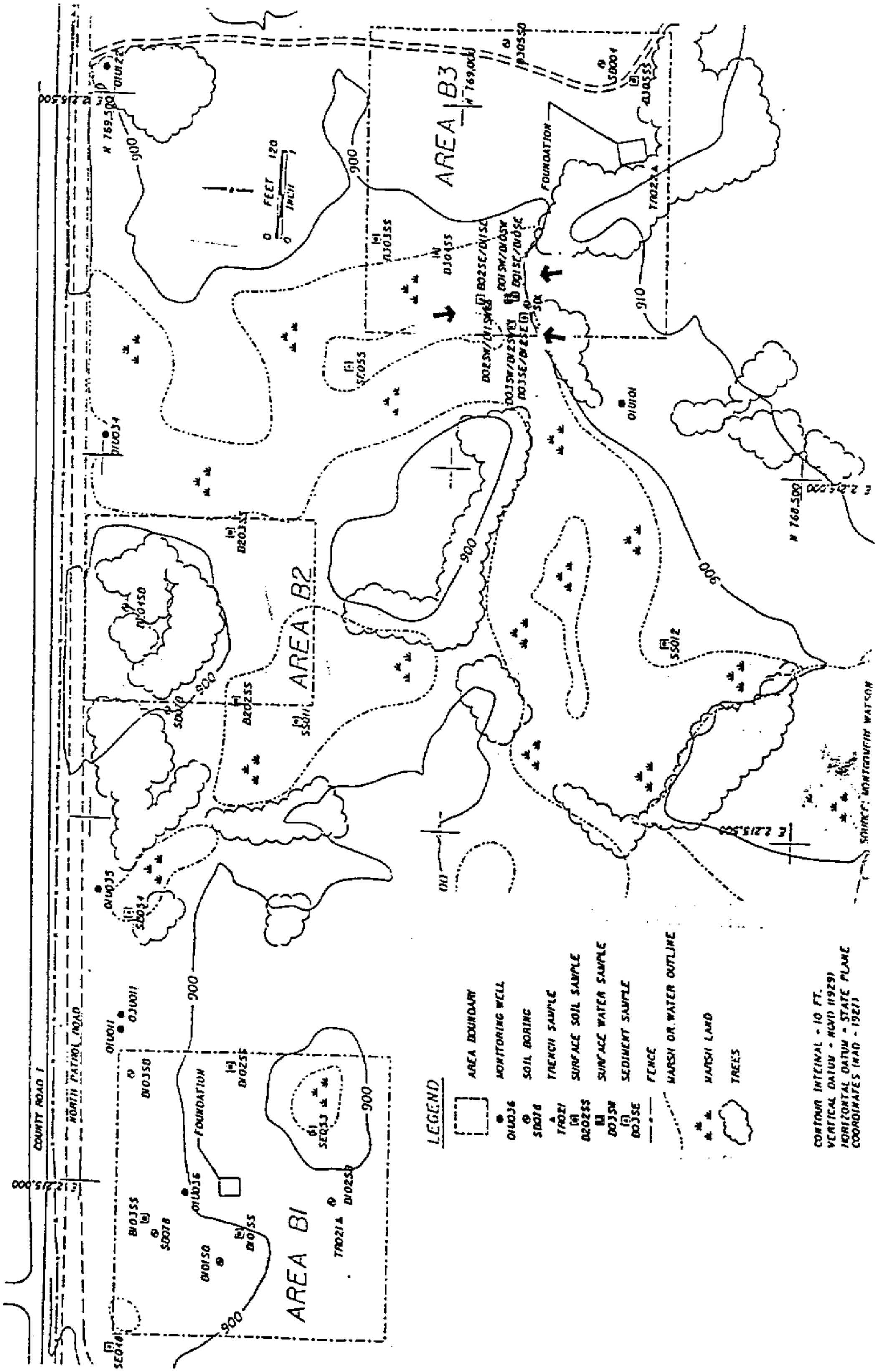

Figure 5. Area B Wetlands sample locations.

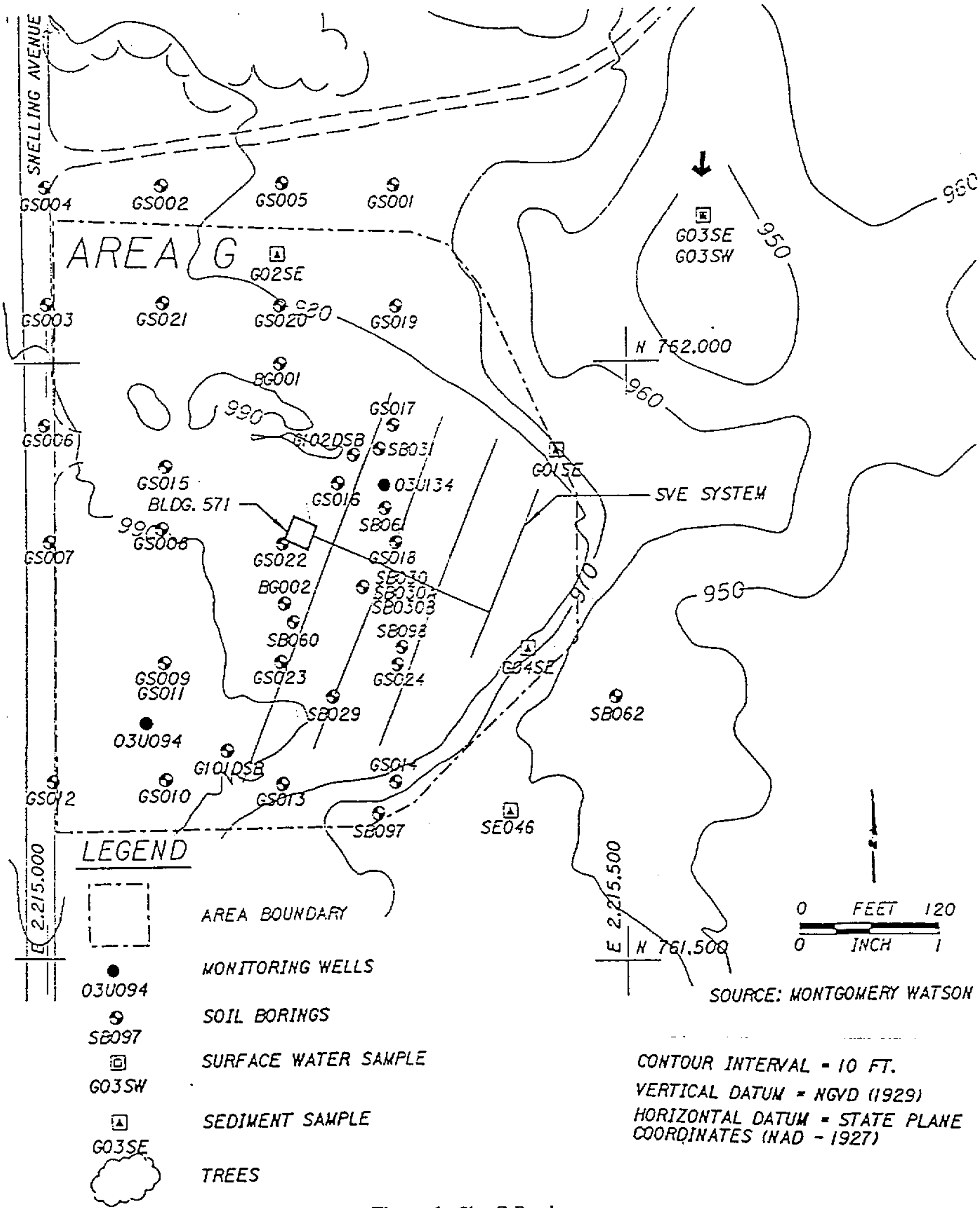

Figure 6. Site G Pond.

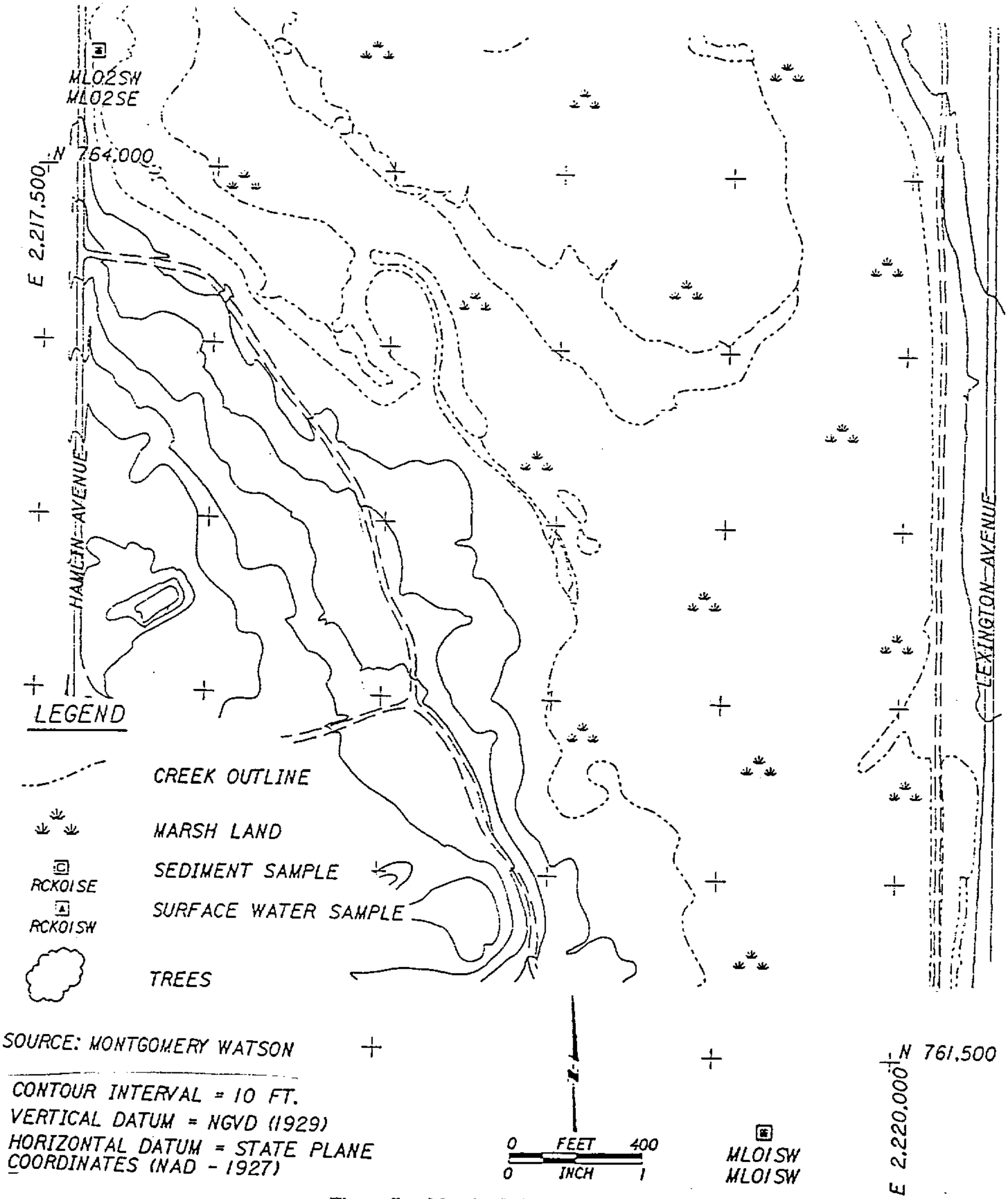

Figure 7a. Marsden Lake sampling locations.

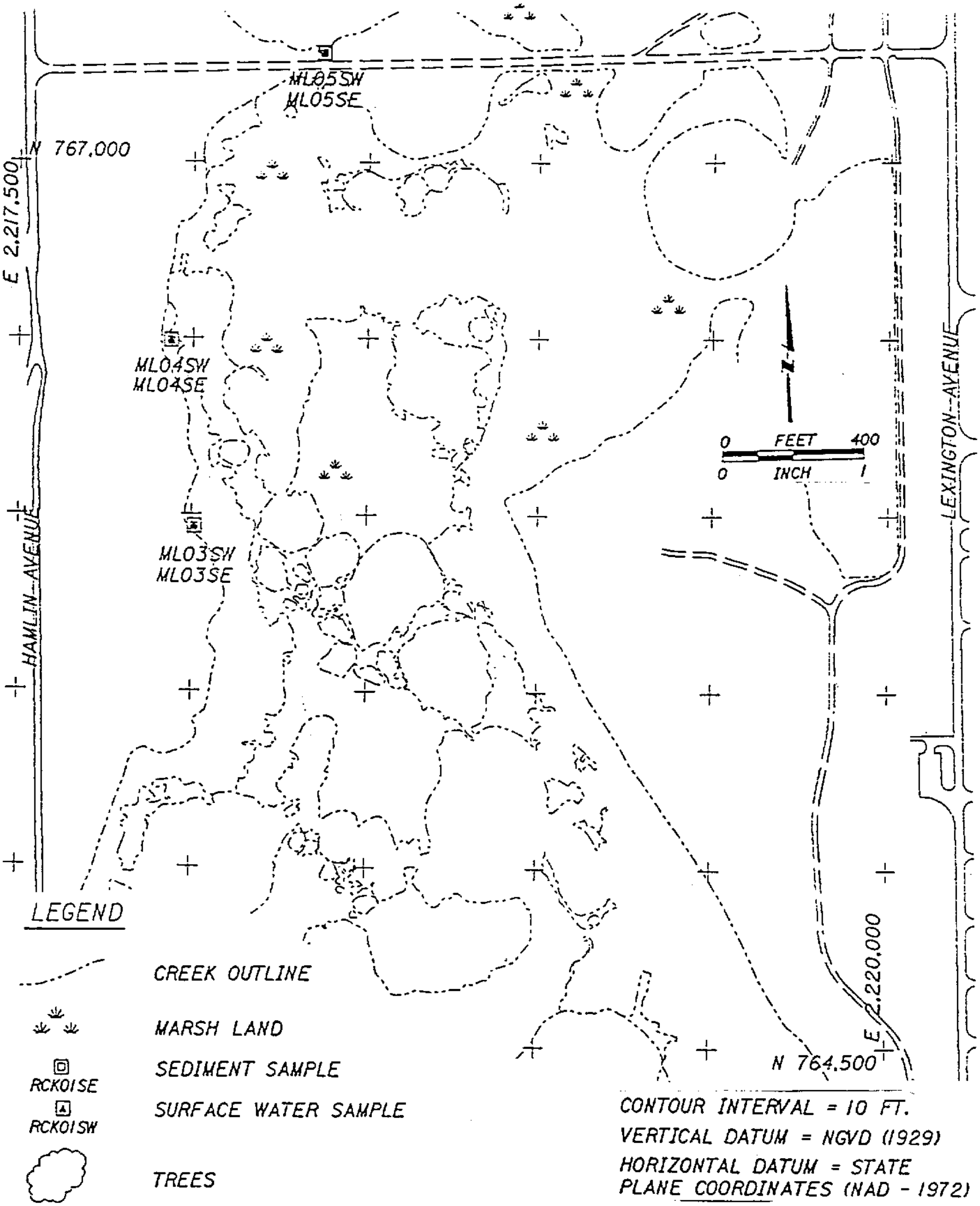

Figure 7b. Marsden Lake sampling locations.

additional three MPCA samples does increase the data base, however further investigation may be needed.

5. EXPOSURE ASSESSMENT. The purpose of the exposure assessment is to assess the magnitude and extent of potential exposures of ecological receptors to the substances of concern.

The majority of this section will address the use of an ecological exposure model to estimate the exposures of wading birds, waterfowl, and aquatic mammals. Direct quantitation of exposures for purely aquatic species (i.e., fish), benthic organisms, and amphibian species have not been attempted here. Rather, as is traditionally done, the exposures are assumed to be maximized for these taxa, where media-specific toxicological criteria, deemed protective for these species, are compared to the detected contaminant concentrations. The results of these direct comparisons are provided in Appendix C, with explanitory text in section 7 (Risk Characterization).

5.1 Use of Ecological Exposure Model. A model has been developed to estimate the potential COC exposures with which the selected endpoint species will likely come into contact. The general form of the model has been taken from the USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993). The modeling of contaminant fate and transport through the food chain has been based on methods documented in previously accepted risk assessments and within the open literature. In some cases, technical judgment was used to estimate the biotic uptake and transport because useable data and relevant fate and transport trends were unavailable.

5.2 Exposure Model Protocol. This section provides equations to estimate oral doses of chemicals of concern for aquatic wildlife, along with discussion of the various input parameters and assumptions involved. To assess risks of exposure to chemical contaminants, potential dose is often the measure used to quantify inadvertent exposures for receptor species. It is assumed that the potential estimated doses calculated herein are analogous to the administered dose in standard toxicological tests. This assumption is appropriate because most of the toxicity reference doses to be used to assess risks are defined as administered doses. The general dose equation (equation 1) used for determining inadvertent exposures of aquatic receptors to the chemicals of concern follows. The representative equations for the components of general dose equation follow, also.

Equation 1 $$TADD = DIADD + SWADD + SEADD$$

TADD: Total Average Daily Dose (mg COC/kg-day)
DIADD: Diet Item Average Daily Dose (mg/kg-day), dose received from diet
SWADD: Surface Water Average Daily Dose (mg\L-day), dose from water consumption
SEADD: Sediment Average Daily Dose (mg/kg-day), dose from sediment ingestion

Equation 2 $$DIADD = \Sigma (C_{ki} \cdot FR_k \cdot NIR_k)$$

C_{ki}: Contaminant Concentration in the k_{th} food type of the i_{th} habitat, or sample location (mg COC/kg wwt)
Fr_k: Foraging Range fraction of intake of the k_{th} food type that is contaminated (unitless)
NIR_k: Normalized Ingestion Rate of the k_{th} food type (g wwt/g-day)

Equation 3 $$SWADD = \Sigma (C_i \cdot FR_i) NIRW$$

C_i: Contaminant Concentration in the i_{th} water source (mg/L)
Fr_i: Foraging Range fraction of water consumed from the i_{th} water source (unitless)
NIRW: Normalized Ingestion Rate of Water (g/g-day)

Equation 4 $$SEADD = \frac{\Sigma (C_{ii} \cdot FS \cdot IR_{total} \cdot FR_{ii})}{BW}$$

C_{ii}: Contaminant Concentration in sediments from the ii_{th} source (mg/kg)
FS: Fraction of Sediment in diet on a dry-weight basis (unitless)
IR_{total}: Ingestion Rate on a dry-weight basis (kg/day)
Fr_{ii}: Foraging Range fraction of total food intake from the ii_{th} source (unitless)
BW: Body Weight (kg)

5.3 Estimating Biotic Fate and Transport. The derivation of diet item contaminant concentrations used in the exposure model have been developed from technical expertise and reviews of relevant literature. The following equations represent the steps in the process of estimating the biological distribution and fate of the substances of concern.

Within these equations, Cki is the contaminant concentration in the k_{th} food type of the i_{th} habitat, or sample location (mg COC/kg wwt); Sc is the sediment concentration (mg/kg); and Wc is the water concentration (mg/L).

5.3.1 Emergent Plants. The following three equations have been utilized to estimate the potential fate of COCs in emergent plants that are food sources for the receptors of concern.

Equation 5	Organics	$C_{ki} = Sc \cdot BAF$
Equation 6	Inorganics	$C_{ki} = \frac{Sc\ (VG_{bg} \cdot RCF)}{Kd_s}$
Equation 7	for BBHC[1]	$C_{ki} = Wc \cdot RCF_d$

A study by Menzie et al. (1992) showed a screening technique to derive organic compound fate in organisms. The fate depends upon the lipid content of the organism and the fraction of organic carbon in the soil/sediment medium. They presented the following algorithm:

$$\text{Bioaccumulation Factor (BAF)} = Y_l/0.66\ f_{oc}$$

where Y_l is defined as the lipid content fraction and f_{oc} is the fraction of organic carbon within the media. This algorithm has been used to estimate the bioaccumulation factor (BAF) for use in equation 5. Equation 6 has been adopted from current USEPA indirect exposure methodology (USEPA, 1994). This equation estimates the COC concentration below-ground, the part of emergent plants fed upon by muskrats, from sediment uptake. VG_{bg} is the below-ground vegetable correction factor of 0.01 (unitless; USEPA, August 1994). RCF is the chemical-specific, root concentration factor on a fresh weight basis [(mg COC/kg tissue wwt)/(μg COC/ml pore water)]. The Kd_s and the RCF are components of this equation and have been referenced from either USEPA (1994) or DOD (1992). The Kd_s term refers to the chemical-specific, soil-water partition coefficient (ml/g). Because some of the RCF data for some substances has been unavailable, these have been given a default of 0.1, the highest RCF found. Beta-Benzene Hexachloride was not detected within the sediments of the TCAAP sites. To remain conservative in the estimation of the potential uptake of this compound in emergent plants, uptake from the water column is assumed. Research by Briggs et al. (1983) developed an equation for aqueous uptake of organics into plants:

$$\log RCF_d = 0.77\ (\log K_{ow}) - 1.52$$

where the RCF_d is the derived root concentration factor (unitless) used in equation 7.

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[1] beta-Benzene Hexachloride (beta Lindane)

5.3.2 Algae and Grasses. Data comprehensive enough for estimating fate and transport within this biotic component was not available. This compartment can make up close to 25% of the diet of aquatic mammals (esp. for muskrats). In lieu of better information, the fate of inorganics in the aquatic system has been assumed to be similar for emergent plants and algae and grasses. It has been assumed that the fate of organic compounds are linked to the predominant route of exposure for algae, through the water column.

Equation 8 — Organics — $C_{ki} = Wc \cdot BCF_{algae}$

Equation 9 — Inorganics — $C_{ki} =$ same as emergent plants (see equation 6)

The BCF_{algae} is the bioconcentration factor for algae and grasses (unitless). The method of LeBlanc (1995) for calculating the BCF has been incorporated to estimate the fate of organics here. His calculation is related to observations of trophic-level and lipid content within a system. This equation is shown as:

$$BCF_{algae} = BCF_{insect} / [(\log P)(8.2)-40]$$

where, log P (or log K_{ow}) is the octanol-water partition coefficient and the BCF_{insect} is the bioconcentration factor for sediment dwelling organisms which has been calculated by a similar method (see below).

5.3.3 Insecta and Annelida. The fate of the TCAAP substances of concern within this biotic component are primarily governed by the principle exposure medium, the sediment. The method of LeBlanc (1995), as mentioned above, has been used to estimate the organic compound bioconcentration factors for sediment dwelling organisms (BCF_s) here. The equation follows.

Equation 10 — Organics and Inorganics — $C_{ki} = Sc \cdot BCF_s$

The BCF_s for inorganic substances has been assumed to be equal to 1. This assumption is based on the role of this interaction within the equation. Simply put, it is a function of what transfers to the receptor during feeding upon these organisms and not necessarily what the sediment organisms uptake, assimilate, and then eliminate. Also, much of the transferred substance can be attached to the exoskeleton and dermal tissue of the diet item. The lipid component of the diet item is assumed to be a determining factor for the uptake of organic compounds, but for the inorganic constituents, a comparable determining factor has not been established (Hare, 1992). Relative metal uptake has been qualitatively established in several cases. These relative distributions of fate can only be useful as qualitative guidelines.

Relative Degree of BCFs in Benthic Insects

Zn > > Cu > Pb
Pb > Cd > Cu
Ca, Cu, Zn > Al, Cd, Ni, Pb
Ca, Cu, Zn > Fe, Mn

Adapted from Hare (1992).

5.3.4 Fish. Estimation of fate and transport of the substances of concern into fish is more difficult than for more sessile organisms that are exposed to a lesser range of concentrations, as are fish. For the purposes of developing screening risk estimates, the migrations of fish species have not been incorporated. As a conservative measure, the uptake into fish considers that the fish eaten by the receptors are consistently exposed to the contaminant concentrations at each sample location. The following equation is used.

Equation 11 Organics and Inorganics $C_{ki} = Wc \cdot BCF_{fish}$

The BCF_{fish} is the bioconcentration factor for fish (unitless). Many of the fish bioconcentration factors (BCF_{fish}) have been taken from two sources (USEPA, 1989; ATSDR profiles). For the inorganic BCFs not found in the literature, a general default BCF of 100 has been assumed. For organic substances, the bioconcentration factor could be calculated as follows:

$$BCF = Y_l \cdot K_{ow}$$

where Y_l is defined as the lipid content fraction of the fish and the K_{ow} is the chemical-specific, octanol-water partition coefficient.

5.3.5 Amphibia and Mollusca. Assuming that contamination levels at each sample location have not eliminated these organisms from the system, the fate and transport into these organisms has been estimated. If these organisms actually do not exist in these areas, then the exposure to their predators does not occur through this food chain pathway. The methods for this estimation have not been used before to the knowledge of the authors, but the following equation is an attempt to perform this estimation:

Equation 12	Organics and Inorganics	$C_{ki} = Sc \cdot BCF_s$

where the BCF_s is the bioconcentration factor for sediment dwelling organisms. The assumption is made that a known $BCF_{insect/annelid}$ approximately equals an unknown $BCF_{amphibia}$. The premise of LeBlanc (1995), as mentioned earlier, is still assumed, whereas its uptake is related to the trophic-status of this biotic component. For inorganics, a better method of estimation was not identified; therefore, the BCF_s of 1 is assumed as it was for the insect/annelid component.

5.4 Model Assumptions. The model has been applied to each of the six sites in the assessment. All of the equations used to calculate the values shown in the spreadsheets are identical for each site. Some components are site specific, such as contaminant concentrations, organic carbon fractions, and FR factors.

Duplicate samples of sediment and surface water were often collected. Data from these samples were also used for the location-specific modeling. In instances where a duplicate of one media sample was collected, the data for the other media was used twice to allow for the comparing of risks between duplicate sample data. For example, if sediment was collected at location A with a field duplicate, the data was presented for samples A.a and A.b. Where the surface water was collected at A but without a duplicate water sample, the complete data for sample location A is surface water at A and sediment at A.a and A.b. For modeling purposes, sample locations A.a and A.b have used the surface water A data for both locations.

To account for receptor home and foraging range influences on exposures, foraging range factors have been included in the model. These factors equal 1.0 for wading birds, amphibians, and aquatic mammals, where 1.0 refers to 100 percent of the receptors' time spent at each sample location. For the waterfowl, with ranges much larger than these other receptors, the range size of the mallard during breeding behavior has been used to estimate its potential exposure, because at breeding the range is typically reduced. During the breeding season, the mallard range nears 111 hectares--about the size of Round Lake (USEPA, 1993). Due to the sizes of and distances between sites, the assumption has been made that the mallard breeding range will be discretely limited to each site. For example, though Sunfish Lake is slightly smaller than 111 hectares, the whole lake has been assumed to represent the mallard breeding range to assess the lake's potential contamination effects. So, the FR factors used for this receptor assume that 100 percent of the exposure at each site is a function of the number of samples taken; that is, equal time at each sample location is assumed.

Table 4. Chemical-specific variables for use in the Biotic Fate and Transport Model

Substances	log K_{ow}	Kd s	RCF	BCF_{fish}	BCF_{sed}	BCF_{algae}
silver	na	0.4	0.1	10	1	na
aluminum	na	33300	0.1	100	1	na
arsenic	na	29	0.008	350	1	na
barium	na	530	0.015	100	1	na
beryllium	na	70	0.0015	100	1	na
cadmium	na	160	0.032	326	1	na
cobalt	na	8.8	0.1	1000	1	na
chromium	na	18	0.0045	127	1	na
copper	na	92	0.1	1180	1	na
magnesium	na	1400	0.1	100	1	na
manganese	na	23	0.1	100	1	na
nickel	na	82	0.004	50	1	na
lead	na	600	na	179	1	na
vanadium	na	100	0.1	100	1	na
zinc	na	940	0.1	578	1	na
mercury	na	57000	10	40000	1	na
heptachlor epoxide	5.40	na	na	$1.4x10^6$	$3.2x10^5$	$7.4x10^4$
PCB 1254	6.48	na	na	$1.6x10^7$	$1.2x10^6$	$9.5x10^4$
DDD	6.02	na	na	$5.7x10^6$	$6.0x10^5$	$6.45x10^4$
DDE	5.69	na	na	$2.6x10^6$	$4.0x10^5$	$6.0x10^4$
DDT	6.36	na	na	$1.2x10^7$	$1.0x10^6$	$8.4x10^4$
acetone	-0.22	na	na	3.3	-0.07	0.002
methylethyl ketone	0.29	na	na	10.5	-0.28	0.007

The "na" denotes a value which is not available.
K_{ow} refers to the octanol-water partition coefficient.
Kd s refers to the soil-water partion coefficient (mL/g) as given in USEPA (1994a and 1994b).
RCF refers to the root concentration factor. The RCF for mercury is a default assumption, where the highest RCF reported in multiplied by an uncertainty factor of 100.
BCF refers to the bioconcentration factor. If the BCF_{fish} is unknown, then the default of 100 is used.

5.5 Biological Assumptions. Assumptions regarding relevant physiology and exposures are a large part of the framework of an exposure model. The EPA's *Wildlife Exposure Factors Handbook* (WEFH; USEPA, 1993) has been used as the primary guide in the production of relevant exposure data. The equations used and referred to in this paragraph are given as the equation number within the WEFH. The biological exposure factors used in the model are shown in Tables 5 and 6 of this report.

5.5.1 Wading Birds. The Great Blue Heron (*Ardea herodias*) has been selected as the surrogate species in which to model overall potential wading bird exposures. The normalized ingestion rate (NIR_{total}) is given in the WEFH, as well as the metabolizable energies (MEs) for fish and insects. These MEs are similar enough in value to assume an ME of 4.00 kcal/g dry weight for this model. The normalized free-living metabolic rate (NFMR) has been derived from the WEFH, p. 2-8. Diet item proportion fractions have been taken from page 2-9, and are based on the summer season habits due to lack of other seasonal data. Equation [4-10] was used to derive NIR_ks. The FR of the Heron has been assumed to be small enough to model exposures at each sample point individually, hence the FR component equals 1.0 for each diet item. The fraction of soil/sediment consumed (assumed sediment only) is estimated using the percentage consumed by shorebirds (p. 4-21) since heron-specific data are unavailable. This assumption is most likely conservative considering that shore birds consume relatively large amounts of sediment (because of their sediment dwelling organisms diet) compared to other avians. Herons, consuming more fish than sediment organisms, should not be expected to inadvertently consume more sediment than shore birds. The media ingestion rate (IR_{total}) has been calculated by adjusting the NIR_{total} with a unit conversion (1 g dry weight = 3 g wet weight). The NIRW has been taken directly from the WEFH.

5.5.2 Waterfowl. The Mallard duck (*Anas platyrhynchos*) has been selected as the surrogate species in which to model waterfowl exposures and toxicity. The NIR_{total} has been calculated by using equation [4-11], with an estimated ME for avian omnivores (p. 3-5) and an NFMR of 300 kcal/kg-day (p. 2-44). The summer season habits of the mallard are used to derive diet item proportion fractions, in lieu of other data. Equation [4-10] was used to describe NIR_ks. The FR factors have been adjusted to reflect the ratio of 1/n, where n equals the number of sample locations per site. The range of the Mallard at breeding approximately equals 111 hectares,

Table 5. Exposure Assumptions for Wildlife Receptors

Parameter	Units	Amphibian (Green frog)	Wading Bird (Great Blue heron)	Waterfowl (Mallard duck)	Mammal (muskrat)
NIRtotal (normalized ingestion rate)	g wwt/kg-d	20	180	270	430
NFMR (normalized free-living metabolic rate)	kcal/kg-d	25	200	300	350
ME (avg. metabolizable energy of diet)	kcal/g wwt	unknown	1.33	1.12	0.82
Pk (proportion of diet food type k)					
P_{fish}	unitless	—	0.94	—	—
$P_{aquatic\ vegetation}$	unitless	0.11	—	0.11	0.75
$P_{algae/grass}$	unitless	—	—	—	0.25
$P_{insects/annelids}$	unitless	0.70	—	0.59	—
$P_{amphibia/crustacea/gastropods}$	unitless	0.19	0.05	0.30	—
$P_{bird/mammal}$	unitless	—	0.01	—	—
NIRk (normalized ingestion rate of food type k)					
NIR_{fish}	g wwt/kg-d	0	169	0	0
$NIR_{aquatic\ vegetation}$	g wwt/kg-d	2.2	0	29.7	323
$NIR_{algae/grass}$	g wwt/kg-d	0	0	0	108
$NIR_{insects/annelids}$	g wwt/kg-d	14	0	159	0
$NIR_{amphibia/crustacea/gastropods}$	g wwt/kg-d	3.8	9.0	81	0
$NIR_{bird/mammal}$	g wwt/kg-d	0	1.8	0	0
FS (fraction of soil/sediment in diet d.w.)	unitless	0.06	0.10	0.02	0.06
IRtotal (media ingestion rate on d.w. basis)	kg dwt/d	0.0003	0.13	0.10	0.17
NIRW (normalized ingestion rate of water)	g/kg-d	100	50	60	1000
BW (body weight)	kg	0.04	2.23	1.1	1.2
HR (home range)	ha	0.0065	1.0	(clutch laying) 111	0.17
FD (foraging distance)	km	(breeding)≤ 6 mo.	3.0	na	—
age at sexual maturity	years	1 - 2	2	1	0.5
clutch/litter size	N (number)	4100	2	9	3 - 7
population density	N/ha	476	0.09	0.04 per pair	2 - 9

Biological dry wt/wet wt unit conversion = ⅓.

Table 6. Foraging Range Factors for Waterfowl at each Waterbody

Model Variable	Marsden Lake	Round Lake	Sunfish Lake	Rice Creek	Pond G	Area B wetlands
FR - diet	0.25	0.06	0.1	0.1	0.33	0.33
FR - water	0.25	0.05	0.1	0.1	0.33	0.33
FR - sediment	0.25	0.06	0.1	0.1	0.25	0.33

roughly the size of Round Lake. The fraction of soil/sediment consumed (assumed sediment only) is derived from p. 4-20 of the WEFH. The IR_{total} has been calculated by adjusting the NIR_{total} with the same unit conversion as the above paragraph describes. The NIRW has been taken directly from the WEFH.

5.5.3 Aquatic Mammal. The Muskrat (*Ondatra zibethicus*) has been selected as the surrogate species in which to model exposures to riparian and wetland-integrating mammals. The NIR_{total} has been calculated by using equation [4-11], with an estimated ME for mammalian herbivores (p. 3-5) and an NFMR of 350 kcal/kg-day (p. 2-340). The derived diet item proportion fractions are considered to remain relatively constant for each season. Equation [4-10] was used to describe NIR_ks. The foraging range of the muskrat has been assumed to be small enough to model exposures at each sample point individually, hence the FR component equals one for each diet item. The fraction of soil/sediment consumed (assumed sediment only) is derived from p. 4-20 of the WEFH. The IR_{total} has been calculated by adjusting the NIR_{total} with the same unit conversion as the above section describes. The NIRW has been taken directly from the WEFH.

5.6 Results of the Model. Based on a consensus decision between the involved parties (see paragraph 2), the assessment endpoint taxa of concern within the TCAAP landscape are waterfowl, wading birds, and aquatic mammals. As stated earlier, the surrogate receptors (i.e., the Mallard, Great Blue Heron, and Muskrat) serve as representative species for the suite of organisms which occur at the TCAAP. The selected surrogate species--the Great-blue heron, the Mallard, and the Muskrat--are used to estimate potential exposures for the assessment endpoint taxa. These estimated doses are used in conjunction with the derived toxicological reference values (TRVs) to calculate a quantitative representation of potential chemical risks (Appendix D). These comparisons are summarized in section 7 (Risk Characterization). Amphibians were not modeled for indirect dietary exposures due to the lack of toxicological data regarding these types of exposures. Rather, risks for this group are presented as simple comparisons of media contaminant concentrations to literature toxicological values which indicate adverse effects upon exposures to ambient water.

The model output are valid for oral exposures only. Dermal exposures and inhalation of particulates and vapors of COCs are not included in the model and in this screening assessment because traditional, standardized methods for estimating these exposures for species in their natural state have not been developed.

5.7 Limitations of Exposure Analysis. This exposure assessment has attempted to address uncertainties in site data, literature data, model function, and biological variation in a conservative fashion. It should be noted that every attempt was made to reduce extreme overconservativism by incorporating current technical methods for evaluating fate and transport. The major limitations of the results of the exposure model are outlined below.

5.7.1 Direct Exposure Pathways. The limited experimental basis for evaluating the effects of dermal and inhalation exposures for most of the COCs for ecological receptors limits this risk assessment from screening for adverse organism responses through these pathways. The exposure model output, presented herein, should be interpreted in light of this fact. The degree of uncertainty that this attribute contributes has been traditionally viewed as a relatively minor underestimation of risk.

5.7.2 Indirect Exposure Pathways. Biotic fate and transport of COCs are a large part of the ecological exposure model. The mathematical expressions of COC fate from the media into the biotic components of the receptors' diet are based on accepted scientific tools when available. These tools use chemical structure-activity relationships, organism characteristics and habits, and other transfer factors to estimate "biological transfer factors" (BTFs) for various COCs in the system. These tools incorporate scientific observations from among current peer-reviewed literature. The degrees of uncertainty that each of these tools contributes varies, depending on the state of the science for the particular observations and concepts. They can be ranked as both under- and overestimations of COC fate and transport, which can similarly vary the current risk estimates. Traditionally, for hazardous waste sites, it has been shown that these models typically overestimate risks, and that subsequent validation efforts for these models reduce the expected risk estimates from indirect exposure.

5.7.3 Exposure Duration. This assessment has calculated hazard quotients for each sample location. Due to habitat considerations and avoidance behavior, it is more than likely that some of the sample locations expressed in the report are not actually being visited by the receptor in question, and that mobile receptors actually limit their time at a particular sample location. The converse may also be true where a receptor, or group of receptors (e.g., a muskrat family), may spend most or all of their time at one or two highly contaminated sample locations. This later case is unlikely for muskrats, though, because most of the sampling locations were not adjacent to observable muskrat homes. But other aquatic receptors, such as mink, might concentrate their activities near one or two contaminated locations. A field validation of hot spot sample locations and correlated frequented habitat has not been performed for all TCAAP sites. However, the assumption of exposure to one sample location has been deemed conservative.

5.7.4 Interspecific Differences. The exposure parameters used in the model have been derived from chosen surrogate species. These results are being used to screen risks for other species in similar taxonomic categories. This introduces inherent uncertainty. Often physiological and behavioral differences can be enough to render the results questionable. Field validation for other species than those used here would be appropriate. For example, the muskrat, though abundant at TCAAP, has different exposures than the mink at TCAAP. The muskrat is exposed to contaminated sediments more readily than the mink because of the sediment/cattail homes they build and their foraging behavior. The mink on the other hand has the potential to uptake more of the bioaccumulating compounds at a site because it is a carnivore (the muskrat is a herbivore) and generally consumes fattier diet items than the muskrat.

5.7.5 Probability Functions. This assessment does not introduce the distribution, nor the ranges, of parameter values used in the model. The probabilities of particular values being higher or lower than the values used here has not been examined. The values used have been chosen as averages, or best estimates, where the choice for a value was made to remain conservative. The probability of exposure due to the receptor FR is a good example of this type of function.

5.7.6 Bioavailability of COCs. Contaminants have been assumed to be 100 percent bioavailable, meaning that the contaminants are in a form which can be assimilated by the receptor. This is not likely to be the case, especially for the inorganics. Adequate data is not available for estimating bioavailability, so the default of 100 percent has been assumed in order to remain conservative.

6. CHARACTERIZATION OF ECOLOGICAL EFFECTS. The purpose of this section is to describe the toxic effects associated with the identified contaminants. Toxicological evaluations involve characterizing the inherent toxicity of the COCs and establishing TRVs for each of the identified COCs. As mentioned previously, the expression of risks in the form of HIs incorporates several toxicological considerations. The HI calculation assumes that individual risks for each COC and exposure are additive. This approach, though potentially questionable for some mixtures of substances, is consistent with USEPA recommendations (USEPA, 1986b). The simple summing of hazard quotients (HQs) to calculate HIs may result in inaccurate estimates of the true risk. The target organs, the mechanisms of toxicity, or other variables intrinsic to the substances may be such that a simple additive approach over- or underestimates risks. In combination, substances can interact to express variations in toxicity where mechanisms of interaction and toxicological interactions are shown. True risks would be better expressed when the HQs are segregated, based on target organ and mechanism of toxicity. But, for the purposes of this assessment, the segregation of COCs based on their mode of action will not be done. Reasons for this include: (1) this ERA is purely a *screening tool* to focus additional field work for ecological risk investigations; (2) by not segregating, the ERA should overestimate risks, and hence remain protective; and (3) the mode of action for some COCs may not be known.

Calcium, magnesium, potassium, and sodium were excluded as ecological chemicals of concern for all media; these analytes are considered to be essential nutrients and are not though to be directly related to TCAAP disposal activities. Evidence suggests that there is little potential for toxic effects in higher organisms resulting from over-exposure to these essential nutrients. The highly controlled physiological regulatory mechanisms for these inorganic ions suggest that there is little, if any, potential for bioaccumulation, and available toxicity data demonstrate that high dietary intakes of these nutrients are well-tolerated among these organiams (NAS, 1977; NRC, 1982; 1984a,b). Such nutrients as sodium have been shown to adversely effect plants, insects, and other invertebrates. These effects if occuring are not likely to influence toxicological impacts to higher organisms.

6.1 Toxicological Reference Values. Toxicity reference values are either pollutant concentration criteria or pollutant dose-response benchmarks which are indicative of specific adverse effects a receptor or group of receptors might show upon exposure to pollutants. In most cases, TRVs represent a level of exposure where adverse effects are expected to *not* occur. Exposures to media concentrations or doses which are at or below the TRV level are expected to be acceptable for the sustainment of receptor health. TRVs for the species of concern here are of six general types, described below:

A) Diet residue value for chemical concentrations in food items causing adverse chronic effects, expressed as mg chemical/kg diet-day

B) Dose level in food causing adverse chronic effects, expressed in units of mg chemical/kg body weight-day

C) Tissue residues associated with adverse chronic effects, expressed in units of mg chemical/kg tissue

D) Soil or sediment values associated with adverse chronic effects, expressed in units of mg chemical/kg sediment

E) Water values associated with adverse chronic effects, expressed in units of μg/L

F) Daily dietary levels causing adverse effects in units of mg chemical/kg body weight-day

The TRV types B, D, and E are the selected methods for this screening ERA. The benchmarks were selected based on some general guidelines. Toxicological data for the selected species (Great blue heron, Mallard, and Muskrat) were used whenever possible. When species-specific data were not available, toxicological data for a surrogate species were used. For example, data for mink were used to evaluate copper toxicity for the muskrat species. Test data were selected for the same exposure routes (i.e., oral exposure) evaluated for the selected species. Data for chronic exposure were preferred over data for subchronic exposure, which, in turn, were preferred over acute exposure. Dosages associated with a no observed adverse effect level (NOAEL) or a lowest observed adverse effect level (LOAEL) were selected over LD50 data (the dosage that is lethal for 50 percent of the test species during a given acute time period).

6.2 Water Quality Benchmarks. Surface water samples from each lake have been compared to water quality screening benchmarks. The benchmarks are a combination of information from the Minnesota Ambient Water Quality Standards (AWQS), USEPA Tier II values, and other sources (Table 7). The benchmarks are designed to be conservatively protective of many different forms of aquatic organisms. The AWQS used to screen for effects are those based upon chronic exposures to aquatic organisms, and are to be considered applicable, relevent or appropriate requirements (ARARs).

Because the toxicities of several inorganics are hardness dependent, the following contaminants of concern were adjusted for water hardness: lead, nickel, silver, and zinc. The MPCA provided hardness adjustments specified for each lake sampled. Surface water HQs have been calculated by dividing the chemical concentrations detected in a sample by the benchmark of the substance.

Table 7. Water Quality Screening Benchmarks (µg/L)

Substances	Minnesota AWQS (class 2B) chronic	Minnesota AWQS (class 2B) acute	USEPA Tier II Values‡ chronic	USEPA Tier II Values‡ acute	Other Sources
aluminum	125	1072	—	—	ns
barium	—	—	3.8	69.1	ns
lead	3.2†	82†	—	—	ns
magnesium	—	—	—	—	82,000[a]
manganese ¤	491	4643	—	—	ns
mercury*	0.007	2.4	—	—	ns
nickel	160†	1400†	—	—	ns
silver	1	2†	—	—	ns
zinc	110†	120†	—	—	ns
heptachlor epoxide	0.0005	0.27	—	—	ns

The '‡' denotes that these values were taken from the review by Suter (1996).
The '—' denotes a criterion is not available or is not applicable.
The '†' denotes that the criteria is hardness-dependent and normalized to 100 mg/l CaCQ.
The '*' denotes criteria for total mercury.
The 'a' denotes that values is based upon a daphnia studies as cited in Suter (1996).
The '¤' denotes that the Minnesota AWQS for manganese is not yet promulgated, but still provided by the MPCA.

6.3 Sediment Quality Benchmarks. The Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Canadian Ontario Ministry of Environment and Energy, 1993) were used as the toxicity benchmarks for most of the contaminants found in sediments at TCAAP (Table 8). These Ontario guidelines are considered by this office as the best available criteria for protection of freshwater benthic species. The guidelines are based on a number of different species and consider a range of contaminant concentrations. Most notably, these guidelines provide criteria for freshwater, whereas traditional guidelines (Long and MacDonald et al., 1995) report on marine and estuarine systems. Other sources were used for silver and acetone, substances not addressed by Ontario guidelines.

The Ontario guidelines are based on long-term effects contaminants may have on sediment-dwelling organisms. The low effect level is the concentration at which ecotoxic effects may become observable and is derived using field-based data on the occurrence of sediment concentrations and benthic species. The Ontario guidelines attempt to be protective of over 95 percent of all benthic organisms. Contaminants that exceeded their OSLEL guideline, but not the background screening concetnration, were not considered contaminants of concern, since they are assumed to be representative of non-site related activities.

Amphibian species are highly exposed to sediments, depending on their life-stage. Adequate criteria for determining quantitative risks do not exist for these species due to the lack of appropriate research and the complex nature of the types of environmental exposures acting on these species. The Ontario guidelines have been used as a part of a weight of evidence approach for the estimation of amphibian risks. Therefore, the hazards estimated for the benthic macroinvertebrates are identical to the risks presented for the amphibians.

Table 8. Sediment Quality Screening Benchmarks (μg/g dry weight)

substances	Ontario Ministry of Environment †		other source
	low effect level	severe effect level	
aluminum	—	—	ns
arsenic	6	33	ns
barium	—	—	ns
beryllium	—	—	ns
cadmium	0.6	10	ns
chromium	26	110	ns
cobalt	—	—	ns
copper	16	110	ns
lead	31	250	ns
mercury	0.2	2	ns
nickel	16	75	ns
silver	—	—	1.0/3.7[a]
vanadium	—	—	ns
zinc	120	820	ns
acetone	—	—	0.00877[B]
methylethyl ketone	—	—	—
PCB 1254	0.06[t]	0.34[t]	ns
p,p-DDD	0.008	0.06	ns
p,p-DDE	0.005	0.19	ns
p,p-DDT*	0.007	0.12	ns

† - MOE (1990)
'—' - not available
a - NOAA ERL/ERM (Long et al. 1995)
b - Secondary Chronic Value (Jones et al. 1996)
t - tentative guideline
* - total DDT (sum of all isomers of DDD, DDE, & DDT)
'ns' - not selected

6.4 Dose-Response Based Values. The method of choice for deriving usable TRVs for avian and mammalian receptors is the metabolic (or body weight) scaling methodology that EPA endorses in noncarcinogenic assessments and reportable quantity documents for adjusting animal data for human application (USEPA, 1985 and 1988). The method combines toxicological data, such as the chronic NOAEL for a species (mammalian or avian), and evaluates the interspecies correlation based on the differences in body weight (as a surrogate to metabolic activity). The general equation follows:

$$D_a = D_b \cdot (BW_b^{\alpha}/BW_a^{\alpha}) = D_b \cdot (Bw_b/BW_a)^{\alpha}$$

where, D_a is the estimated dose producing a given effect to species a, D_b is the known dose producing a given effect to species b, and the BWs are the respective body weights. The α represents the power to which the body weight relationships are scaled. For mammalian species the α-value is equal to 0.25 (ORNL 1996). Typically, extrapolations for avian receptors have not occured, rather generally larger uncertainty factors have been utilized. Here, we do apply this scaling method for avians for performing extrapolations of toxicity of pesticides; however, the α-value selected is -0.15 and is based upon the work of Mineau et al. (1996). These researchers found much different α-values for birds when examining pesticide toxicity in acute exposures in birds. This method is not applied to non-organic substances and its use is defensible when pesticides are the COCs of concern. Uncertainty factors are used for extrapolations of metal toxicity.

Toxicological profiles and descriptions of the original studies used to develop each TRV are listed below. The references for the original studies are provided. Table 9 summarizes this information. For illustrative purposes, the following TRV derivation calculation is provided for muskrat exposures to mercury. The values are associated with a study of methyl mercury chloride toxicity in mink performed by Wobeser et al. (1976).

(A) Derivation of the study's reference value

$$subchronicNOAEL_t = \frac{(1.1\frac{mgHg}{kgfood})x(137\frac{gfood}{day})x(\frac{1kg}{1000g})}{1kgBW_t} = \frac{0.15mgHg}{kgBW \cdot day}$$

(B) Application of uncertainty factor to account for chronic exposures (i.e., the test measured subchronic exposure).

$$chronicNOAEL_t = \frac{0.15mg}{kg \cdot day} x0.10uncertaintyfactor = \frac{0.015mg}{kgBW \cdot day}$$

(C) Metabolic scaling for inter-species extrapolation.

$$TRV_{muskrat} = \frac{0.015mg}{kgBW \cdot day} x (\frac{1kgBW_t}{1.2kgBW_{muskrat}})^{0.25} = \frac{0.01mg}{kgBW \cdot day}$$

▸ **Silver:** The food chain is not reported to be a significant route of exposure to terrestrial receptors for silver; however, fathead minnows and freshwater invertebrates have been found to accumulate silver (HSDB, 1994). Data are scarce for systemic toxicological effects due to silver.

Avians No data found.

Mammals The data used here has been taken from work presented in the Registry of Toxic Effects of Chemical Substances Database (RTECS, 1995). This study on guinea pig toxicity to silver observed an LD50 of 5000 mg/kg. A chronic NOAEL is estimated using an uncertainty factor of 0.01 to derive a benchmark dose of 50 mg/kg-day.

Amphibians No data found.

▸ **Aluminum:**

Avians Taken from ORNL (1996). The study for aluminum comes from Carriere (et al. 1989) testing Ringed Doves. One dose level of 1000 ppm Al (as $Al_2(SO_4)_3$) was found to be the NOAEL. This value represents a reproductive response to an oral dosage. The study considered exposure over 4 months, so this dose is considered to be a chronic NOAEL. A food consumption rate of 0.01727 kg/day and body weight of 0.155 kg was applied to the administered dose to render a TRV for this species at 109.7 mg/kg·day.

Mammals Taken from ORNL (1996). This comes from Ondreicka et al. (1966) studying mice. One dose level of 19.3 mg Al/kg·day was the LOAEL. This value represents a reproductive response to an oral dose of spiked water. Significantly reduced growth in generations 2 and 3 suggests a chronic LOAEL. The chronic NOAEL was derived with an uncertainty factor of 0.1, multiplied to the chronic LOAEL. A body weight of 0.03 kg was applied to the value to render a TRV for this species of 1.93 mg/kg·day.

Amphibians No data found.

Table 9. Summary of Toxicological Reference Values (TRVs) for Wildlife.

Chemical of Concern	Amphibians (Green frog)	Wading Birds (Great blue herons)	Waterfowl (Mallard duck)	Mammal (Muskrat)
aluminum	—	109.7	109.7	0.77
arsenic	—	2.46	2.46	0.05
barium	—	20.8	20.8	3.96
beryllium	—	—	—	0.49
cadmium	0.021[1]	1.45	1.45	0.01
chromium	—	1.0	1.0	2.41
cobalt	0.936[1]	—	—	23.7
copper	—	47.0	47.0	11.2
lead	500[1]	3.85	3.85	5.88
mercury	—	0.0064	0.0064	0.01
nickel	—	77.4	77.4	29.4
silver	—	—	—	13.6
vanadium	—	11.4	11.4	0.14
zinc	—	14.5	14.5	118
acetone	20000[1]	—	—	7.35
aroclor 1254	2.02[1]	0.203	0.183	0.02
heptachlor epoxide	—	—	—	0.10
methyl ethyl ketone	—	—	—	1302
DDT	1000[1]	0.003	0.002	0.59[3]
DDD	0.4[1]	0.003[2]	0.002[2]	0.59[3]
DDE	—	0.003[2]	0.002[2]	0.59

All values (except for amphibians) are expressed as doses of mg COC/kg bw ·day.
Amphibian TRVs are expressed as surface water criteria (mg/L).
The "—" denotes a data gap in toxicity information.
1 - Value taken from the literature and adjusted with uncertainty factors where appropriate.
2 - Data gap in toxicity information; value for DDT used in leiu of a better option.
3 - Data gap in toxicity information; value for DDE used in leiu of a better option.

- **Arsenic:**

Avians Taken from ORNL (1996). A study of Copper Acetoarsenite (USFWS, 1969) toxicity to male Brown-headed Cowbirds was used. This compound contains arsenic in the highly toxic, trivalent form. Four dose levels were analyzed with the NOAEL reported at 25 ppm. The endpoint was mortality from a dosed diet. The study considered exposure over 7 months and is considered to be a chronic exposure. A body weight of 0.049 kg and a consumption rate of 0.01087 kg/day was applied to render a TRV of 2.46 mg/kg·day.

Mammals Taken from ORNL (1996). This study comes from Schroeder and Mitchner (1971) evaluating mice toxicity to arsenite, the trivalent form. One dose level of 5 mg As\L +

0.06 mg As/kg food was the LOAEL. The endpoint was reproductive success. The parameters of body weight (0.03 kg), water consumption (0.0075 L/day), and food consumption rate (0.0055 kg/day) were applied to derive total LOAEL. These mice showed declining litter sizes with each generation, 1 through 3. The value, considered a chronic LOAEL, has been adjusted with an uncertainty factor of 0.1 to estimate the chronic NOAEL. The derived TRV is 0.126 mg/kg·day.
Amphibians No data found.

▸ **Barium:**

Avians Taken from ORNL (1996). This study by Johnson et al. (1960) investigated barium hydroxide toxicity to 1-day-old chicks. Eight dose levels were studied, with a dose of 2000 ppm being the NOAEL. The endpoint was mortality through oral ingestion. A body weight of 0.121 kg and a consumption rate of 0.0126 kg/day was applied to the value to estimate a subchronic NOAEL. Because the study was 4 weeks in duration, a multiplicative uncertainty factor of 0.1 was inserted to arrive at a chronic NOAEL of 20.8 mg/kg·day.

Mammals Taken from ORNL (1996). Perry et al. (1983) studied the effects of barium chloride on rats for 16 months. The endpoint was growth and hypertension through ingestion of spiked water. No effect on consumption or growth was observed, but cardiovascular hypertension was observed. Because the significance of hypertension in wild populations is unknown, a NOAEL of 100 ppm is based on the "no growth" observation. Factors for body weight (0.435 kg) and water consumption (0.022 L/day) were used to derive the chronic NOAEL of 5.1 mg/kg·day.

Amphibians No data found.

▸ **Beryllium:**

Avians No data found.

Mammals Taken from ORNL (1996). Schroeder and Mitchner (1975) studied the toxic effects of this chemical on rats as beryllium sulfate. The rats were exposed orally for over 1 year. The endpoints were longevity and weight loss. One dose level of 5 ppm beryllium was observed. Factors for body weight (0.35 kg) and water consumption (0.046 L/d) were used to derive a chronic NOAEL of 0.66 mg/kg-day.

Amphibians No data found.

▸ **Cadmium:** Cadmium has been reported to interfere with renal synthesis of a metabolically active form of vitamin D, which could explain skeletal abnormalities found in embryos exposed to cadmium (HSDB, 1994). Moreover, the addition of cadmium has been shown to affect the accumulation of other metals (e.g., lead), and has been shown to initiate metallothionein production and have an antagonistic, not additive, influence on waterfowl toxicity (Jordan et al., 1990).

Avians Taken from ORNL (1996). White and Finley (1978) observed the effects of cadmium chloride on Mallard ducks. A NOAEL of 15.2 ppm was indicated from three oral dose levels. For the duration of the study, >90 days, the endpoint was reproduction, specifically the production of eggs. Factors of body weight (1.153 kg) and consumption rates (0.110 kg/day) were applied to estimate the chronic NOAEL of 1.45 mg/kg·day.

Mammals Taken from ORNL (1996). Cadmium chloride exposures in rats were studied by Wills et al. (1981). Effects upon reproduction were observed during the exposure period of 4 generations. A chronic NOAEL was estimated to be 0.008 mg/kg·day.

Amphibians A toxicity criteria for this substance has been derived from a study by Ferrari et al. (1993). This investigation documented an LC50 of 2650 μg/L for *Bufo arenarum*.

- **Cobalt:**

Avians No data found.

Mammals Rats were examined for their adverse effects from cobalt toxicity (Pedigo et al. 1988). Decreased fertility was the endpoint, with a value of 2650 mg/kg. An uncertainty factor of 0.01 was used to estimate a chronic NOAEL of 26.5 mg/kg-day.

Amphibians A toxicity criteria for this substance has been derived from Plowman (1991). This investigation reported a LOAEL of 23.4 mg/L for embryo teratogenesis in *Xenopus laevis*.

- **Chromium:**

Avians Taken from ORNL (1996). Haseltine et al. studied the effects of Cr^{+3} as $CrK(SO_4)_2$ in the diet of Black ducks. The observational endpoint was reproductive for two dose levels. The duration of the study was 10 months, including the critical reproductive lifestage. A chronic NOAEL dose of 10 ppm was indicated. Factors for body weight (1.25 kg) and food consumption (125 g/day) were applied to estimate a TRV of 1 mg/kg·day.

Mammals Taken from ORNL (1996). A study on rats investigating the effects of doses of Cr^{+6} as $K_2Cr_2O_4$ in water was performed by Mackenzie et al. (1958). Changes in body weight and food consumption patterns were the endpoints for six dose levels over a 1-year duration. Factors for body weight (0.35 kg) and water consumption (0.046 L/day) were applied to estimate a chronic NOAEL and TRV of 3.28 mg/kg·day.

Amphibians No data found.

- **Copper:** Availability of copper to organisms has been found to be positively correlated to the acidic nature of surface water (HSDB, 1994). Relatively little information is found for avian toxicity due to copper, however.

Avians Taken from ORNL (1996). Mehring et al. (1960) studied the effects of copper oxide on 1-day-old chicks. For 10 weeks, reproductive endpoints through 11 dietary doses were observed. A NOAEL was observed at 570 ppm. Factors for body weight (0.534 kg) and food consumption (0.044 kg/day) were applied to estimate the TRV of 47 mg/kg·day.

Mammals Taken from ORNL (1996). Aulerich et al. (1982) studied copper sulfate effects on mink. Reproductive endpoints were observed for four dietary doses over 357 days and during kit development stages. Factors for body weight (1.0 kg) and consumption (0.137 kg/day) were applied to derive the TRV of 11.71 mg/kg·day.

Amphibians No data found.

▸ **Lead:** Lead has been found to bioaccumulate and become organ specific in a variety of organisms. Log BCFs for fish have been reported from 1.38 - 1.65; higher BCFs are found for benthic macroinvertebrates (HSDB, 1994). Tissues of specificity in fish have been localized predominately in the integument. Principle exposure to ducks has been via direct ingestion from lead shot. Livers of 28 species with no known lead exposure ranged from 0.3 - 7 ppm (HSDB, 1994). Calcium, needed by birds for egg production, may also influence the adsorption of lead (Goyer, 1978, *in* Jordan et al. 1990).

Avians Taken from ORNL (1996). American Kestrels were studied for adverse toxic effects from dietary exposure to metallic lead (Pattee, 1984). Reproductive endpoints were tested for two dose levels over 7 months. Fifty ppm lead was indicated as the NOAEL, and is considered a chronic value. Factors for body weight (0.130 kg) and food consumption (0.01 kg/day) were applied to estimate the TRV of 3.85 mg/kg·day.

Mammals Taken from ORNL (1996). Azar et al. (1973) studied the effects of lead acetate on rats over three generations. Reproductive endpoints were examined from dietary exposure at five dose levels. 100 ppm lead was indicated as the chronic NOAEL. Factors for body weight (0.35 kg) and consumption rate (0.028 kg/day) were applied to derive the TRV of 8 mg/kg·day.

Amphibians A toxicity criteria for lead in amphibians has been derived from Steele et al. (1991). This study observed mortality at 500 μg/L in *Bufo americana*.

▸ **Mercury:** Mercury has been found to partition in increasing amounts to liver, kidney, and fat tissues in waterfowl, respectively. Moreover, there is a relatively great amount of interspecific variability in bioaccumulation of mercury concentrations in these tissues (Johnson and Morris, 1971; Lindsay and Dimmick, 1983). Whether this variability in bioaccumulation is interspecific physiological differences or those resulting from differences in life history traits is not known. Intraspecific variability in Wood ducks has been found where fledglings had higher mercury concentrations than adults (Lindsey and Dimmick, 1983).

Avians Taken from ORNL (1996). Heinz (1979) examined the toxicity of methyl mercury dicyandiamide to mallard ducks over three generations. One dietary dose level was tested for reproductive success endpoints. A chronic LOAEL was determined at 0.5 ppm. Factors to account for body weight (1 kg), consumption rates (0.128 kg/day), and LOAEL-NOAEL uncertainty (0.1) were applied to estimate a TRV of 0.0064 mg/kd·day.

Mammals Taken from ORNL (1994). Wobeser et al. (1976) studied methyl mercury chloride dietary exposures in mink. The study duration was 93 days and mortality, weight loss, and ataxia was observed. A chronic NOAEL of 0.015 mg/kg·day was derived.
Amphibians No data found.

▸ **Nickel:**
Avians Taken from ORNL (1996). A study by Cain and Pafford (1981) examined the effects of nickel sulfate on Mallard ducklings. Over 90 days, at three dietary dose levels, mortality, growth, and behavior endpoints were tested. A chronic NOAEL was indicated at 774 ppm. Factors for body weight (0.782 kg) and food consumption (78.2 g/day) were applied to estimate a TRV of 77.4 mg/kg·day.
Mammals Taken from ORNL (1996). Ambrose et al. (1976) studied the effects of nickel sulfate hexahydrate on rat reproductive capacities through three generations. Reduced offspring body weights were observed. Three dietary dose levels were examined, and a chronic NOAEL of 500 ppm was indicated. Factors for body weight (0.35 kg) and food consumption (0.028 kg/day) were applied to derive the TRV of 40 mg/kd·day.
Amphibians No data found.

▸ **Vanadium:**
Avians Taken from ORNL (1996). White and Dieter (1978) studied the toxicity of vanadyl sulfate to Mallard ducks for 12 weeks. Three dose levels were applied in the diet of the organisms. Mortality, body weight, and blood chemistry were the endpoints. No effects were observed at any dose level; therefore the chronic NOAEL was determined to be 110 ppm V in food, the highest experimental dose. Factors of body weight (1.17 kg) and food consumption (0.121 kg/day) were applied to estimate the TRV of 11.38 mg/kg·day.
Mammals Taken from ORNL (1996). The toxicology of sodium metavanadate ($NaVO_3$) to rats through oral intubation was examined by Domingo et al. (1986). Reproductive endpoints were investigated prior to and through gestation, delivery, and lactation. Examination of three dose levels indicated a chronic (critical life-stage) LOAEL of 5 mg/kg·day. Factors for LOAEL to NOAEL uncertainty (0.1) and body weight (0.26 kg) were applied to derive a TRV of 0.21 mg/kg·day.
Amphibians No data found.

▸ **Zinc:** As with silver, toxicological data for zinc exposure is lacking. Bioconcentration factors for benthic macroinvertebrates range from 85 in soft-shelled clams (*Mya arenaria*) to 16,700 for adult oysters (*Crassostrea virginica*) (HSDB, 1994).
Avians Taken from ORNL (1996). Zinc exposure in White leghorn hens was studied by Stahl et al. (1990). Exposures were administered over 44 weeks — reproductive endpoints were evaluated. From this study, a chronic NOAEL has been estimated at 14.5 mg/kg·day.

Mammals Taken from ORNL (1996). Schlicker and Cox (1968) studied the toxicity of Zinc Oxide on rats over a 16 day gestation period. The endpoints were fetal resorption rates and fetal growth rates. Two dietary doses were examined, lending a chronic NOAEL (at critical life-stage) of 2000 ppm. Factors for body weight (0.35 kg) and food consumption (0.028 kg/day) were applied to this value to estimate a TRV of 160 mg/kg·day.

Amphibians No data found.

- **Acetone:**

Avians No data found.

Mammals Taken from ORNL (1996). The EPA (1986) investigated rat toxicity to acetone over a 90-day period, with endpoints of liver and kidney damage. Three oral intubation doses were tested to derive a subchronic NOAEL of 100 mg/kg·day. This value was adjusted with factors for body weight (0.35 kg), ingestion rate (0.028 kg/day), and subchronic-chronic uncertainty (0.1) to estimate the TRV of 10 mg/kg·day.

Amphibians Pollard and Adams (1988) investigated Acris gryllus responses to acetone exposure. They reported impaired development at 10,000 μg/l acetone. In lieu of other data, this value is used as the benchmark from which the TRV criterion is derived.

- **Aroclor 1254 (or PCB 254):** Polychlorinated biphenols (PCBs) are highly lipophilic and have relatively long environmental half-lives. Bioconcentration factors as high as 24,000 have been found to accumulate from a 90-day exposure for Cape Stumpnose (*Rhabdosarqus holubi*; HSDB 1994). Bioconcentration has been found to geometrically potentiate with length of exposure. As previously mentioned, PCBs have been found to indirectly cause delays in breeding and nesting initiation which has been linked to reduce densities of pelicans, cormorants, and Peregrine falcons (Peakall 1972). PCBs are found to partion to muscles, liver, kidney, and fatty tissue (HSDB 1994). Levels of PCB concentrations lower than those which cause an effect in egg shell thinning have been found to cause embryonic death in piscivorous birds (Fox 1976, *in* Hoffman et al. 1986). PCB concentrations have been linked to overall decreased growth in Black-crowned heron embryos (Hoffman et al. 1986).

Avians Taken from ORNL (1996). Dahlgren et al. (1972) studied the effects of Aroclor 1254 on Ring-necked pheasant egg hatchability over 17 weeks. Weekly oral doses (at two dose levels) were administered via gelatin capsules. A chronic LOAEL was determined to be 1.8 mg/kg·day. A factor for LOAEL-NOAEL uncertainty (0.1) was applied to determine a TRV of 0.18 mg/kg·day.

Mammals Taken from ORNL (1996). McCoy et al. (1995) evaluated dietary aroclor 1254 exposures in oldfield mice (*Permyscus poliontus*). The study duration of 12 months was considered chronic, and an estimated chronic NOAEL of 0.068 mg/kg·day was assigned.

Amphibians A toxicity criterion for this chemical has been derived from Birge et al. (1978) studying *Bufo americanus*. They found an LC50 of 2.02 μg/L for exposure to this chemical.

▸ **p,p' - DDT (and metabolites):** DDT (p,p'-dichlorodiphenyltrichloroethane) and its breakdown products, DDD and DDE, are man-made compounds which are highly hydrophobic and highly lipophilic (log Kow = 6.38). Therefore, DDT is considered to significantly bioconcentrate and biomagnify in the food chain. DDE is ubiquitous in the environment and found to accumulate in many species of animals no matter the location. Bioaccumulative rates have also been determined for many aquatic plants which range from 495-6360 for exposure durations of 30 days (HSDB, 1994). DDT has been found to interfere with avian reproduction in the following ways.

- DDT/DDE increases liver enzyme production which directly influences estrogen production. This results in nesting delay for many species of exposed birds (Peakall, 1972). This delay is crucial to reproductive success since many birds have developed life histories precisely timed to resource availability. These effects are greater for PCB exposure than for those from DDT/DDE.

- DDT/DDE decreases calcium availability to egg production through inhibition of carbonic hydroxylase (which assists in making calcium available to the oviduct via the blood) and interferes with calcium storage in bone marrow (Peakall, 1972).

The presence of DDT/DDE has also been found to lead to mortality in Great Blue Heron, American Kestrels, and Bald Eagles. High levels have been found in brain and liver tissue (Call et al. 1976). Interspecific variability of DDE metabolism for five duck species examined has been used to explain the relative differences in tissue concentrations (i.e., in muscle, liver, and fat tissues from specimens collected concurrently at the same locations). Green-winged Teal have been found to accumulate two to eight times less DDE than larger ducks (Johnson and Morris, 1971).

Avians Taken from ORNL (1996). Brown pelican exposures to DDT were studied by Anderson et al. (1975). Reproductive endpoints were monitored during the evaluation lasting 5 years. A chronic NOAEL was estimated at 0.0028 mg/kg·day.

Mammals Taken from ORNL (1996). Fitzhugh (1948) studied rat toxicology with DDT for a 2-year period. Four dietary dose levels were analyzed for reproductive success, and a NOAEL of 10 ppm was determined. Factors for body weight (0.35 kg) and consumption (0.028 kg/day) were applied to estimate a TRV of 0.8 mg/kg·day.

Amphibians Sanders (1970) reported two differing results for congeners of these substances. An LC50 of 400 μg/L was observed for *Pseudacris triseriata* exposed to DDD, while an LC50 of 1000 μg/L was seen for *Bufo woodhousei fowerli* exposed to DDT. No data was found for DDE exposure in amphibians. These values are the benchmarks from which the TRV criteria are derived.

▸ **Heptachlor epoxide:**

Avians No data found.

Mammals Taken from ORNL (1996). Crum et al. (1993) reported a chronic LOAEL of 1.0 mg/kg·day in mink for this compound. A chronic NOAEL was estimated to be 0.1 mg/kg·day.

Amphibians No data found.

▸ **Methylethyl ketone:**

Avians No data found.

Mammals Taken from ORNL (1996). A paper by Cox et al. (1975) reported a chronic NOAEL for rats exposed to this chemical in water as an oral dose. A chronic NOAEL was determined to be 1771 mg/kg·day.

Amphibians No data found.

6.5 Toxicological Uncertainties. The preceding data were collected and TRVs determined based upon dose-response and accumulation-response information. This information has been adjusted or scaled to compensate for uncertainties inherent in these extrapolations. Some of the major uncertainties are:

- Use of laboratory and nonsite specific data to estimate criteria.
- The use of regional (e.g., Ontario) sediment guidelines as criteria for systems in Minnesota, as opposed to state-specific guidelines.
- Inter- and intraspecific variation in exposure and response.
- Variation in assimilation through the ingestion of these COCs.
- Lack of gender and sensitive-lifestage toxicity data.
- Interdependency of response due to presence or absence of other catalyzing and potentiating substances.
- Other effects not monitored or suspected which may be important in the sustainment of ecological health.

These uncertainties may be dependent upon a variety of factors (biotic or abiotic) and can enhance, decrease, or otherwise alter the expected effects to the receptors of concern presented here. The intention is to err on the conservative side. Given these uncertainties, these values are deemed appropriate to be useful in providing a screening-level tool to prioritize and identify problem habitats and sites.

7. RISK CHARACTERIZATION. Risk characterization combines the data gathered in the exposure and toxicity assessments to arrive at a qualitative and/or quantitative measure of risk. This section also addresses additional studies, uncertainties, and issues which bear on the complete understanding of the potential for adverse effects st these sites. Herein, the information on potential exposure and effects will be integrated into risk statements for each site. The quantitative risk analysis that has been performed has separated the estimated hazards based upon the measurement endpoints. All quantitative risk values represent these endpoints.

In review, the stated assessment endpoints (paragraph 3.3) are:

- Water quality, which ensures the health of aquatic organisms.
- Sediment quality, which ensures the health of benthic organisms.
- Healthy populations of riparian fauna, e.g., avians, mammals, and amphibians.

The specific measurement endpoints will be expressed as HQs. Traditionally, HQs are ratios of the expected dose of a substance through exposure divided by a value that represents a safe dose. This ratio can be shown as follows:

$$HQ = \frac{\text{exposure dose}}{\text{toxicity value}}$$

where the HQ represents the risks of one substance to one receptor at a given set of exposure assumptions. This assessment has also expressed the comparisons of media criteria to the detected concentrations of substances at TCAAP in the HQ ratio. In this instance, the ratio will appear as follows.

$$HQ = \frac{\text{detected concentration}}{\text{media criteria value}}$$

The combination of HQs can help to estimate the total risks to a receptor at a site for all contamination. HQs can be combined in an additive fashion to form an HI. In this report, the HI is used as the decision point for determining further efforts. It should be noted that there are some significant rules that govern the combination of HQs. These are discussed in detail in section 6.

In human health risk assessment, an HI of 1 denotes a "trigger" that both identifies unacceptable risk and requires an action be taken to reduce this risk. Ecological risk estimates generally contain more uncertainty than their human health counterparts (due in part to the consideration of multiple species), and require a scaling of HIs that buffers against these and safeguard against frequent overestimates of risk. For these reasons, HIs generated as part of this risk assessment will be interpreted as shown below.

- HI < 1 = a safe location
- 1 ≤ HI ≤ 10 = area of potential concern
- HI > 10 = area of probable adverse effects

Tables that summarize the chemical-specific and location-specific hazards are provided in the following appendices. Within Appendix B, the surface water and sediment data can be found. Appendix C summarizes the aquatic and benthic organism risks (in HQ and HI format) and the contaminants driving any risks. Appendix D presents the chemical specific HQs for the chosen riparian wildlife receptors.

7.1 Protocol for Determining Hazard within Sediments and Water. The following text describes the steps involved in the calculation and presentation of the hazards to sediment and other aquatic organisms. The actual HQs are shown in Appendix C.

Only hazards from previously selected COCs are evaluated. Other substances found to be present, but not related to site-activities (and not defined as contaminants), have not been considered quantitatively. As per the request of the regulatory parties (December 1994, 1997 technical review committe meeting, reference 1), hazards or HQs are to be calculated on a sample-by-sample basis. This method is evident in the tables of Appendix C. For each sample location, if the COC was not detected at the detection limit, then the hazard equals zero. If the COC concentration at any sample location is less than the toxicological screening benchmark, then the hazard equals zero. For sediments, if the COC concentration is less than the calculated background screening value, then the hazard is defined as zero. Though, additive HIs are presented in Appendix C, they are not true descriptions of actual risks — they are presented for comparative purposes.

7.2 Wildlife Hazards and Level-of-Confidence of Risk Descriptors. The tables in Appendix D (showing the HQ and HI values for wildlife) also present a level-of-confidence designation associated with each HI. These designations have been selected based on a professional judgment review of the data (or lack of data) which has been used to generate these risk estimates. These level-of-confidence designations can be used by the risk managers to assist in determining reasonable risk management decisions. The designations are defined and described as follows.

7.2.1 Level (a). A conservative estimate of risk. This confidence level is assigned when the data used to generate the HI contains from zero to two contaminants with little to no toxicological data, and where the lack of information is deemed insignificant. Consider wading bird risks at Sunfish Lake location SFL02, for example. The HI is 8 here, with a level-of-confidence of (a). Due to other conservative factors inherent in the estimation of exposure and toxicity to the suite of contaminants at this location, this data gap is judged to be insignificant.

7.2.2 Level (b). An uncertain estimate of risk, where the toxicological data limitations are relatively minor. This confidence level is assigned when the data used to generate the hazard index contains from two to three gaps in toxicological data, and where these gaps are deemed to be potentially insignificant. Consider wading bird risks at Sunfish Lake location SFL09.A, for example. The HI is 5 here, with a level-of-confidence of (b). Data gaps are present in this risk estimate due to unknown toxicological characteristics of cobalt and methylethyl ketone in this taxonomic group. In this case, the potential for underestimation of overall risks is not likely considering the other conservative assumptions regarding other contaminants, nonetheless an uncertainty exists.

7.2.3 Level (c). An uncertain estimate of risk, where the toxicological data limitations are relatively major. This confidence level is assigned when the data used to generate the hazard index contains from several to many gaps in toxicological data, and where these gaps are deemed to be significant. Consider amphibian risks at Area B Wetlands location B03.B, for example. The modeled HI is $3x10^{6}$ here, with a level-of-confidence of (c). Data gaps are extensive in this risk estimate due to unknown toxicological characteristics of aluminum, barium, chromium, copper, iron, nickel, vanadium, and zinc in this taxonomic group. To address these data gaps, a weight-of-evidence approach was used, i.e., additional HIs were presented for the amphibians which were based on the Ontario sediment guidelines. These additional risk estimates can provide a more realistic assessment, though still uncertain.

7.3 Screening Risk Model Results for Round Lake. Quantitative risk values for each measurement endpoint are presented in Appedices C and D. As can be seen, the overall risks are far from uniform across the lake. The vast majority of the risk for the endpoints as a whole is derived from sediment contamination and that contamination potentially occurring in various biotic components of the system as they serve as diet items for the receptors. The areas near sampling locations RL05, RL07, RL09, and RL14 are showing the highest risk relative to the system. The contaminants that have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

7.4 Screening Risk Model Results for Sunfish Lake. Quantitative risk values for each measurement endpoint are presented in Appedices C and D. As can be seen, the overall risks are uniform across the sampling area of the lake. The majority of the risk for the endpoints as a whole is derived from sediment contamination and that contamination potentially occurring in various biotic components of the system as they serve as diet items for the receptors. The risk associated with waterborne contamination is also consistent with the other risks. The areas near sampling locations SFL06 and SFL07 show the highest risk across the system. The aquatic mammals are estimated to be at the highest risk from contamination at Sunfish Lake. The contaminants that have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

7.5 Screening Risk Model Results for Marsden Lake. Quantitative risk values for each measurement endpoint are presented in Appendices C and D. As can be seen, the overall risks are uniform across the sampling area of the lake. The presented HIs indicate that the majority of the risk for the endpoints as a whole is derived from sediment contamination and that contamination potentially occurring in various biotic components of the system as they serve as diet items for the receptors. Avian species are estimated to be at the highest risk from contamination at Marsden Lake. The contaminants that have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

7.6 Screening Risk Model Results for Rice Creek. Quantitative risk values for each measurement endpoint are presented in Appendices C and D. As can be seen, the overall risks are somewhat uniform across the sampling area of the creek. This system is not nearly as impacted as the other systems associated with the TCAAP. Hazards above 10 occur for aquatic mammals and wading birds only, except for one instance of surface water contamination at RCK01. Mammalian species are estimated to be at the highest risk from contamination at Rice Creek. The contaminants that have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

Table 10. Results of Tier I Risk Model Screening Evaluation. Showing the substances which have the potential to produce adverse effects based upon the Tier I screening assumptions.

	Ecological Receptors					
Site	Aquatic Organisms	Benthic Organisms	Amphibians	Wading Birds	Waterfowl	Aquatic Mammals
Round Lake	barium* zinc	cadmium* chromium copper* silver zinc	insufficient information	zinc	none	aluminum* cadmium vanadium
Sunfish Lake	aluminum barium* zinc	chromium copper* lead* zinc	insufficient information	aluminum chromium zinc	aluminum chromium*	aluminum* vanadium
Rice Creek	aluminum barium* manganese zinc	none	insufficient information	zinc	none	aluminum*
Marsden Lake	aluminum barium* manganese zinc	zinc DDD* DDE DDT	insufficient information	zinc DDD* DDE DDT	DDD DDE DDT	aluminum* vanadium
Site G Pond	aluminum barium* manganese zinc	copper lead zinc PCB 1254* DDD* DDE DDT	insufficient information	zinc PCB 1254* DDD* DDE DDT	PCB 1254 DDD DDE DDT*	aluminum vanadium PCB 1254*
Area B Wetlands	aluminum barium* manganese* zinc	DDD* DDE DDT	insufficient information	DDD DDE DDT	DDD DDE DDT	aluminum* vanadium DDD

The "*" denotes substances which may likely contribute the most to potential risk — based upon the hazard quotient value. When ecotoxicological information is not readily available, then the substance is not listed above and it is treated as an uncertainty.

Table 11. Significant Wildlife Exposure Pathways. Showing the substance which has the potential to produce adverse effects through the pathway.

	Ecological Receptor		
Site	Wading birds	Waterfowl	Aquatic Mammals
Round Lake	fish ingestion (Zn)	none	sediment ingestion (Al, Cd, & V)
Sunfish Lake	fish ingestion (Zn) sediment & benthos ingestion (Al & Cr)	benthos ingestion (Al, Cr)	sediment ingestion (Al, V)
Rice Creek	fish ingestion (Zn)	none	sediment ingestion (Al)
Marsden Lake	ingestion of benthos (DDD, DDE, DDT) ingestion of fish (Zn)	ingestion of benthos (DDD, DDE, DDT)	sediment ingestion (Al & V)
Site G Pond	ingestion of benthos (DDD, DDE, DDT, & PCB) ingestion of fish (Zn)	ingestion of benthos (DDD, DDE, DDT, & PCB)	ingestion of vegetation (PCB) sediment ingestion (Al & V)
Area B Wetlands	ingestion of benthos (DDD, DDE, DDT)	ingestion of benthos (DDD, DDE, DDT)	ingestion of benthos (DDD) sediment ingestion (Al & V)

7.7 Screening Risk Model Results for the Area B Wetlands. Quantitative risk values for each measurement endpoint are presented in Appendices C and D. As can be seen, the overall risks are not uniform across the sampling area. The risks are concentrated at B01 and B02. These pothole wetlands have not been sampled adequately enough to statistically understand the potential for risks across the system. Nonetheless, the risks here are relatively moderate, save for B01 and B02, as compared to the other sites. The contaminants that seem to have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

7.8 Screening Risk Model Results for the Site G Pond. Quantitative risk values for each measurement endpoint are presented in Appendices C and D. This pond is small, but it has not been sampled adequately enough to statistically understand the potential for risks across the system. The contaminants that seem to have the potential for causing adverse effects are presented in Table 10. The exposure pathways that contribute to the wildlife risk results are identified in Table 11.

7.9 Benthic Community Diversity Evaluation. During the summer of 1993 a benthic community evaluation was conducted by USACHPPM for Round Lake, Sunfish Lake, and Rice Creek. A reference lake, Snail Lake, was chosen to serve as the background condition comparison. The complete report is enclosed as Appendix E. A summary of this report follows.

Rice Creek is below average in stream quality as it enters the TCAAP. It remains so throughout its course and as it exits the post. One species, the chironomid, *Glyptotendipes loberiferus*, dominated all stations, accounting for approximately 75 to 80 percent of all individuals. High numbers of this species are often indicative of organic pollution by sewage waste. Diversity ranged from 1.18 to 1.44 (see Tables 3 and 4 in Appendix E). At Rice Creek 1, the diversity (1.44) was moderately low. A total of 1,710 individuals from 20 taxa were found. However, 75 percent of those individuals were the chironomid, *Glyptotendipes loberiferus*. The second most common species, 11 percent, was the amphipod, *Crangonyx gracilis*. At Rice Creek 2, the macroinvertebrate community found at Rice Creek 2 was almost identical to that found at Rice Creek 1. Rice Creek 3 was very similar to Rice Creek 1 and 2, with one exception. *Glyptotendipes loberiferus* still dominated, but the second most common species was *Simulium* spp.

Species found in Round Lake are typical of a eutrophic pond. They are common or widespread in distribution. The species present possess a mix of tolerance to organic enrichment and adverse water quality conditions. No single species dominated the community, and the diversity ranged from moderate to moderately high (1.86 to 2.76) (see Tables 5 and 6 in Appendix E). Five species were abundant at Round Lake 1 (10 to 14% each). They are widespread in distribution and/or are tolerant. The diversity was moderately high. Five different species were abundant (10-31 percent) at Round Lake 2. They are widespread, indifferent to water quality, or moderately tolerant. The diversity was moderate. Round Lake 3 was somewhat similar to Round Lake 2. Six different species were common or abundant (9-24 percent). These species are widespread, indifferent to water quality, and/or moderately tolerant. The diversity was moderate. There were fewer species and fewer individuals at Round Lake 4 than at any of the other Round Lake stations. There were no aquatic worms or chironomids, and few amphipods. The species present are not known to be indicative of water quality. The diversity was moderately low.

Sunfish Lake is a eutrophic lake bordering on overenrichment. Species found in Sunfish Lake are common, and the predominant ones are moderately to very tolerant of organic overenrichment. Diversity is moderately low to moderate. Sunfish 1 is dominated by the aquatic worm, *Aulodrilus americanus*, which is moderately tolerant of organic enrichment. Other species either require an organic environment or are tolerant of adverse water quality conditions. The diversity was moderately low (see Tables 5 and 6 in Appendix E). At Sunfish 2, the three most numerous species are all tolerant of an organically rich environment. Other species are present but are rare. The diversity was moderate. At Sunfish 3, the two of the three most numerous species are both very tolerant of adverse water quality conditions. The diversity was moderate.

At Snail Lake, half the individuals at Snail Lake 1 are of amphipod species, which is widespread and requires an organic environment. The next five most numerous species are typical of organic environments. The diversity was moderate (see Tables 5 and 6 in Appendix E).

7.10 Sediment-Metal Bioavailability. The MPCA has initiated the evaluation of the bioavailability of the metals in the impacted sediments. The screening risk model results presented above are conservative in that they consider that the chemical conditions in the sediments allow for all the metal contaminants to be biologically availabile. In reality, the chemical conditions within the sediments are likely to keep at least some of the contamination unavailable, and hence not able to cause toxicity.

In March 1994, the MPCA sent eight sediment core samples to the Lake Superior Research Institute to be analyzed for acid volatile sulfide (AVS) and simultaneously extractable metals (SEM). Six of the core samples were from Round Lake and the other two were from Sunfish Lake. These analyses were designed to investigate the bioavailability of the contaminating metals in the sediments. Appendix F presents these data.

Several researchers have suggested that AVS is an important partitioning phase determining the bioavailability of divalent transition metals, i.e., cadmium, copper, lead, nickel, mercury, and zinc (Di Toro et al., 1990; Ankley et al., 1991; Carlson et al., 1991; Di Toro et al., 1992; Ankley et al., 1993; Allen et al., 1993; Casas and Crecelius, 1994). Normalization of these sediment-metal concentrations to AVS concentrations have accurately predicted sediments to be toxic to commonly used toxicity test organisms when molar SEM/AVS ratios are greater than one. Sediment-metals react with AVS to form insoluble sulfides during anoxic conditions. Most freshwater and marine sediments contain sufficient AVS for this phase to be the predominant determinant of toxicity. The other sorption phases (i.e., humic acids and the other organic compounds--hydrous metal oxides and ion exchange sites on clay minerals) provide additional binding for metals and are expected to be important only for low AVS sediments (e.g., fully oxidized sediments).

Some have contended that the SEM/AVS ratio shows variation in its predictive capabilities (Ankley et al., 1993). Though these arguments are persuasive, the SEM/AVS ratio does seem to predict when sediments are toxic. However, the SEM/AVS ratio cannot quantify the magnitude of toxicity beyond indicating lethality. In addition, spatiotemporal variability exists for AVS content. Vertical depth and seasonal variations in sediment AVS are assumed to occur, e.g., during lake turnover at the transition between seasons. These variations in AVS content, associated with other chemical parameters, have the potential to confound the accurate prediction of bioavailable metals.

The results of the MPCA sampling effort indicate that the SEM/AVS ratios are moderate to low for all locations in Round Lake except for one location (RL 2). Refer to Table 12.

Table 12. Results of the MPCA SEM/AVS Sampling.

MPCA Sample Location		Nearby OU-2 FS Sample Locations	Results SEM/AVS ratio	Implication for Toxicity
Round Lake	RL 1	RL01 & RL02	0.14	not expected
	RL 2	RL04 & RL06	1.35	likely to occur
	RL 3	RL05 & RL09	0.34	not expected
	RL 4	RL20	0.16	not expected
	(duplicate) RL 4	RL20	0.16	not expected
Sunfish Lake	SFL 1	SFL01 & SFL02	0.47	not expected
	SFL 2	SFL04, SFL05, SFL06	—	likely to occur

A ratio for SFL 2 could not be calculated because the AVS value was below the detection limit of the method used. The metals at Sunfish Lake location 2 could be expected to be highly available, as the analysis indicated very little AVS was present in the sediment to bind co-located metals.

In summary, the supporting SEM/AVS data indicate that the more likely areas of sediment exposure risk can be expected to occur near the northern portion of Round Lake and near the central portion of Sunfish Lake near the landfill. These data are limited and do not justify a robust conclusion. In fact, at various seasons or during brief periodic oxidation periods within these lakes (i.e., seasonal turnover), the volatilization of AVS from sediments can occur and, hence, render portions of the previously bound metal sulfides bioavailable and potentially toxic. Overall, from this data set, Sunfish Lake seems to contain less AVS in its sediment than Round Lake, which, if true, would imply that contaminating metals within Sunfish Lake are more bioavailable and, therefore, more toxic.

7.11 Evaluation of Surface Water Data from 1994 and 1995 Annual Monitoring. In response to the large variation in some COC concentrations in surface water, the surface water database considered in this risk assessment includes recent annual monitoring report data. These data can be found in Appendix B and were selected from the 1994 and 1995 Annual

Monitoring Reports (TCAAP 1995, 1996). The report for the monitoring in fiscal year 1996 has not yet been finalized, therefore any fiscal year 1996 data that it might add to this evaluation has not been considered.

The annual monitoring effort routinely samples 14 surface water sampling stations during each fiscal year. Of these locations, ten have been selected for use in the risk assessment. The selection was based upon the monitoring location being relevant to one of the sites assessed herein — data from the monitoring has expanded the data base for Round Lake, Rice Creek, and Marsden Lake. The following monitoring locations have been considered (refer to Figures 8a and 8b for their geographical placement:

- Round Lake — station 20500
- Rice Creek — stations 20700, 20200, 20300, 20800, and 21100
- Marsden Lake — stations 20100, 21200, 21300, and 21400

The annual monitoring data has been able to assist in the evaluations of zinc, lead, and mercury only. Aluminum is not an analyte which is monitored. Some organics are monitored, however only PCBs are risk assessment COCs. Annual monitoring report data for PCBs (no detections) does not affect the conclusions of the risk assessment.

Monitoring data for both lead and mercury in surface waters are consistent with the database within this risk assessment. However, zinc concentrations in both the 1994 and 1995 monitoring reports were much less than the concentrations found during the OU-2 FS first round of sampling (October 1992), and closer by comparison to the concentration levels detected in the second round (June 1993). This data provides some indication that the zinc detections during October 1992 are suspect. This is important because it is these October data which are forcing the high risk modeling estimates from zinc at these sites.

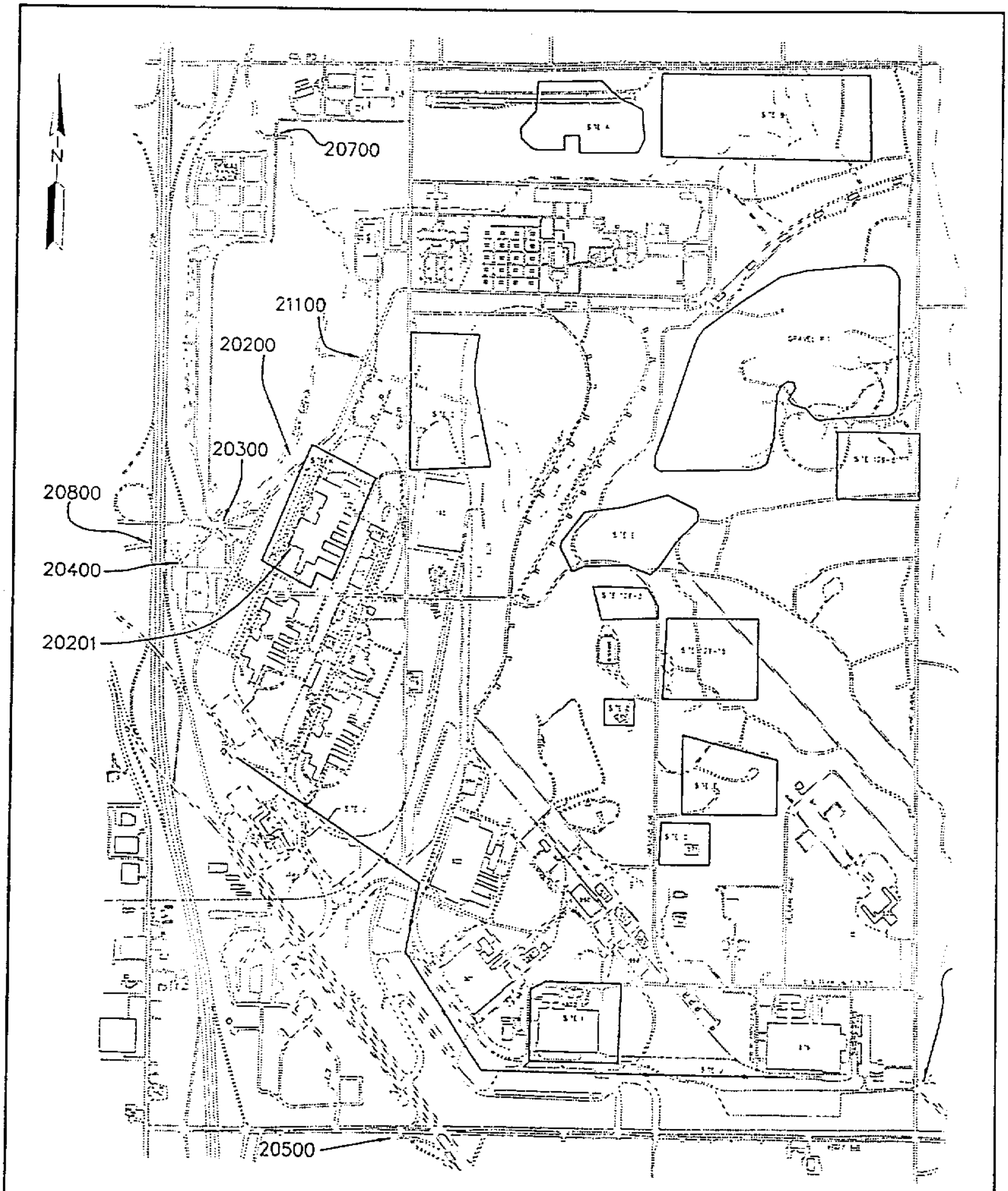

Figure 8a. Surface water annual monitoring stations at TCAAP (western side of installation).

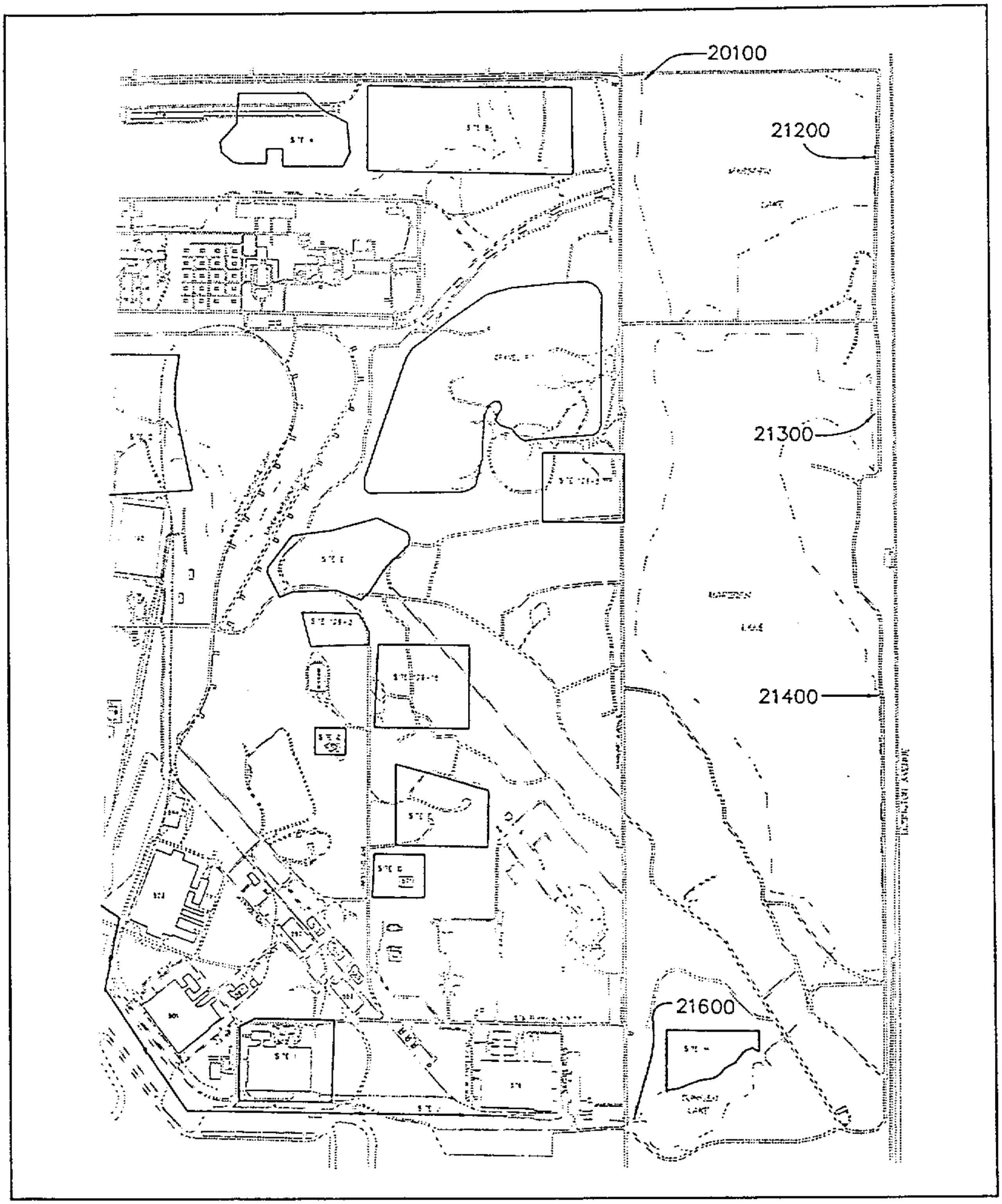

Figure 8b. Surface water annual monitoring stations at TCAAP (eastern side of installation).

8. DATA LIMITATIONS AND UNCERTAINTY. Within this report, when uncertainty was introduced by particular data sets, lack of data, or uncertain data and assumptions, these cases were discussed. This section is an overview of the universe of uncertainties associated with the specific characterization of risk. The limitations and uncertainties associated specifically with hazard identification (paragraph 4.4), exposure estimation (paragraph 5.7), and toxicological effects (paragraph 6.5) have been discussed previously. Limitations and caveats associated with the application of the findings of this assessment will be outlined here. Ecological risk assessment is not an exact science in its current state; therefore, the uncertainties inherent in the approach need to be outlined.

8.1 Indirect Effects. This screening assumes that any toxicological effect that could affect individuals would have the same complementary effect on the population. This may ignore any indirect or populational effects not addressed by the toxicological criteria identified. For example, changes in prey densities, interspecific competition, mate recognition, predator avoidance behavior, and habitat alterations have the potential to affect population densities more so than direct causes (Orians, 1986). Further, NOAELs may not include characteristics that are most important in reproductive performance and population sustainability. Patterns describing factors that influence population densities are complex and variable. Any variation in relative population densities due to chemical exposure may not be fully realized in this assessment.

8.2 Background. Relatively low levels ($\leq$1 ppm) of pesticides that are ubiquitous in the environment are responsible for much of the risk at Marsden Lake and Area B Wetlands. Since there is no history of pesticide disposal practices at TCAAP, it is likely that these pesticide concentrations are due to normal application, and are not likely to exceed local background concentrations.

8.3 Food Web Modeling. Food web modeling is inherently uncertain. Contaminant trophic transfer estimates are often the most critical and uncertain component of food web models. The USACHPPM has found that food web modeling typically results in an overestimation of exposure and, therefore, risk. Thus, modeled dietary exposures to receptors of concern are expected to be conservative, and produce conservative estimates of risk.

8.4 Toxicological Data and Population Level Effects. Ecological risk assessment should evaluate population level effects except in the case of threatened or endangered species. The toxicological endpoints used in this assessment were not necessarily related to population level impacts such as reproductive success, fecundity, etc., due to sparse toxicity data for some of the contaminants of concern. Thus, in some instances, this assessment assumes that any effect on the individual will also result in a population level effect.

8.5 Uncertainties Associated with Amphibians. No true amphibian risks were determined in this assessment. However, this finding can be misleading and needs to be viewed with caution. The amphibian toxicological literature is dominated by LC50 studies, which are not appropriate for this evaluation since chronic effects and NOAELS are desired. Extrapolating from LC50s to chronic NOAELS adds such a large degree of uncertainty that this procedure is prohibitive. In addition, amphibian risks are based on surface water exposures only since sediment partitioning and amphibian dermal absorption of the contaminants of concern cannot be evaluated at this time due to a lack of data in the literature. Dietary exposures to amphibians was also not evaluated due to changes in diet between life stages. Thus, risks to amphibians as presented in this assessment are most likely underestimated.

8.6 Uncertainties Associated with Surface Water. Surface waters were sampled for heavy metals on two occasions because the first round (October 1992) produced consistently elevated aluminum and zinc concentrations. The contractor believed that these results were likely to indicate that a laboratory error was made, but not identified. Therefore, they proceeded with a second round of sampling in June 1993. The second round produced aluminum and zinc concentrations that were much lower than the first round (Appendix B). All surface water data from rounds one and two were used in this risk assessment (Appendix C). The approporiate information is not available to justify that the October 1992 data set was associated with unacceptable degrees of laboratory error. Thus, risks to aquatic organisms must consider the October 1992 data set, however risks may be overestimated.

8.7 Marsden Lake and Area B Wetlands Characterization. Few sediment and surface water samples were taken from Marsden Lake and the Area B Wetlands. Thus, the estimated ecological risks associated with exposure to potential contamination in these areas are highly uncertain. Ecological risks at these sites need to be evaluated when more complete characterization of these wetlands occurs.

8.8 Detection Limits and Screening Benchmarks. The data set used in this assessment is limited in its ability to properly screen some COCs for toxic effects. First, there are four sediment COCs and three surface water COCs which had analytical detection limits which were greater than the screening toxicty benchmark previously identified in Tables 7 and 8 (see Table 13). Second, there are a number of sediment contaminants which do not have readily available toxicity screening benchmarks — which renders an incomplete evaluation of their potential for causing toxic effects. Information presented in Table 14 provides an evaluation of those cases where sediment contaminants without screening benchmarks are present.

Table 13. Problematic cases where toxic effects screening is inadequate.

Media and Contaminant of Concern		OU-2 FS Detection Limit	Risk Assessment Toxicity Benchmark*	Degree of Impact upon Uncertainty
SEDIMENTS	arsenic	12.7 μg/g	6 - 33 μg/g	moderate
	acetone	0.045 μg/g	0.00877 μg/g	moderate
	p,p,-DDT& metabolites	~ 0.01 μg/g	0.005 - 0.19 μg/g	moderate
SURFACE WATER	barium	20.0 μg/L	3.8 - 69.1 μg/L	low
	cadmium	5.5 μg/L	1.1 - 33 μg/L	low
	copper	20 μg/L	9.8 - 18 μg/L	high
	mercury	0.74 μg/L	0.007 - 2.4 μg/L	moderate
	silver	12.5 μg/L	0.36 - 4.1 μg/L	high

The "*" denotes that if a range is shown that it represents the low-to-severe effect levels (sediments) and chronic-to-acute exposure condition (water).

The degree of impact upon the risk assessment that the detection limit issue has varies depending upon the COC of interest. By knowing and utilizing the range of effects possible with the range of contaminant concentrations, the degree of impact can be estimated. For example, consider arsenic in sediments. The detection limit for arsenic was 12.7 μg/g and this actually falls between the low and severe effect levels (but closer to the low end) identified in the Ontario guidelines (Table 13). Therefore, the level of added uncertainty is lessor than for copper, for instance. In the case of copper, the detection limit (20 μg/L) is not even below the acute standard (18 μg/L) — hence, the high degree of added uncertainty in this case.

In evaluating the problematic cases outlined in Table 14, it becomes clear that both aluminum and vanadium in sediments cannot be eliminated from further consideration in the risk assessment process. Based upon the frequency of detection and concentrations levels, the presence of the other COCs do not seem add any great degree of uncertainty to the risk conclusions. Therefore these COCs can be justifibly removed from further evaluations. In the case of cobalt in sediments, no regional background data is available to determine whether or not this metal should actually be considered a COC. However, any potential cobalt toxicity, if present, is not likely to add appreciably to the overall risks at these sites.

Table 14. Summary of detected substances in sediment with no toxicity screening value.

Study Area & Substance	Study Area Concentration † range (µg/g)	mean (std)	Background Screening Concentration (µg/g)	Frequency of Detection ‡
ROUND LAKE				
aluminum	11,500 - 15,400	12,917 (1,353)	10,674	6/18
cobalt	<2.5 - 19.7	17 (3)	unavailable	6/18
vanadium *	28.3 - 63	41 (9)	15.0	13/18
SUNFISH LAKE				
acetone	0.17 - 0.32	0.27 (0.09)	unavailable	3/12
aluminum	11,800 - 18,000	13,744 (1,769)	10,674	9/12
barium	265	—	238	1/12
methyl ethyl ketone	0.01 - 0.05	0.03 (0.013)	unavailable	8/12
vanadium	24.3 - 61.5	46.7 (9.5)	15.0	12/12
RICE CREEK				
cobalt	<2.5 - 6.77	5.7 (1.5)	unavailable	3/11
vanadium	15.3	—	15.0	1/11
POND G				
aluminum	12,000	—	10,674	1/1
cobalt	16.8	—	unavailable	1/1
vanadium	43.2	—	15.0	1/1
AREA B WETLANDS				
aluminum	18,000	—	10,674	1/6
cobalt	3.1 - 25.2	9 (8)	unavailable	6/6
barium	269	—	238	1/6
beryllium	1.33	—	1.2	1/6
vanadium	18.0 - 58.6	28 (17)	15.0	5/6
MARSDEN LAKE				
aluminum	12,700	—	10,674	1/5
barium	239	—	238	1/5
cobalt	14.9 - 18.4	17 (2.5)	unavailable	3/5
vanadium	21.7 - 45.5	33.4 (8.4)	15.0	5/5

† The range of concentrations and mean with standard deviation which exceed the background screening concentration (as shown). This range does not include the concentration ranges which are below the background screening value.
‡ The frequency of samples which exceed the background screening value.
* This data do not include a single detection of 892 µg/g at RL09SE.

8.9 Contamination in Deep Sediments in Round Lake. The assessment documents a process used to define potential ecological effects which may be occurring in the systems previously identified. Because of this scope, the assessment only evaluated surficial sediment contamination, that is, contaminants within the 0 to 1 foot depth interval. This evaluation defines "current" risks, where the deep sediments are not significantly disturbed. The potential for contaminants presently in the deep sediments at Round Lake (deeper than 1 foot below the surface) to become biologically available in the future (due to disturbances) has not been critically examined. This situation limits the risk information available to assist in the management of the lake over the long term. Appendix I presents the comments which identify this limitation.

9. RISK ASSESSMENT CONCLUSIONS. This investigation has been able to narrow down the chemicals and areas considered to contain the most potential for ecological risk based on expected individual species responses, benthic community evaluations, and other supporting data. This report also outlines the data gaps which can potentially hinder risk-based management decisions. It should be noted that this assessment screens for the *potential* for adverse impacts; therefore, the report does not document that impacts are definitively occurring now, or will occur in the future.

9.1 Round Lake. Though Round Lake appears to be typical of a natural eutrophic pond environment, chemical impacts could be occurring. Barium and zinc in the surface waters may be able to cause toxic effects in the water column. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

The substances thought to be contributing the most to potential risk in sediment are limited to the metals: aluminum, cadmium, chromium, copper, silver, vanadium, and zinc. Aquatic mammals, wading birds, benthic organisms, and amphibians of the system are predicted to be impacted by the contamination.

The northern portion of the lake appears to pose more risk to benthic organisms based on the screening risk model. However, the benthic evaluation indicates that this might not be the case. These benthic evaluations indicate that the southern end, near the lake's outfall, is more impacted in terms of biodiversity.

A limited bioavailability investigation of sediment metals shows that there might be sufficient acid volatile sulfide in the sediments to bind cadmium, copper, mercury, and zinc. Because acid volatile sulfide levels in sediments are dynamic and vary seasonally and only a few samples were collected during one season, this data does not provide conclusive evidence that these metals are biologically unavailable.

The hot spot contamination of DDT and its metabolites are limited in extent and are unlikely to be causing any significant effects. The potential for effects in wading birds at Round Lake were identified, but this estimate relies upon zinc concentrations in water. Based upon all the collected information on zinc concentrations in water at Round Lake, wading birds risks are not likely to be significant. This conclusion is supported by the knowledge that zinc is not likely to sufficiently bioaccumulate in fish to create a problem for these birds. The screening model assumed that zinc would bioaccumulate 100 times from the water concetration. This assumption was taken from old USEPA guidance (1989). New guidance from EPA's Great Lakes Initiative (USEPA 1993) falls in line with recent literature, and recommends that zinc not be considered a bioaccumulator in fish tissues.

The potential for effects in aquatic mammals at Round Lake were identified, based upon the concentrations of aluminum, cadmium, and vanadium in sediments which may be ingested by the animals during foraging and den building activities. However, a healthy number of muskrat dens have recently been present in the northern portion of the lake. These dens were surveyed by USACHPPM (Keith Williams and Matt McAtee) during the winter of 1994. Based upon this information, it seems unlikely that the potential risks estimates for mammals with the conservative risk model are accurate.

9.2 Sunfish Lake. Sunfish Lake sediments show signs of organic overenrichment and might also be suffering from chemical impacts, though these chemical stresses are relatively less than those potentially occurring within Round Lake. Aluminum, barium, and zinc in the surface waters may be able to cause toxic effects in the water column. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

The substances thought to be contributing the most to these risks in the sediment are: aluminum, chromium, copper, lead, vanadium, and zinc. Benthic macroinvertebrates, amphibians, wading birds, and waterfowl are potentially at risk. Though numerous muskrat homes and other mammalian tracks and dens have been observed, aquatic mammals are predicted to be experiencing the highest chemical risks at Sunfish Lake.

A limited bioavailability investigation for sediment metals shows that there is a potential for adequate acid volatile sulfide in the sediments to bind much of the zinc, copper, lead, and cadmium, however only two samples were collected during one season.

Risks may be present for wading birds ingesting aluminum and chromium within sediment and in tissues of benthic organisms. Aquatic mammals may be at risk through the ingestion of aluminum and vanadium in sediments, though numerous muskrat homes and other mammalian tracks and dens have been observed during 1994 surveys by USACHPPM (Keith Williams and

Matt McAtee).

9.3 Marsden Lake. Marsden Lake has not been adequately characterized for chemical contamination, nor for its specific ecology. Based upon the available data, the most significant potential for risks are due to detections of pesticides and zinc in the sediments. Aluminum, barium, and zinc in surface water have the potential to cause toxicity. The surface water data for zinc are not as robust as they could be — for data collected since October 1992 do not support significant risks from zinc. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

Sampling at Marsden Lake has been extremely limited and the extent of the contamination already detected is not known. In addition, no water or sediment samples were taken near the grenade range or along the eastern shore (the area receiving off-post urban/highway runoff). The risks described here may not accurately reflect the amount of risk that might exist.

9.4 Rice Creek. Rice Creek is impacted by organic pollution before it enters TCAAP. Though some chemical impact risks have been predicted by this assessment, the benthic macroinvertebrate survey provides evidence that the creek is not adversely affected by TCAAP operations. In the surface water, barium may have the potential for causing toxicity. Zinc does not pose a hazard to aquatic organisms. Though levels of zinc which exceed water quality standards were detected during the OU-2 Feasibility Study, additional sampling during the OU-2 FS (June 1993) and the annual monitoring programs of 1994 and 1995 at five Rice Creek stations indicate that water concentrations of zinc do not exceed the standard.

The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

9.5 Area B Wetlands. The Area B Wetlands have not been adequately characterized for contaminant presence nor for ecology. Based upon the available data for Area B3, the most significant potential for risks are due to detections of pesticides in the sediments. Aluminum, barium, manganese, and zinc in surface water have the potential to cause toxicity. Aluminum and vanadium in the sediments may potentially impact aquatic mammals, in addition to the pesticides.

The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

This site provides some of the best TCAAP habitat for amphibian species, but insufficient toxicity information exists to screen the contaminants for their ability to be toxic to these species throughout their life-cycle without performing toxicity testing.

The sediments and surface water at Areas B1 and B2 have not been characterized. The shallow and deep soils, and groundwater at Areas B1 and B2 were characterized during the Operable Unit 2 Feasibility Study; however, contamination of the surrounding soils and groundwater was not found.

9.6 Site G Pond. Pond G is relatively small compared to the other aquatic habitats associated with TCAAP and contamination here will not likely contribute to overall ecological impact at the installation. Based upon only one sample at one location, all ecological receptors are expected to exhibit unacceptable risks when exposed to Pond G. In surface water, barium, and zinc may be consistently toxic. In the sediments, copper, lead, zinc, PCB 1254, and p,p-DDT metabolites are likely to be causing toxic conditions for sediment organisms. The assessment remains inconclusive with regards to potential risk from copper, mercury, and silver in the surface waters. This is due to method detection limits which were inadequate for screening purposes.

9.7 Limitations. This ERA is a screening risk assessment in that it does not definitively assess ecological risks but, rather, defines the potential for adverse effects to occur. The limitations implicit with this assessment are presented below, in order of importance and impact on the conclusions.

This risk assessment has been limited in its ability to assess the risks from sediment contamination of p,p-DDT and metabolites because of inadequate analytical detection limits; and aluminum and vanadium because of a lack of benthic toxicological data. Method detection limits for copper, mercury, and silver in surface waters were inadequate for screening purposes.

In some instances, the calculated potential risks may be attributed to background. Relatively low levels ($\leq$1 ppm) of pesticides that are ubiquitous in the environment are responsible for much of the predicted potential risk at Marsden Lake and Area B Wetlands, for example. Since there is no history of pesticide disposal practices at TCAAP, it is likely that these pesticide concentrations are due to normal application and do not exceed local background concentrations.

The surface water database includes several different sampling events and monitoring. The results for zinc in particular, and for aluminum (but to a lessor extent), produced inconsistent concentrations across most sites. However, all surface water data from rounds one and two were used in this risk assessment. Thus, any estimated risks posed by aluminum and zinc are fairly uncertain.

The Area B Wetlands and Marsden Lake are not fully characterized. Risks were characterized based on available data. However, adequate risk evaluations of these two wetland areas cannot be performed at this time due to limited data.

Large data gaps exist for screening amphibian risks since toxicological data for many contaminants of concern are not available. Thus, the risks presented in the Appendices for amphibians are misleading and need to be viewed with caution.

Exposures to environmental contaminants via dietary consumption were modeled for the receptors of concern since no biological body burden sampling was conducted. In a number of studies, the USACHPPM found that food web modeling produces conservative estimates of exposure and, thus, risk. Risks associated with prey consumption need to be viewed with this in mind. Food web modeling, however, does focus future work on receptors most likely at risk, so that the diets of these organisms can be sampled with a minimum of unnecessary field and laboratory costs.

The potential for contaminants presently in the deep sediments at Round Lake (deeper than 1 foot below the surface) to become biologically available in the future has not been critically examined. This situation invokes a limitation of this assessment to provide information to assist in the management of the lake over the long term.

10. RECOMMENDATIONS. The following investigations are recommended to close data gaps and carry out a more focused evaluation of potential ecological risks in a Tier II risk assessment.

10.1 Round Lake. For the sediments, perform sediment toxicity tests at the southern end of the lake, a bioavailability evaluation at the northern end, and collect concurrent benthic community diversity data during both studies. Design the toxicity tests to determine if the benthic impacts in the southern portion of the lake are related to toxicity. Design the bioavailablity study to evaluate the remaining contaminants of concern in sediment: aluminum, cadmium, chromium, copper, silver, vanadium, and zinc. Two Tier II studies are currently underway at USACHPPM which address these remaining sediment contamination issues.

For surface waters, collect water samples from several locations in the lake every quarter for one year. The purpose of this data collection is to provide the necessary data to determine if barium, cadmium, copper, mercury, silver, and zinc concentrations consistently exceed their water quality benchmarks.

Review the compatible use directives of the U.S. Fish and Wildlife Service as they pertian to their management of the lake as a unit in the Minnesota Valley National Wildlife Refuge and determine if they will impact the risk assessments.

10.2 Sunfish Lake. For the sediments, perform a bioavailability evaluation and collect concurrent benthic community diversity data. Design this to evaluate the remaining contaminants of concern in sediment: chromium, copper, lead, and zinc. A Tier II study is currently underway at USACHPPM which begins to address the remaining sediment contamination issues at Sunfish Lake.

For surface waters, collect water samples from several locations in the lake every quarter for one year. The purpose of this data collection is to provide the necessary data to determine if aluminum, barium, cadmium, copper, mercury, silver, and zinc concentrations consistently exceed their water quality benchmarks.

10.3 Marsden Lake. Perform additional sediment and surface water sampling at areas suspected to be impacting the lake in order to better characterize the nature and extent of any TCAAP waste contamination. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a COC, perform a screening risk evaluation similar to the one performed in this report.

10.4 Rice Creek. For the sediments, no further action is needed. For surface waters, collect water samples from three locations in the creek every quarter for one year. The locations should include one upstream, one downstream, and one in between. Design this monitoring to determine if aluminum, barium, cadmium, copper, silver, and mercury concentrations consistently exceed their water quality benchmarks.

10.5 Area B Wetlands. Perform sediment and surface water sampling at Areas B1 and B2 in order to better characterize the nature and extent of any TCAAP waste contamination. Sample several locations in each area pothole wetland. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a COC, perform a screening risk evaluation similar to the one performed in this report.

Perform toxicity tests using amphibian species on Area B3 sediments and surface waters to close the data gap associated with the prediction of risks to amphibians. Perform toxicity tests using aquatic biota on Area B3 surface waters to determine if aluminum, barium, cadmium, copper, mercury, silver, manganese, and zinc are producing toxic effects.

10.6 Site G Pond. Perform additional sediment and surface water sampling at several locations in order to better characterize the nature and extent of any TCAAP waste contamination. After these data are collected, determine the contaminants of concern (COC) using the process outlined in this report. For any substance identified as a COC, perform a screening risk evaluation similar to the one performed in this report.

11. PRELIMINARY TIER II RISK ASSESSMENT STUDIES. Two preliminary Tier II studies are underway at USACHPPM which begin to address remaining sediment contamination issues at Round Lake and Sunfish Lake. These studies are close to completion and will likely be finalized before the end of 1997. These studies will appear in the record as appendices in the Tier II Work Plan, after receiving the appropriate regulatory review.

- A sediment toxicity study is being performed for Round Lake under the direction of the USACHPPM Surface Water and Wastewater Program. Sediments were collected in July 1995. Both laboratory toxicity studies and benthic community diversity evaluations have been conducted and data analyses and report preparation are currently underway.

- A sediment-metal bioavailability study is being performed for Round and Sunfish Lakes under the direction of the USACHPPM Environmental Health Risk Assessment and Risk Communication Program. The field work was completed in September 1995. This work will expand upon the bioavailability assessments previously performed by the MPCA. Sediment chemistry characteristics, benthic bioaccumulation responses, and benthic community indices are being evaluated.

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APPENDIX A

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APPENDIX B

SEDIMENT AND SURFACE WATER ANALYTICAL DATA

<u>Table Description</u> <u>page</u>

Table B-1. Summary of Analytical Results for Round Lake Sediments (0-1 ft depth)

Substance	RL02	RL05	RL06	RL07	RL08	RL09	RL10	RL11	RL12	RL13	RL14	RL15	RL16	RL17.A	RL17.B	RL18	RL19	RL20
aluminum	5820.0	8850.0	13100.0	11500.0	2810.0	12000.0	7350.0	6920.0	10500.0	10000.0	15400.0	1260.0	7010.0	5290.0	8300.0	12900.0	12600.0	1850.0
antimony	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9
arsenic	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7
barium	154.0	121.0	196.0	182.0	51.6	213.0	157.0	138.0	181.0	170.0	214.0	11.6	138.0	120.0	171.0	177.0	156.0	15.2
beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	0.74	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
calcium	8880.0	9400.0	23300.0	22600.0	5460.0	56000.0	9060.0	13000.0	11700.0	53000.0	18500.0	1810.0	15200.0	12300.0	16700.0	15900.0	16400.0	3680.0
cadmium	<0.427	2.73	<0.427	3.81	<0.427	7.53	<0.427	<0.427	<0.427	<0.427	5.08	<0.427	<0.427	<0.427	<0.427	11.2	<0.427	<0.427
chromium	21.0	56.8	64.9	96.5	20.9	110.0	15.2	68.2	72.7	39.6	55.2	3.96	<0.974	11.8	19.7	172.0	142.0	4.23
cobalt	18.0	13.3	19.7	<2.5	<2.5	19.1	<2.5	<2.5	<2.5	14.1	19.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
copper	43.2	521.0	608.0	[illegible]05.0	139.0	1250.0	20.9	350.0	399.0	196.0	168.0	<3.38	<3.38	<3.38	51.0	365.0	320.0	<3.38
cyanide	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22
iron	13000.0	16000.08	23000.0	19000.0	4500.0	26000.0	19000.0	12000.0	16000.0	16000.0	23000.0	2600.0	11300.0	10000.0	14000.0	20000.0	18200.0	3000.0
lead	<10.0	9.7	<10.0	<10.0	<10.0	113.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	299.0	257.0	<10.0
magnesium	2880.0	8280.0	8470.0	6200.0	1340.0	9990.0	3650.0	3440.0	4340.0	7270.0	5799.0	906.0	4260.0	3370.0	4360.0	6100.0	5300.0	786.0
manganese	295.0	367.0	561.0	319.0	90.5	750.0	335.0	325.0	435.0	351.0	301.0	62.0	372.0	303.0	517.0	525.0	377.0	51.5
mercury	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087
molybdenum	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
nickel	<7.5	<7.5	<7.5	<7.5	<7.5	32.2	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5
potassium	859.0	1330.0	1930.0	1890.0	445.0	1520.0	1170.0	<142.0	1750.0	1720.0	2610.0	<142.0	<142.0	<142.0	1820.0	<142.0	<142.0	<142.0
selenium	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4
silver	<0.5	<0.5	2.45	86.8	<0.5	1.07	58.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
sodium	237.0	302.0	589.0	522.0	165.0	300.0	361.0	628.0	706.0	445.0	5790.0	<50.0	1190.0	570.0	774.0	1320.0	1210.0	124.0
thallium	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
vanadium	30.3	37.6	49.9	46.3	11.6	37.8	36.1	28.3	46.0	39.5	63.0	5.02	40.6	31.0	46.7	<2.0	<2.0	7.04
zinc	82.5	414.0	399.0	639.0	125.0	892.0	90.0	341.0	453.0	263.0	270.0	10.3	122.0	78.8	98.3	860.0	772.0	21.4
VOCs	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
h. epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
PCB 1248	<0.040	<0.040	<0.040	<0.040	<0.040	1.280 R	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
PCB 1254	<0.040	<0.040	<0.040	<0.040	<0.040	0.240 R	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
α-endosulfan	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
p,p-DDD	<0.011	<0.011	<0.011	<0.011	<0.011	0.40	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
p,p-DDE	<0.014	<0.014	<0.014	<0.014	<0.014	0.15	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
p,p-DDT	<0.010	<0.010	<0.010	<0.010	<0.010	0.33	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

values in $\mu g/g$ '—' analytes not analyzed VOCs - volatile organic compounds SVOCs - semivolatile compounds TPH - total petroleum hydrocarbons R - the data is rejected (unusable)
Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993).

Table B-2. Summary of Analytical Results of Detected Substances in Sunfish Lake Sediments (0-1 ft depth)

Substance	SFL01	SFL02	SFL03	SFL04.a	SFL04.b	SFL05	SFL06	SFL07	SFL08	SFL09.a	SFL09.b	SFL10
aluminum	18000.0	13100.0	14700.0	13600.0	13500.0	13000.0	12800.0	13200.0	7780.0	10100.0	11800.0	9760.0
antimony	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9
arsenic	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7
barium	265.0	178.0	191.0	155.0	150.0	172.0	168.0	173.0	143.0	217.0	218.0	170.0
beryllium	<0.25	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7
calcium	9640.0	7400.0	9490.0	8130.0	8460.0	6710.0	5820.0	683.0	8230.0	3030.0	4000.0	3630.0
cadmium	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	1.50	1.96	<0.427
chromium	229.0	188.0	183.0	97.7	93.3	264.0	250.0	183.0	38.2	42.4	43.2	34.9
cobalt	27.0	<2.5	19.4	17.1	17.9	21.1	22.0	<2.5	<2.5	15.8	16.8	11.8
copper	92.1	85.9	79.7	67.9	65.7	126.0	90.3	105.0	38.8	38.0	47.6	28.7
cyanide	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22
iron	24000.0	21000.0	22000.0	21000.0	21000.0	21000.0	17000.0	18000.0	9700.0	18000.0	23000.0	14000.0
lead	192.0	128.0	133.0	105.0	110.0	202.0	134.0	144.0	82.2	73.0	82.3	102.0
magnesium	5490.0	4780.0	5320.0	5940.0	6220.0	4390.0	3610.0	3860.0	2700.0	2790.0	3570.0	2920.0
manganese	380.0	371.0	365.0	342.0	361.0	370.0	296.0	319.0	406.0	435.0	600.0	454.0
mercury	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087
nickel	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5
potassium	2520.0	1770.0	2200.0	1870.0	1760.0	1660.0	1880.0	1940.0	1620.0	1180.0	1530.0	1220.0
silver	<0.5	<0.5	<0.5	2.69	<0.5	<0.5	<0.5	4.82	<0.5	<0.5	<0.5	<0.5
sodium	471.0	461.0	425.0	353.0	361.0	455.0	371.0	413.0	293.0	177.0	207.0	169.0
thallium	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
vanadium	61.5	44.3	54.4	50.0	50.9	48.0	47.7	44.2	24.3	45.3	53.7	36.0
zinc	329.0	286.0	343.0	240.0	229.0	334.0	339.0	279.0	113.0	401.0	501.1	230.0
acetone	<0.045	<0.045	0.32	0.32	<0.045	<0.045	<0.045	<0.045	<0.045	<0.045	<0.045	0.17
methylethyl ketone	<0.005	<0.005	0.04	0.05	<0.005	0.03	<0.005	0.02	0.03	0.02	0.01	0.04
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
TPH	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—
UNK069	—	—	—	—	—	—	—	—	400.0	—	—	—
UNK091	—	—	0.04	—	—	—	—	—	—	—	—	—
UNK092	—	—	—	—	—	—	—	—	—	—	—	0.05

values in $\mu g/g$ '—' not analyzed in sample VOCs - volatile organic compounds SVOCs - semivolatile compounds TPH - total petroleum compounds
Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993)
nd - no compounds were detected for the entire analytical group 'UNK' - an unknown compounds

Table B-3. Summary of Analytical Results of Detected Substances in Rice Creek Sediments (0-1 ft depth)

Substance	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.a	RCL06.b	RCK07	RCK08	RCK09	RCK10
aluminum	1270.0	1130.0	1290.0	1370.0	987.0	1430.0	1540.0	1100.0	3610.0	1210.0	3700.0
antimony	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9
arsenic	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7
barium	21.9	15.7	25.9	25.1	9.95	34.7	23.2	16.1	90.2	16.2	33.0
beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
cadmium	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427
calcium	4010.0	4140.0	3330.0	3180.0	2100.0	9400.0	1990.0	3580.0	51000.0	2970.0	10000.0
chromium	3.8	4.05	4.04	4.06	2.78	7.71	6.77	4.72	11.2	4.38	7.54
cobalt	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	3.92	<2.5	6.77	<2.5	6.35
copper	<3.38	<3.38	<3.38	<3.38	<3.38	<3.38	<3.38	<3.38	7.82	<3.38	8.31
cyanide	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22
iron	3200.0	3700.0	4500.0	3400.0	2500.0	5600.0	3700.0	3600.0	11000.0	3200.0	7500.0
lead	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
magnesium	1360.0	1310.0	1330.0	1130.0	844.0	3420.0	1080.0	1210.0	1300.0	1110.0	4440.0
manganese	78.3	58.9	253.0	56.7	108.0	320.0	54.9	89.8	460.0	101.0	102.0
mercury	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087
molybdenum	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
nickel	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	13.7	<7.5	15.0
potassium	<142.0	<142.0	<142.0	<142.0	<142.0	<142.0	296.0	<142.0	890.0	<142.0	241.0
selenium	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4
silver	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
sodium	<50.0	677.0	68.3	69.0	64.4	69.7	68.6	71.0	147.0	<50.0	390.0
thallium	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
vanadium	5.48	5.93	4.71	6.23	<2.0	10.1	9.51	4.98	15.3	3.55	11.7
zinc	12.9	13.1	16.2	11.7	8.72	19.4	13.7	12.7	38.6	11.7	36.8
VOCs	—	—	—	—	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—
Pesticides/PCBs	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
herbicides	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—

values in μg/g '—' not analyzed VOCs - volatile organic compounds SVOCs - semivolatile organic compounds TPH - total petroleum hydrocarbons
Data set from Operable Unit 2 Feasibility Study Sampling Effort (October 1992) nd - no compounds detected for entire analytical group

Table B-4. Summary of Analytical Results of Detected Substances in Marsden Lake and Pond G Sediments (0-1 ft depth)

	Marsden Lake Samples					Pond G Sample
Substance	M01	M03	M04	M05.a	M05.b	G03
aluminum	12700.0	6530.0	9100.0	8590.0	7040.0	12000.0
antimony	<82.9	<82.9	<82.9	<82.9	<82.9	<82.9
arsenic	<12.7	<12.7	<12.7	<12.7	<12.7	<12.7
barium	239.0	140.0	132.0	202.0	159.0	266.0
beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
cadmium	<0.427	<0.427	<0.427	<0.427	<0.427	<0.427
calcium	8790.0	6350.0	2020.0	10000.0	9350.0	4010.0
chromium	22.8	9.46	17.9	14.4	12.8	25.4
cobalt	<2.5	<2.5	14.9	18.4	14.9	16.8
copper	37.1	<3.38	20.0	17.4	14.9	39.4
cyanide	<1.22	<1.22	<1.22	<1.22	<1.22	<1.22
iron	16000.0	13000.0	14000.0	18000.0	16000.0	16000.0
lead	131.0	<10.0	27.1	<10.0	<10.0	84.8
magnesium	3770.0	1920.0	2250.0	3150.0	2960.0	2790.0
manganese	385.0	426.0	273.0	703.0	930.0	640.0
mercury	<0.087	<0.087	<0.087	<0.087	<0.087	<0.087
molybdenum	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
nickel	<7.5	<7.5	16.4	<7.5	<7.5	24.9
potassium	1060.0	<142.0	503.0	718.0	<142.0	1470.0
selenium	<12.4	<12.4	<12.4	<12.4	<12.4	<12.4
silver	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
sodium	337.0	<50.0	121.0	201.0	<50.0	154.0
thallium	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
vanadium	45.5	21.7	32.9	34.1	32.7	43.2
zinc	171.0	39.5	56.8	132.0	141.0	138.0
VOCs	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—
PCB 1254	<0.04	<0.04	<0.04	<0.04	<0.04	1.55
PCB 1248	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
p,p-DDD	0.129	0.094	0.27	0.12	<0.011	1.00
p,p-DDE	<0.014	<0.014	0.17	<0.014	<0.014	0.12
p,p-DDT	<0.01	<0.01	<0.01	0.07	<0.01	0.31
herbicides	—	—	—	—	—	—
TPH	—	—	—	—	—	—
explosives	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—

values in $\mu g/g$ '—' not analyzed VOCs-volatile organic compounds SVOCs-semivolatile organic compoundsTPH-total petroleum hydrocarbons.
Data set from Operable Unit 2 Feasibility Study Sampling Effort (October 1992)

Table B-5. Summary of Analytical Results in Area B Wetland Sediments

	Operable Unit 2 Feasibility Study Samples (μg/g)			MPCA Samples (μg/g)		
Substance	B01SE	B02SE	B03SE	B10SE	B11SE	B12SE
aluminum	3650.0	18000.0	4470.0	5200.0	7100.0	3700.0
antimony	<82.9	<82.9	<82.9	<50	<50	<50
arsenic	<12.7	<12.7	<12.7	5.0	11.0	5.0
barium	39.8	269.0	68.0	51.0	92.0	43.0
beryllium	<0.25	1.33	<0.25	<0.5	0.6	<0.5
cadmium	<0.427	<0.427	<0.427	<0.6	<0.6	<0.6
calcium	14000.0	8990.0	9600.0	—	—	—
chromium	9.59	35.2	17.6	8.1	10.0	5.7
cobalt	7.99	25.2	8.6	3.6	5.6	3.1
copper	7.89	34.9	8.84	12.0	15.0	7.9
cyanide	<1.22	<1.22	<1.22	—	—	—
iron	8400.0	26000.0	9500.0	—	—	—
lead	<10.0	31.2	<10.0	5.4	14.0	6.7
magnesium	6370.0	6130.0	4690.0	—	—	—
manganese	156.0	403.0	128.0	120.0	100.0	87.0
mercury	<0.087	<0.087	<0.087	<0.01	0.02	<0.01
molybdenum	<4.0	<4.0	<4.0	—	—	—
nickel	14.5	33.8	15.1	9.9	13.0	8.3
potassium	450.0	2010.0	631.0	—	—	—
selenium	<12.4	<12.4	<12.4	<0.25	0.29	<0.25
silver	<0.5	<0.5	<0.5	<1.2	<1.2	<1.2
sodium	86.2	161.0	92.1	—	—	—
thallium	<12.5	<12.5	<12.5	<10	<10	<10
vanadium	20.3	58.6	24.3	18.0	21.0	15.0
zinc	31.0	126.0	40.7	27.0	46.0	23.0
volatile organics (VOCs)	—	—	—	—	—	—
semivolatile organics (SVOCs)	—	—	—	<0.33-1.6	<0.33-1.6	<0.33-1.6
herbicides	—	—	—	—	—	—
total petroluem hydrocarb..ns	—	—	—	—	—	—
explosives	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—
deldrin	0.016	<0.008	<0.008	—	<0.1	<0.1
PCB 1254	R <0.04	R 0.193	R <0.04	—	<1.0	<1.0
p,p-DDD	3.9	0.168	<0.011	—	<0.1	0.6
p,p-DDE	0.29	<0.014	<0.014	—	<0.1	<0.1
p,p-DDT	0.77	0.036	<0.01	<0.1	<0.1	<0.1

'R' - this flag represents values which has been deemed unusable due to poor data quality.
'—' - sample was not analyzed for the substance. MPCA analytical scan included other pesticides and PCB congeners. However, no additional detections occurred.

Table B-6a. Summary of Analytical Results for Round Lake Surface Water

	October 1992 Data											
Substance	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.a	RL09.b	RL10	RL11
aluminum	<107.0	<107.0	132.0	<107.0	116.0	127.0	<107.0	<107.0	<107.0	<107.0	153.0	<107.0
antimony	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1
arsenic	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
barium	44.4	41.3	40.3	40.3	40.3	36.3	40.3	39.3	37.3	38.3	40.3	<20.0
beryllium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
calcium	34800.0	32100.0	30900.0	30300.0	31200.0	30000.0	29100.0	30900.0	30500.0	31100.0	31700.0	3430.0
cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chromium	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0
cobalt	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
copper	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
cyanide	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2
iron	571.0	259.0	213.0	<120.0	282.0	175.0	<120.0	<120.0	158.0	144	252.0	<120.0
lead	M <1.3	M 3.85	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3	M <1.3
magnesium	10200.0	9650.0	9550.0	9480.0	9550.0	9270.0	9330.0	9230.0	9480.0	9450.0	9410.0	<500.0
manganese	43.2	32.1	49.2	28.1	46.2	30.1	32.1	28.1	34.1	35.1	38.2	19.1
mercury	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	2.1	<0.74	<0.74	<0.74	<0.74	<0.74
molybdenum	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9
nickel	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1
potassium	2370.0	2390.0	2470.0	2290.0	2250.0	2310.0	2370.0	2250.0	2230.0	2340.0	2290.0	<1250.0
selenium	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9
silver	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
sodium	33700.0	32000.0	32000.0	32000.0	32300.0	31500.0	31600.0	32100.0	31500.0	31200.0	31400.0	<500.0
thallium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
vanadium	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
zinc	542.0	609.0	624.0	647.0	522.0	546.0	413.0	621.0	497.0	557.0	598.0	436.0
VOCs	—	—	—	—	—	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—
Pest./PCBs	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

values in $\mu g/l$ '—' analytes not analyzed VOCs - volatile organic compounds
SVOCs - semivolatile compounds
TPH - total petroleum hydrocarbons. Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met.. The 'nd' denotes that no compounds were detected for the entire analytical group.

Table B-6b. Summary of Analytical Results for Round Lake Surface Water

	October 1992 Data										June 1993 Data	
Substance	RL12	RL13	RL14	RL15	RL16.a	RL16.b	RL17	RL18	RL19	RL20	RL101	RL102
aluminum	<107.0	154.0	<107.0	<107.0	<107.0	<107.0	150.0	<107.0	<107.0	<107.0	<141.0	<141.0
antimony	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<3.0	<3.0
arsenic	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<2.5	<2.5
barium	37.3	41.3	42.3	39.3	39.3	44.4	42.3	46.4	40.3	43.3	78.4	23.1
beryllium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<5.0
calcium	30800.0	32500.0	32400.0	31000.0	31300.0	32700.0	31600.0	31700.0	32800.0	33300.0	97800.0	22500.0
cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<4.0	<4.0
chromium	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<6.0	<6.0
cobalt	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
copper	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<8.1	<8.1
cyanide	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	—	—
iron	<120.0	174.0	134.0	<120.0	<120.0	<120.0	142.0	<120.0	<120.0	<120.0	893.0	160.0
lead	M 2.5	M <1.3	M <1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
magnesium	9320.0	9400.0	9480.0	9370.0	9420.0	9950.0	9330.0	9920.0	9890.0	9910.0	23700.0	9130.0
manganese	26.1	38.2	34.1	28.1	31.1	31.1	34.1	28.1	27.1	17.1	285.0	31.8
mercury	<0.74	<0.74	1.17	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.24	<0.24
molybdenum	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	<30.9	—	—
nickel	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<34.3	<34.3
potassium	2290.0	2340.0	2250.0	2370.0	2200.0	2410.0	2310.0	2410.0	2410.0	2360.0	2110.0	1290.0
selenium	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<3.0	<3.0
silver	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<4.6	<4.6
sodium	32200.0	31500.0	31300.0	31800.0	32100.0	33700.0	32900.0	33400.0	33400.0	32700.0	72300.0	32600.0
thallium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<7.0	<7.0
vanadium	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<11.0	<11.0
zinc	592.0	815.0	507.0	540.0	490.0	693.0	653.0	427.0	625.0	743.0	109.0	<21.1
VOCs	—	—	—	—	—	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—
Pest./PCBs	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

values in μg/l '—' analytes not analyzed VOCs - volatile organic compounds
SVOCs - semivolatile compounds
TPH - total petroleum hydrocarbons. Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met.. The 'nd' denotes that no compounds were detected for the entire analytical group.

Table B-7. Summary of Analytical Results for Sunfish Lake Surface Water

Substance	October 1992 Data											June 1993 Data	
	SFL01	SFL02	SFL03	SFL04	SFL05	SFL06.a	SFL06.b	SFL07	SFL08	SFL09	SFL10	SFL101	SFL102
aluminum	139.0	133.0	129.0	129.0	121.0	126.0	161.0	126.0	483.0	936.0	1070.0	<141.0	<141.0
antimony	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<3.0	<3.0
arsenic	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<2.5	<2.5
barium	27.2	27.2	31.3	33.3	32.3	27.2	34.3	30.2	43.3	58.5	49.4	16.3	14.3
beryllium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<5.0
calcium	13600.0	13900.0	14600.0	15100.0	14500.0	14500.0	15700.0	14300.0	16500.0	20000.0	186000.0	15500.0	15300.0
cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<4.0	<4.0
chromium	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<6.0	<6.0
cobalt	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
copper	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<8.1	<8.1
cyanide	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	—	—
iron	331.0	527.0	333.0	326.0	371.0	344.0	403.0	345.0	1540.0	4200.0	2740.0	168.0	180.0
lead	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	2.5	1.9	1.99	<1.3	<1.3
magnesium	2990.0	3070.0	3370.0	3410.0	3440.0	3370.0	3740.0	3280.0	3830.0	5020.0	4360.0	4190.0	4110.0
manganese	23.1	27.1	29.10	30.1	30.1	30.1	33.1	30.1	473.0	990.0	416.0	19.8	20.9
mercury	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.24	<0.24
molybdenum	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	—	—
nickel	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<34.3	<34.3
potassium	1460.0	1550.0	1650.0	1680.0	1650.0	1720.0	1750.0	1500.0	1870.0	2050.0	1960.0	<375.0	<375.0
selenium	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<3.0	<3.0
silver	<12.5	<12.5	<12.5	<12.5	<12.5	24.0	<12.5	<12.5	<12.5	<12.5	<12.5	<4.6	<4.6
sodium	11000.0	11200.0	12100.0	12300.0	12400.0	12400.0	13500.0	11900.0	12800.0	12900.0	12100.0	15800.0	15700.0
thallium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<7.0	<7.0
vanadium	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<11.0	<11.0
zinc	262.0	303.0	250.0	286.0	221.0	253.0	199.0	269.0	286.0	263.0	329.0	<21.1	<21.1
VOCs	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—	—
heptachlor epoxide	<0.006	<0.006	<0.006	<0.006	<0.006	0.013	D <0.006	0.011	<0.006	<0.006	<0.006	—	—

values in μg/l   '—' analytes not analyzed   VOCs - volatile organic compounds   SVOCs - semivolatile compounds
TPH - total petroleum hydrocarbons. Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met.. The 'nd' denotes that no compounds were detected for the entire analytical group. The 'D' denotes sample was diluted.

Table B-8. Summary of Analytical Results for Rice Creek Surface Water

	October 1992 Data											June 1993 Data	
Substance	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06	RCK07	RCK08.a	RCK08.b	RCK09	RCK10	RCK101	RCK102
aluminum	117.0	111.0	112.0	150.0	139.0	<107.0	<107.0	<107.0	114.0	<107.0	190.0	<141.0	<141.0
antimony	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<37.1	<3.0	<3.0
arsenic	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<2.5	<2.5
barium	76.6	74.6	72.6	33.3	32.3	75.6	73.6	74.6	78.6	77.6	76.6	66.2	64.1
beryllium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<5.0
calcium	46900.0	49000.0	48200.0	50000.0	49000.0	49000.0	48200.0	48400.0	52000.0	48000.0	50000.0	47100.0	45800.0
cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<4.0	<4.0
chromium	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<6.0	<6.0
cobalt	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
copper	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<8.1	<8.1
cyanide	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	<8.2	—	—
iron	571.0	603.0	586.0	639.0	746.0	765.0	639.0	620.0	683.0	596.0	1230.0	568.0	546.0
lead	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	M <1.3	M <1.3	M <1.3	M <1.3	1.4	<1.3
magnesium	13900.0	14100.0	14400.0	14300.0	14400.0	14200.0	14200.0	13900.0	14800.0	14200.0	14400.0	12700.0	12400.0
manganese	158.0	161.0	159.0	157.0	195.0	200.0	199.0	191.0	210.0	191.0	246.0	181.0	175.0
mercury	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	D <0.74	<0.74	<0.74	<0.24	<0.24
molybdenum	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	<31.0	—	—
nickel	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<63.1	<34.3	<34.3
potassium	2240.0	2420.0	2390.0	2260.0	2330.0	2150.0	2330.0	2180.0	2510.0	2360.0	2300.0	2280.0	2190.0
selenium	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<14.9	<3.0	<3.0
silver	<12.5	<12.5	<12.5	51.9	<12.5	24.0	<12.5	<12.5	<12.5	<12.5	<12.5	<4.6	<4.6
sodium	12100.0	12700.0	13900.0	13500.0	14200.0	13700.0	14200.0	14400.0	15000.0	14700.0	15100.0	11400.0	11300.0
thallium	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<7.0	<7.0
vanadium	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<11.0	<11.0
zinc	287.0	365.0	306.0	440.0	371.0	355.0	302.0	322.0	535.0	340.0	406.0	<21.1	<21.1
VOCs	—	—	—	—	—	—	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—	—	—	—	—	—	—
heptachlor epoxide	0.007	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	D <0.006	<0.006	<0.006	—	—

values in $\mu g/l$ '—' analytes not analyzed VOCs - volatile organic compounds SVOCs - semivolatile compounds
TPH - total petroleum hydrocarbons. Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met.. The 'nd' denotes that no compounds were detected for the entire analytical group. The 'D' denotes sample was diluted.

Table B-9. Summary of Analytical Results for Marsden Lake and Pond G Surface Water

	October 1992 Data				June 1993 Data		Pond G
Substance	ML01	ML02	ML03	ML04	ML101	ML102	G03
aluminum	28300.0	479.0	<107.0	<107.0	<141.0	166.0	156.0
antimony	<37.1	<37.1	<37.1	<37.1	<3.0	<3.0	<37.1
arsenic	<6.0	<6.0	<6.0	<6.0	<2.5	<2.5	<6.0
barium	1530.0	48.4	47.4	95.8	32.6	29.7	37.3
beryllium	3.2	<2.5	<2.5	<2.5	<5.0	<5.0	<2.5
calcium	93000.0	24000.0	30300.0	46300.0	16800.0	22700.0	12700.0
cadmium	<5.0	<5.0	<5.0	<5.0	<4.0	<4.0	<5.0
chromium	45.8	<15.0	<15.0	<15.0	<6.0	<6.0	<15.0
cobalt	75.1	<25.0	<25.0	31.4	<25.0	<25.0	<25.0
copper	73.3	<20.0	<20.0	<20.0	<8.1	<8.1	<20.0
cyanide	<8.2	<8.2	<8.2	<8.2	—	—	<8.2
iron	280000.0	2740.0	397.0	40000.0	1220.0	1790.0	1770.0
lead	23.4	2.1	<1.3	<1.3	<1.3	<1.3	<1.3
magnesium	19700.0	6230.0	7540.0	17900.0	4750.0	5480.0	3380.0
manganese	3600.0	344.0	40.2	3700.0	167.0	279.0	113.0
mercury	<0.74	<0.74	<0.74	<0.74	<0.24	<0.24	<0.74
molybdenum	<30.9	<30.9	<30.9	<30.9	—	—	<30.9
nickel	71.8	<63.1	<63.1	<63.1	<34.3	<34.3	<63.1
potassium	4100.0	1500.0	<1250.0	<1250.0	1320.0	1770.0	5210.0
selenium	<14.9	<14.9	<14.9	<14.9	<3.0	<3.0	<14.9
silver	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5
sodium	15000.0	8930.0	12200.0	3710.0	3710.0	10200.0	1690.0
thallium	<2.5	<2.5	<2.5	<2.5	<7.0	<7.0	<2.5
vanadium	110.0	<20.0	<20.0	<20.0	<11.0	<11.0	<20.0
zinc	712.0	320.0	348.0	312.0	<21.1	<21.1	190.0
VOCs	—	—	—	—	—	—	—
SVOCs	—	—	—	—	—	—	—
herbicides	—	—	—	—	—	—	—
TPH	—	—	—	—	—	—	—
explosives	—	—	—	—	—	—	—
dioxins/furans	—	—	—	—	—	—	—
Pesticides/PCBs	nd	nd	nd	nd	nd	nd	nd

values in μg/l '—' analytes not analyzed VOCs - volatile organic compounds

SVOCs - semivolatile compounds TPH - total petroleum hydrocarbons. Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met.. The 'nd' denotes that no compounds were detected for the entire analytical group. The 'D' denotes sample was diluted.

Table B-10. Summary of Analytical Results for Area B Wetlands Surface Water

Substance	B01	B02	B03.a	B03.b
aluminum	1660.0	296.0	631.0	563.0 D
antimony	<37.1	<37.1	<37.1	<37.1 D
arsenic	<6.0	<6.0	<6.0	<6.0
barium	115.0	69.9	101.0	89.7 D
beryllium	<2.5	<2.5	<2.5	<2.5 D
calcium	55000.0	51000.0	61000.0	57000.0 D
cadmium	<5.0	<5.0	<5.0	<5.0 D
chromium	<15.0	<15.0	<15.0	<15.0 D
cobalt	<25.0	<25.0	<25.0	<25.0 D
copper	<20.0	<20.0	<20.0	<20.0 D
cyanide	<8.2	<8.2	<8.2	<8.2 D
iron	7670.0	1490.0	5410.0	6750.0 D
lead	2.22	<1.3	<1.3	1.4
magnesium	15200.0	13500.0	13800.0	13600.0 D
manganese	1550.0	696.0	947.0	915.0 D
mercury	<0.74	<0.74	<0.74	<0.74 D
molybdenum	<30.1	<30.1	<30.1	<30.9 D
nickel	<63.1	<63.1	<63.1	<63.1 D
potassium	10700.0	1940.0	5390.0	5240.0 D
selenium	<14.9	<14.9	<14.9	< 14.9
silver	<12.5	<12.5	<12.5	<12.5 D
sodium	3020.0	2760.0	2870.0	2780.0 D
thallium	<2.5	<2.5	<2.5	<2.5 D
vanadium	<20.0	<20.0	<20.0	<20.0 D
zinc	235.0	218.0	229.0	211.0 D
VOCs	—	—	—	—
SVOCs	—	—	—	—
herbicides	—	—	—	—
TPH	—	—	—	—
explosives	—	—	—	—
dioxins/furans	—	—	—	—
Pesticides/PCBs	nd	nd	nd	nd

values in μg/l '—' analytes not analyzed VOCs - volatile organic compounds
SVOCs - semivolatile compounds TPH - total petroleum hydrocarbons.
Data set from Operable Unit 2 Feasibility Study Sampling Effort (1992-1993). The 'M' denotes that the duplicate injection precision criteria was not met. The 'nd' denotes that no compounds were detected for the entire analytical group. The 'D' denotes sample was diluted.

Table B-11. Summary of Relevent 1994 Annual Monitoring Report Data for Round Lake Surface Waters (μg/L)

	Sample Date and Lab ID # from Monitoring Location 20500*				
Substance	11 Nov 93 1699-01 & -03	9 Feb 94 2288-01	10 Mar 94 2465-03	9 May 94 2872-01 & -05	25 Aug 94 3750-01 & -03
PCB 1016	—	—	—	<1.00	—
PCB 1232	—	—	—	<0.10	—
PCB 1242	—	—	—	<0.10	—
PCB 1248	—	—	—	<0.10	—
PCB 1254	—	—	—	<0.10	—
PCB 1260	—	—	—	<0.10	—
trichloroethene	<1.04	—	<1.04	<1.04	<1.04
1,1-dichloroethene	<1.01	—	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	—	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	—	<0.97	<0.97	<0.97
methylene chloride	<1.41	—	<1.41	<1.41	<1.41
silver	—	—	—	<1.93	—
cadmium	0.14	0.10	—	0.29	<0.10
chromium	<2.18	7.42	—	<2.18	3.62
copper	5.41	8.23	—	4.26	31.0
nickel	<5.94	<5.94	—	<5.94	13.4
lead	—	—	—	<2.65	—
mercury	—	—	—	<0.70	—
cyanide	<8.35	<8.35	—	<5.00	<8.35
zinc	35.10	100.0	—	114.0	88.2

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-12a. Summary of Relevent 1994 Annual Monitoring Report Data for Rice Creek Surface Waters ($\mu g/L$)

	Sample Date and Lab ID #															
	Monitoring Location 20700						Monitoring Location 21100					Monitoring Location 20200*				
Substance	11/11/93 1699-01 1699-08	10/02/94 NC	10/03/94 2465-10	3/05/94 2850-01	12/05/94 2900-01 2900-02	25/08/94 3750-01 3750-08	11/11/93 1699-01 1699-09	10/02/94 NC	10/03/94 2465-09	12/05/94 2900-01 2900-07	25/08/94 3750-01 3750-09	11/11/93 1699-01 1699-11	10/02/94 NC	10/03/94 2465-05	12/05/94 2900-01 2900-09	25/08/94 3750-01 3750-10
PCB 1016	—	—	—	—	<1.00	—	—	—	—	<1.00	<1.00	—	—	—	<1.00	—
PCB 1232	—	—	—	—	<0.10	—	—	—	—	<0.10	<0.10	—	—	—	<0.10	—
PCB 1242	—	—	—	—	<0.10	—	—	—	—	<0.10	<0.10	—	—	—	<0.10	—
PCB 1248	—	—	—	—	<0.10	—	—	—	—	<0.10	<0.10	—	—	—	<0.10	—
PCB 1254	—	—	—	—	<0.10	—	—	—	—	<0.10	<0.10	—	—	—	<0.10	—
PCB 1260	—	—	—	—	<0.10	—	—	—	—	<0.10	<0.10	—	—	—	<0.10	—
trichloroethene	<1.04	—	<1.04	<1.04	<1.04	<1.04	<1.04	—	<1.04	<1.04	<1.04	32.00	—	3.26	<1.04	5.57
1,1-dichloroethene	<1.01	—	<1.01	<1.01	<1.01	<1.01	<1.01	—	<1.01	<1.01	<1.01	<1.01	—	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	—	<1.16	<1.16	<1.16	<1.16	<1.16	—	<1.16	<1.16	<1.16	<1.16	—	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	—	<0.97	<0.97	<0.97	<0.97	<0.97	—	<0.97	<0.97	<0.97	<0.97	—	<0.97	<0.97	<0.97
methylene chloride	<1.41	—	<1.41	<1.41	<1.41	21.0	<1.41	—	<1.41	<1.41	20.4	<1.41	—	<1.41	<1.41	4.82
silver	—	—	—	—	<1.93	—	—	—	—	<1.93	—	—	—	—	<1.93	—
cadmium	<0.10	0.10	—	—	<0.10	<0.10	<0.10	0.58	—	<0.10	<0.10	<0.10	0.39	—	<0.10	<0.10
chromium	<2.18	<2.18	—	—	<2.18	2.37	<2.18	<2.18	—	<2.18	2.86	<2.18	<2.18	—	<2.18	<2.18
copper	<0.50	3.81	—	—	<0.50	6.17	2.51	8.22	—	<0.50	9.90	2.75	3.21	—	1.98	11.10
nickel	<5.94	<5.94	—	—	<5.94	<5.94	<5.94	<5.94	—	<5.94	<5.94	<5.94	<5.94	—	<5.94	7.02
lead	—	—	—	—	<2.65	—	—	—	—	<2.65	—	—	—	—	<2.65	—
mercury	—	—	—	—	<0.70	—	—	—	—	<0.70	—	—	—	—	<0.70	—
cyanide	<8.35	<8.35	—	—	<5.0	<8.35	<8.35	<8.35	—	<8.35	<8.35	<8.35	<8.35	—	<5.00	<8.35
zinc	<29.40	<29.40	—	—	33.10	70.10	<29.40	100.00	—	37.1	62.10	<29.40	30.10	—	40.10	211.00

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-12b. Summary of Relevent 1994 Annual Monitoring Report Data for Rice Creek Surface Waters (μg/L)

	Sample Date and Lab ID #									
	Monitoring Location 20300*					Monitoring Location 20800				
Substance	11/11/93 1699-01 1699-11	10/02/94 NC	10/03/94 2465-06	12/05/94 2900-01 2900-10	25/08/94 3750-01 3750-11	11/11/93 1699-01 1699-05	9/02/94 2288-01	10/03/94 2465-01	9/05/94 2872-01 2872-03	25/08/94 3750-01 3750-05
PCB 1016	—	—	—	<1.00	—	—	—	—	<1.00	—
PCB 1232	—	—	—	<0.10	—	—	—	—	<0.10	—
PCB 1242	—	—	—	<0.10	—	—	—	—	<0.10	—
PCB 1248	—	—	—	<0.10	—	—	—	—	<0.10	—
PCB 1254	—	—	—	<0.10	—	—	—	—	<0.10	—
PCB 1260	—	—	—	<0.10	—	—	—	—	<0.10	—
trichloroethene	<1.04	—	<1.04	<1.04	<1.04	<1.04	—	<1.04	<1.04	<1.04
1,1-dichloroethene	<1.01	—	<1.01	<1.01	<1.01	<1.01	—	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	—	<1.16	<1.16	<1.16	<1.16	—	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	—	<0.97	<0.97	<0.97	<0.97	—	<0.97	<0.97	<0.97
methylene chloride	<1.41	—	<1.41	<1.41	10.00	<1.41	—	<1.41	<1.41	6.50
silver	—	—	—	<1.93	—	—	—	—	<1.93	—
cadmium	<0.10	0.29	—	<0.10	<0.10	0.20	0.29	—	<0.10	<0.10
chromium	4.58	<2.18	—	<2.18	<2.18	<2.18	<2.18	—	<2.18	2.26
copper	<0.50	9.57	—	1.88	8.56	<0.50	2.96	—	1.68	6.00
nickel	<5.94	<5.94	—	<5.94	7.01	<5.94	<5.94	—	<5.94	<5.94
lead	—	—	—	<2.65	—	—	—	—	<2.65	—
mercury	—	—	—	<0.70	—	—	—	—	<0.70	—
cyanide	<8.35	<8.35	—	<5.0	<8.35	<8.35	<8.35	—	<5.00	<8.35
zinc	<29.40	100.00	—	40.10	142.00	<29.40	50.10	—	58.10	48.10

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-13. Summary of Relevant 1994 Annual Monitoring Report Data for Marsden Lake Surface Waters (μg/L)

	Sample Date and Lab ID #							
	Monitoring Location 21400	Monitoring Location 21300	Monitoring Location 21200	Monitoring Location 20100*				
Substance	12/05/94 2900-01 2900-04	12/05/94 2900-01 2900-03	12/05/94 2900-01 2900-04 2900-05	11/11/93 1699-01	10/02/94 NC	10/03/94 2465-04	12/05/94 2900-01 2900-05 2900-06	25/08/94 3750-01 3750-07
PCB 1016	<1.00	<1.00	<1.00	—	—	—	<1.00	—
PCB 1232	<0.10	<0.10	<0.10	—	—	—	<0.10	—
PCB 1242	<0.10	<0.10	<0.10	—	—	—	<0.10	—
PCB 1248	<0.10	<0.10	<0.10	—	—	—	<0.10	—
PCB 1254	<0.10	<0.10	<0.10	—	—	—	<0.10	—
PCB 1260	<0.10	<0.10	<0.10	—	—	—	<0.10	—
trichloroethene	<1.04	<1.04	<1.04	<1.04	—	<1.04	<1.04	<1.04
1,1-dichloroethene	<1.01	<1.01	<1.01	<1.01	—	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	<1.16	<1.16	<1.16	—	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	<0.97	<0.97	<0.97	—	<0.97	<0.97	<0.97
methylene chloride	<1.41	<1.41	<1.41	<1.41	—	<1.41	<1.41	<1.41
silver	<1.93	<1.93	<1.93	—	—	—	<1.93	—
cadmium	0.10	0.19	0.10	<0.10	0.68	—	<0.10	<0.10
chromium	<2.18	<2.18	<2.18	<2.18	<2.18	—	<2.18	2.95
copper	2.08	3.17	1.78	<0.50	2.50	—	1.09	7.85
nickel	<5.94	<5.94	<5.94	<5.94	<5.94	—	<5.94	<5.94
lead	<2.65	<2.65	<2.65	—	—	—	<2.65	—
mercury	<0.70	<0.70	<0.70	—	—	—	<0.70	—
cyanide	<5.00	<5.00	<5.00	<8.35	<8.35	—	<5.00	<8.35
zinc	55.10	50.10	49.10	31.10	40.10	—	45.10	114.00

The '—' denotes that sample was not collected. The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-14. Summary of Relevent 1995 Annual Monitoring Report Data for Round Lake Surface Waters (μg/L)

	Sample Date and Lab ID # from Monitoring Location 20500*			
Substance	8 Nov 94 4332-01 & -03	1 Feb 95 4819-01 & -03	3 May 95 5413-09 & -12	14 Aug 95 6350-01 & -03
PCB 1016	—	—	<0.10	—
PCB 1232	—	—	<0.10	—
PCB 1242	—	—	<0.10	—
PCB 1248	—	—	<0.10	—
PCB 1254	—	—	<0.10	—
PCB 1260	—	—	<0.10	—
trichloroethene	<1.04	<1.04	<1.04	—
1,1-dichloroethene	<1.01	<1.01	<1.01	—
1,1,1-trichloroethane	<1.16	<1.16	<1.16	—
1,1-dichloroethane	<0.97	<0.97	<0.97	—
methylene chloride	<1.41	<1.41	<1.41	—
silver	—	<1.93	2.18	<1.93
cadmium	0.19	0.40	0.18	0.23
chromium	<2.18	<2.18	<2.18	<2.18
copper	9.14	10.00	20.10	4.85
nickel	<5.94	9.16	<5.94	R<5.94
lead	—	<2.65	<2.65	<2.65
mercury	—	<0.70	<0.70	<0.70
cyanide	<8.35	<8.35	<8.35	<8.35
zinc	56.10	174.00	127.00	92.20

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-15a. Summary of Relevent 1995 Annual Monitoring Report Data for Rice Creek Surface Waters (μg/L)

	Sample Date and Lab ID #										
	Monitoring Location 20700				Monitoring Location 21100			Monitoring Location 20200*			
Substance	9/11/94 4343-02	1/02/95 4819-01 4819-08	2/05/95 5413-01 5413-09	14/08/95 6350-01 6350-08	9/11/94 4343-03	2/05/95 5413-05 5413-09	14/08/95 6350-09 6350-01	9/11/94 4343-04	1/02/95 4819-01 4819-09	2/05/95 5413-04 5413-09	14/08/95 6350-01 6350-10
PCB 1016	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
PCB 1232	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
PCB 1242	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
PCB 1248	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
PCB 1254	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
PCB 1260	—	—	<0.10	—	—	<0.10	<0.10	—	—	<0.10	—
trichloroethene	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	5.88	7.16	6.56	3.30
1,1-dichloroethene	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97
methylene chloride	<1.41	<1.41	<1.41	<1.41	2.90	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41
silver	—	<1.93	<1.93	<1.93	—	<1.93	<1.93	—	<1.93	<1.93	<1.93
cadmium	<0.10	0.17	<0.10	0.16	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14
chromium	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
copper	2.41	9.33	6.99	1.88	30.00	5.31	1.29	6.46	14.40	5.41	4.06
nickel	<5.94	<5.94	<5.94	R<5.94	<5.94	<5.94	R9.52	<5.94	<5.94	<5.94	R<5.94
lead	—	—	<2.65	—	—	<2.65	—	—	—	<2.65	—
mercury	—	—	<0.70	—	—	<0.70	—	—	—	<0.70	—
cyanide	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35
zinc	<29.40	<29.40	36.10	<29.40	47.10	34.10	49.10	42.10	<29.40	31.10	<29.40

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-15b. Summary of Relevent 1995 Annual Monitoring Report Data for Rice Creek Surface Waters (μg/L)

	Sample Date and Lab ID #							
	Monitoring Location 20300*				Monitoring Location 20800			
Substance	9/11/94 4343-05	1/02/95 4819-10 4819-01	2/05/95 5413-03 5413-09	14/08/95 6350-11 6350-01	8/11/94 4332-01 4332-05	1/02/95 4819-01 4819-05	3/05/95 5413-13 5413-09	14/08/95 6350-01 6350-05
PCB 1016	—	—	<0.10	—	—	—	<0.10	—
PCB 1232	—	—	<0.10	—	—	—	<0.10	—
PCB 1242	—	—	<0.10	—	—	—	<0.10	—
PCB 1248	—	—	<0.10	—	—	—	<0.10	—
PCB 1254	—	—	<0.10	—	—	—	<0.10	—
PCB 1260	—	—	<0.10	—	—	—	<0.10	—
trichloroethene	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04
1,1-dichloroethene	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01
1,1,1-trichloroethane	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16
1,1-dichloroethane	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97
methylene chloride	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41
silver	—	<1.93	<1.93	<1.93	—	<1.93	<1.93	<1.93
cadmium	<0.10	0.29	<0.10	0.25	<0.10	<0.10	0.10	0.39
chromium	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
copper	8.29	5.96	4.33	3.96	6.25	8.78	3.55	2.38
nickel	<5.94	<5.94	7.46	R<5.94	<5.94	<5.94	<5.94	R<5.94
lead	—	—	<2.65	—	—	—	<2.65	—
mercury	—	—	<0.70	—	—	—	<0.70	—
cyanide	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35
zinc	53.10	<29.40	34.10	<29.40	41.10	<29.40	38.10	96.20

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-16. Summary of Relevant 1995 Annual Monitoring Report Data for Marsden Lake Surface Waters (μg/L)

	Sample Date and Lab ID #						
	Monitoring Location 21400	Monitoring Location 21300	Monitoring Location 21200	Monitoring Location 20100*			
Substance	2/05/95 5413-08 5413-09	2/05/95 5413-07 5413-09	2/05/95 5413-06 5413-09	9/11/94 4343-01	1/02/95 4819-01 4819-07	2/05/95 5413-02 5413-09	14/08/95 6350-01 6350-07
PCB 1016	<0.10	<0.10	<0.10	—	—	<0.10	—
PCB 1232	<0.10	<0.10	<0.10	—	—	<0.10	—
PCB 1242	<0.10	<0.10	<0.10	—	—	<0.10	—
PCB 1248	<0.10	<0.10	<0.10	—	—	<0.10	—
PCB 1254	<0.10	<0.10	<0.10	—	—	<0.10	—
PCB 1260	<0.10	<0.10	<0.10	—	—	<0.10	—
trichloroethene	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	—
1,1-dichloroethene	<1.01	<1.01	<1.01	<1.01	<1.01	<1.01	—
1,1,1-trichloroethane	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	—
1,1-dichloroethane	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	—
methylene chloride	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41	—
silver	<1.93	19.70	28.00	—	—	<1.93	—
cadmium	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	0.13
chromium	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
copper	9.64	6.33	13.70	11.20	7.33	6.89	4.26
nickel	<5.94	6.17	<5.94	<5.94	<5.94	11.60	R7.56
lead	<2.65	<2.65	<2.65	—	<2.65	3.42	3.57
mercury	<0.70	<0.70	<0.70	—	—	<0.70	—
cyanide	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35	<8.35
zinc	46.10	53.10	58.10	35.10	<29.40	49.10	55.10

The '—' denotes that sample was not collected.
The '*' denotes that the location is a NPDES Permit Monitoring Station.

Table B-17. Total Organic Carbon (TOC) Data †

Sample location and number		Collection date	TOC (%)
Round Lake	RL1	16 February 1994	2.4
	RL2	16 February 1994	6.2
	RL3a and RL3b	16 February 1994	16
	RL4a and RL4b	16 February 1994	18
Sunfish Lake	SF2	16 February 1994	9.8
Marsden Lake	Marsden 1	17 February 1994	27
	Marsden 2	17 February 1994	7.8
	Marsden 3	17 February 1994	21
	Marsden 4	16 February 1994	16
Area B wetlands	B10SE	26 January 1994	0.58
	B11SE	26 January 1994	9.9
	B12SE	26 January 1994	2.4

† Data collected and provided by the Minnesota Pollution Control Agency.

APPENDIX C

TIER I RISK ESTIMATES USING WATER AND SEDIMENT SCREENING BENCHMARKS

Table Description page

Hazard Indices for Benthic Organisms

Hazard Indices for Aquatic Organisms (based on OU-2 FS Data and MPCA Data Area B)

Table C-1. Calculated Hazards for Benthic Organisms in Round Lake

Substance	RL02	RL05	RL06	RL07	RL08	RL09	RL10	RL11	RL12	RL13	RL14	RL15	RL16	RL17.a	RL17.b	RL18	RL19	RL20
aluminum	0	0	—	—	0	—	0	0	0	0	—	0	0	0	0	—	—	0
cadmium	0	4.6	0	6.4	0	13	0	0	0	0	8.5	0	0	0	0	19	0	0
chromium	0	2.2	2.5	3.7	0	4.2	0	2.6	2.8	1.5	2.1	0	0	0	0	6.6	5.5	0
cobalt	—	—	—	0	0	—	0	0	0	—	—	0	0	0	0	0	0	0
copper	2.7	33	38	57	8.7	78	1.3	22	25	12	11	0	0	0	3.2	23	20	0
lead	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	9.6	8.3	0
nickel	0	0	0	0	0	2.0	0	0	0	0	0	0	0	0	0	0	0	0
silver	0	0	2.5	87	0	1.1	59	0	0	0	0	0	0	0	0	0	0	0
vanadium	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—
zinc	0	3.5	3.3	5.3	1.0	7.4	0	2.8	3.8	2.2	2.3	0	1.0	0	0	7.2	6.4	0
p,p-DDD	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0
p,p-DDE	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0
p,p-DDT	0	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	0
Additive Hazard Index	2.7	43	46	160	9.7	240	60	27	32	16	24	0	1.0	0	3.2	65	40	0

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-2. Calculated Hazards for Benthic Organisms in Sunfish Lake

Substance	SFL01	SFL02	SFL03	SFL04.a	SFL04.b	SFL05	SFL06	SFL07	SFL08	SFL09.a	SFL09.b	SFL10
aluminum	—	—	—	—	—	—	—	—	0	0	—	0
barium	—	0	0	0	0	0	0	0	0	0	0	0
cadmium	0	0	0	0	0	0	0	0	0	2.5	3.3	0
chromium	8.8	7.2	7.0	3.8	3.6	10	9.6	7.0	1.5	1.6	1.7	1.3
cobalt	—	0	—	—	—	—	—	0	0	—	—	—
copper	5.8	5.4	5.0	4.2	4.1	7.9	5.6	6.6	2.4	2.4	3.0	1.8
lead	6.2	4.1	4.3	3.4	3.5	6.5	4.3	4.6	2.7	2.4	2.7	3.3
silver	0	0	0	2.7	0	0	0	4.8	0	0	0	0
vanadium	—	—	—	—	—	—	—	—	—	—	—	—
zinc	2.7	2.4	2.6	2.0	1.9	2.8	2.8	2.3	0	3.3	4.2	1.9
acetone	0	0	36	36	0	0	0	0	0	0	0	0
methylethyl ketone	0	0	—	—	0	—	0	—	—	—	—	—
Additive Hazard Index	24	19	55	52	13	27	22	25	6.6	12	15	8.3

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-3. Calculated Hazards for Benthic Organisms in Rice Creek

Substance	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.a	RCK06.b	RCK07	RCK08	RCK09	RCK10
cobalt	—	—	—	—	—	—	—	—	0	0	—
vanadium	0	0	0	0	0	0	0	0	—	0	0
Additive Hazard Index	0	0	0	0	0	0	0	0	0	0	0

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-4. Calculated Hazards for Benthic Organisms in Marsden Lake and Pond G

	Marsden Lake Samples					Pond G Sample
Substance	M01	M03	M04	M05.a	M05.b	G03
aluminum	—	0	0	0	0	—
barium	—	0	0	0	0	—
chromium	0	0	0	0	0	0
cobalt	0	0	—	—	—	—
copper	2.3	0	0	0	0	2.5
lead	4.2	0	0	0	0	2.7
vanadium	—	—	—	—	—	—
zinc	1.4	0	0	1.1	1.2	1.2
PCB 1254	0	0	0	0	0	26
p,p-DDD	16	12	34	15	0	125
p,p-DDE	0	0	34	0	0	24
p,p-DDT	0	0	0	10	0	44
Additive Hazard Index	24	12	69	27	1.2	225

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-5. Calculated Hazards for Benthic Organisms in Area B Wetlands

	OU 2 Feasibility Study Data			MPCA Data		
Substance	B01	B02	B03	B10	B11	B12
aluminum	0	—	0	0	0	0
arsenic	0	0	0	0	1.8	0
barium	0	—	0	0	0	0
beryllium	0	—	0	0	0	0
chromium	0	1.4	0	0	0	0
cobalt	—	—	—	—	—	—
copper	0	2.2	0	0	0	0
mercury	0	0	0	0	0	0
nickel	0	2.1	0	0	0	0
vanadium	—	—	—	—	—	—
zinc	0	1.1	0	0	0	0
p,p-DDD	488	21	0	na	0	75
p,p-DDE	58	0	0	na	0	0
p,p-DDT	110	5.1	0	0	0	0
Additive Hazard Index	656	33	0	0	1.8	75

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The '—' denotes a potential hazard, however no toxicological screening benchmark is available. The 'na' denotes that this analyte was not analyzed for in sample.

Table C-6a. Calculated Hazards for Aquatic Organisms in Round Lake

	October 1992 Data											
Substance	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.a	RL09.b	RL10	RL11
aluminum	0	0	1.1	0	0	1	0	0	0	0	1.2	0
barium	12	11	11	11	11	9.6	11	10	9.8	10	11	0
lead	0	1.4	0	0	0	0	0	0	0	0	0	0
magnesium	0	0	0	0	0	0	0	0	0	0	0	0
manganese	0	0	0	0	0	0	0	0	0	0	0	0
mercury	0	0	0	0	0	0	300	0	0	0	0	0
zinc	5.4	6	6.2	6.4	5.2	5.4	4.1	6.1	4.9	5.5	5.9	4.3
Additive Hazard Index	17	18	18	17	16	16	314	16	15	16	18	4.0

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead and zinc are normalized to hardness of 94 mg/L $CaCO_3$. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-6b. Calculated Hazards for Aquatic Organisms in Round Lake

	October 1992 Data										June 1993 Data	
Substance	RL12	RL13	RL14	RL15	RL16.a	RL16.b	RL17	RL18	RL19	RL20	RL101	RL102
aluminum	0	1.2	0	0	0	0	1.2	0	0	0	0	0
barium	9.8	11	11	11	11	12	11	12	11	11	21	6.1
lead	0	0	0	0	0	0	0	0	0	0	0	0
magnesium	0	0	0	0	0	0	0	0	0	0	0	0
manganese	0	0	0	0	0	0	0	0	0	0	0	0
mercury	0	0	167	0	0	0	0	0	0	0	0	0
zinc	5.9	8.1	5	5.3	4.9	6.9	6.5	4.2	6.2	7.4	0*	0*
Additive Hazard Index	16	19	190	15	16	19	19	16	16	17	21	6

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead and zinc are normalized to hardness of 94 mg/L $CaCO_3$. The '—' denotes a potential hazard, however no toxicological screening benchmark is available. The '*' denotes that the zinc benchmark was normalized to a hardness of 338 mg/L.

Table C-7. Calculated Hazards for Aquatic Organisms in Sunfish Lake

	October 1992 Data											June 1993 Data	
Substance	SFL01	SFL02	SFL03	SFL04	SFL05	SFL06.a	SFL06.b	SFL07	SFL08	SFL09	SFL10	SFL101	SFL102
aluminum	1.1	1.1	1	1	0	1	1.3	1	3.9	7.5	8.6	0	0
barium	7.2	7.2	8.2	8.8	8.5	7.2	9.0	7.9	11	15	13	0	0
lead	0	0	0	0	0	0	0	0	1.7	1.3	1.3	0	0
magnesium	0	0	0	0	0	0	0	0	0	0	0	0	0
manganese	0	0	0	0	0	0	0	0	0	2	0	0	0
silver	0	0	0	0	0	24	0	0	0	0	0	0	0
zinc	4.1	4.7	3.9	4.5	3.5	4.0	3.1	4.2	4.5	4.1	5.2	0	0
h. epoxide	0	0	0	0	0	26	0	22	0	0	0	0	0
Additive Hazard Index	12	13	13	15	12	62	14	35	21	28	28	0	0

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead, nickel and zinc are normalized to hardness of 55 mg/L $CaCO_3$. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-8. Calculated Hazards for Aquatic Organisms in Rice Creek

	October 1992 Data											June 1993 Data	
Substance	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06	RCK07	RCK08.a	RCK08.b	RCK09	RCK10	RCK101	RCK102
aluminum	0	0	0	1.2	1.1	0	0	0	0	0	1.5	0	0
barium	20	20	19	8.8	8.5	20	19	20	21	20	20	17	17
lead	0	0	0	0	0	0	0	0	0	0	0	0	0
magnesium	0	0	0	0	0	0	0	0	0	0	0	0	0
manganese	0	0	0	0	0	0	0	0	0	0	0	0	0
silver	0	0	0	52	0	24	0	0	0	0	0	0	0
zinc	1.7	2.4	2.0	2.9	2.4	2.3	2.0	2.1	3.5	2.2	2.6	0	0
h. epoxide	14	0	0	0	0	0	0	0	0	0	0	na	na
Additive Hazard Index	36	22	21	65	12	46	21	22	24	22	25	17	17

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead, nickel and zinc are normalized to hardness of 155 mg/L $CaCO_3$. The '—' denotes a potential hazard, however no toxicological screening benchmark is available. The 'na' denotes that the analytee was not analyzed in sample.

Table C-9. Calculated Hazards for Aquatic Organisms in Marsden Lake and Pond G

	October 1992 Data				June 1993 Data		Pond G
Substance	ML01	ML02	ML03	ML04	ML101	ML102	G03
aluminum	226	3.8	0	0	0	1.3	1.2
barium	403	13	12	25	8.6	7.8	9.8
lead	12	1.0	0	0	0	0	0
magnesium	0	0	0	0	0	0	0
manganese	7.3	0	0	7.5	0	0	0
nickel	0	0	0	0	0	0	0
zinc	9.1	4.1	4.4	4.0	0	0	2.4
Additive Hazard Index	657	22	16	37	9	9	14

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead, nickel and zinc are normalized to a hardness of 70 and 62 mg/L CaCQ(for Marsden Lake and Pond G, respectively). The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

Table C-10. Calculated Hazards for Aquatic Organisms in Area B Wetlands

Substance	B01	B02	B03.a	B03.b
aluminum	13	2.4	5.0	4.5
barium	30	18	27	24
lead	1.3	0	0	0
magnesium	0	0	0	0
manganese	3.2	1.4	1.9	1.9
zinc	3.4	3.2	3.3	3.1
Additive Hazard Index	51	25	37	34

All values are hazard quotients (HQs), unles otherwise indicated, and equal zero if site concentration is less than screening benchmark or less than the detection limit. The hazards for lead, nickel and zinc are normalized to a hardness of 62 mg/L CaCQ. The '—' denotes a potential hazard, however no toxicological screening benchmark is available.

APPENDIX D

HAZARD INDICES FOR WILDLIFE

Table Description page

Where pesticides significantly increased the risk estimate, the HIs due to pesticide exposures have been seperated from the rest of the risk for comparison purposes.

TABLE D-1a
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Round Lake

Sample Locations	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.A	RL09.B	RL10
Silver	na	0	na	na	0	*	*	0	*	*	*
Aluminum	na	*	na	na	*	*	*	*	*	*	*
Barium	na	*	na	na	*	*	*	*	*	*	*
Cadmium	na	0	na	na	0	0	0	0	0	0	0
Cobalt	na	0	na	na	0	0	0	0	0	0	0
Chromium	na	*	na	na	*	*	*	*	*	*	*
Copper	na	*	na	na	*	*	*	*	*	*	*
Magnesium	na	--	na	na	--	--	--	--	--	--	--
Manganese	na	--	na	na	--	--	--	--	--	--	--
Nickel	na	0	na	na	0	0	0	0	*	*	0
Lead	na	7.7E-06	na	na	0	0	0	0	0	0	0
Vanadium	na	*	na	na	*	*	*	*	*	*	*
Zinc	na	*	na	na	*	*	*	*	*	*	*
Mercury	na	0	na	na	0	0	*	0	0	0	0
p,p - DDD	na	0	na	na	0	0	0	0	0	0	0
p,p - DDE	na	0	na	na	0	0	0	0	*	*	0
p,p - DDT	na	0	na	na	0	0	0	0	0	0	0
HI	na	8E-06	na	na	0	0	0	0	0	0	0
(weight of evidence)	na	c	na	na	c	c	c	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-1b
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Round Lake

Sample Locations	**RL11**	**RL12**	**RL13**	**RL14**	**RL15**	**RL16.A**	**RL16.B**	**RL17.A**	**RL17.B**	**RL18**	**RL19**	**RL20**
Silver	0	0	0	0	0	0	0	0	0	0	0	0
Aluminum	*	*	*	*	*	*	*	*	*	*	*	*
Barium	*	*	*	*	*	*	*	*	*	*	*	*
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0	0	0
Chromium	*	*	*	*	*	0	0	*	*	*	*	*
Copper	*	*	*	*	0	0	0	0	*	*	*	0
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	**4.9E-06**	0	0	0	0	0	0	0	0	0	0
Vanadium	*	*	*	*	*	*	*	*	*	0	0	*
Zinc	*	*	*	*	*	*	*	*	*	*	*	*
Mercury	0	0	0	*	0	0	0	0	0	0	0	0
p,p - DDD	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDE	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDT	0	0	0	0	0	0	0	0	0	0	0	0
HI	0	**5E-06**	0	0	0	0	0	0	0	0	0	0
(weight of evidence)	c	c	c	c	c	c	c	c	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-2a
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Round Lake

Sample Locations	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.A	RL09.B	RL10
Silver	na	0	na	na	0	*	*	0	*	*	*
Aluminum	na	0.38	na	na	0.59	0.87	0.74	0.18	0.77	0.77	0.50
Barium	na	0.09	na	na	0.07	0.10	0.09	0.05	0.10	0.10	0.09
Cadmium	na	0	na	na	0.01	0	0.02	0	0.03	0.03	0
Cobalt	na	*	na	na	*	*	0	0	*	*	0
Chromium	na	0.15	na	na	0.40	0.46	0.68	0.15	0.78	0.78	0.11
Copper	na	0.01	na	na	0.07	0.08	0.12	0.02	0.16	0.16	0.00
Magnesium	na	--	na	na	--	--	--	--	--	--	--
Manganese	na	--	na	na	--	--	--	--	--	--	--
Nickel	na	0	na	na	0	0	0	0	0.00	0.00	0
Lead	na	0.03	na	na	0.02	0	0	0	0.18	0.18	0
Vanadium	na	0.02	na	na	0.02	0.03	0.03	0.01	0.02	0.02	0.02
Zinc	na	4.19	na	na	3.95	4.10	3.45	4.32	4.28	4.68	4.13
Mercury	na	0	na	na	0	0	2220.77	0	0	0	0
p,p - DDD	na	0	na	na	0	0	0	0	7.25E+05	7.25E+05	0
p,p - DDE	na	0	na	na	0	0	0	0	1.79E+05	1.79E+05	0
p,p - DDT	na	0	na	na	0	0	0	0	1.01E+06	1.01E+06	0
HI	na	5	na	na	5E+00	6	2226	5	2E+06	2E+06	5
(weight of evidence)	na	a	na	na	a	b	b	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-2b
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Round Lake

Sample Locations	RL11	RL12	RL13	RL14	RL15	RL16.A	RL16.B	RL17.A	RL17.B	RL18	RL19	RL20
Silver	0	0	0	0	0	0	0	0	0	0	0	0
Aluminum	0.45	0.68	0.67	0.99	0.08	0.45	0.45	0.36	0.56	0.83	0.81	0.12
Barium	0.05	0.09	0.09	0.11	0.04	0.08	0.08	0.08	0.09	0.10	0.09	0.04
Cadmium	0	0	0	0.02	0	0	0	0	0	0.05	0	0
Cobalt	0	0	*	*	0	0	0	0	0	0	0	0
Chromium	0.48	0.51	0.28	0.39	0.03	0	0	0.08	0.14	1.22	1.01	0.03
Copper	0.05	0.05	0.03	0.02	0	0	0	0	0.01	0.05	0.04	0
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0.02	0	0	0	0	0	0	0	0.49	0.42	0
Vanadium	0.02	0.03	0.02	0.04	0.00	0.02	0.02	0.02	0.03	0	0	0.00
Zinc	3.29	4.46	5.77	3.70	3.65	3.43	4.80	4.49	4.51	3.77	5.01	5.04
Mercury	0	0	0	1237.28	0	0	0	0	0	0	0	0
p,p - DDD	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDE	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDT	0	0	0	0	0	0	0	0	0	0	0	0
HI	4	6	7	1243	4	4	5	5	5	6	7	5
(weight of evidence)	a	a	a	a	a	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-3a
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Round Lake

Sample Locations	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.A	RL09.B	RL10
Silver	na	0	na	na	0	*	*	0	*	*	*
Aluminum	na	0.10	na	na	0.14	0.21	0.19	0.05	0.20	0.20	0.12
Barium	na	0.01	na	na	0.01	0.02	0.02	0.00	0.02	0.02	0.01
Cadmium	na	0	na	na	0.00	0	0.00	0	0.00	0.00	0
Cobalt	na	*	na	na	*	*	0	0	*	*	0
Chromium	na	0.04	na	na	0.10	0.12	0.17	0.04	0.20	0.20	0.03
Copper	na	0.00	na	na	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Magnesium	na	--	na	na	--	--	--	--	--	--	--
Manganese	na	--	na	na	--	--	--	--	--	--	--
Nickel	na	0	na	na	0	0	0	0	0.00	0.00	0
Lead	na	3.5E-06	na	na	0.00	0	0	0	0.02	0.02	0
Vanadium	na	0.00	na	na	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Zinc	na	0.08	na	na	0.41	0.39	0.63	0.12	0.88	0.88	0.09
Mercury	na	0	na	na	0	0	0.00	0	0	0	0
p,p - DDD	na	0	na	na	0	0	0	0	1.71E+06	1.71E+06	0
p,p - DDE	na	0	na	na	0	0	0	0	4.21E+05	4.21E+05	0
p,p - DDT	na	0	na	na	0	0	0	0	2.37E+06	2.37E+06	0
HI	na	0	na	na	7E-01	1	1	0	5E+06	5E+06	0
(weight of evidence)	na	a	na	na	a	b	b	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-3b
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Round Lake

Sample Locations	RL11	RL12	RL13	RL14	RL15	RL16.A	RL16.B	RL17.A	RL17.B	RL18	RL19	RL20
Silver	0	0	0	0	0	0	0	0	0	0	0	0
Aluminum	0.11	0.17	0.16	0.25	0.02	0.11	0.11	0.09	0.14	0.21	0.21	0.03
Barium	0.01	0.02	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.00
Cadmium	0	0	0	0.00	0	0	0	0	0	0.00	0	0
Cobalt	0	0	*	*	0	0	0	0	0	0	0	0
Chromium	0.12	0.13	0.07	0.10	0.01	0	0	0.02	0.04	0.31	0.26	0.01
Copper	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	2.3E-06	0	0	0	0	0	0	0	0.04	0.04	0
Vanadium	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0	0	0.00
Zinc	0.33	0.44	0.26	0.27	0.01	0.12	0.12	0.08	0.10	0.84	0.76	0.02
Mercury	0	0	0	0.0006	0	0	0	0	0	0	0	0
p,p - DDD	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDE	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDT	0	0	0	0	0	0	0	0	0	0	0	0
HI	1	1	1	1	0	0	0	0	0	1	1	0
(weight of evidence)	a	a	a	a	a	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE E-4a
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Round Lake

Sample Locations	RL01	RL02	RL03	RL04	RL05	RL06	RL07	RL08	RL09.A	RL09.B	RL10
Silver	0	0	0	0	0	0.00	0.06	0	0.00	0.00	0.04
Aluminum	0	65.00	0.02	0	98.99	146.48	128.44	31.38	134.03	134.03	82.29
Barium	0.01	0.34	0.01	0.01	0.27	0.43	0.41	0.12	0.47	0.47	0.35
Cadmium	0	0	0	0	2.35	0	3.28	0	6.48	6.48	0
Cobalt	0	0.01	0	0	0.00	0.01	0	0	0.01	0.01	0
Chromium	0	0.07	0	0	0.20	0.23	0.34	0.07	0.39	0.39	0.05
Copper	0	0.03	0	0	0.40	0.47	0.70	0.11	0.96	0.96	0.02
Magnesium	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0.01	0.01	0
Lead	0	0.00	0	0	0.01	0	0	0	0.17	0.17	0
Vanadium	0	1.86	0	0	2.31	3.07	2.85	0.71	2.32	2.32	2.22
Zinc	0.00	0.01	0.01	0.01	0.03	0.03	0.05	0.01	0.07	0.07	0.01
Mercury	0	0	0	0	0	0	0.21	0	0	0	0
p,p - DDD	0	0	0	0	0	0	0	0	0.36	0.36	0
p,p - DDE	0	0	0	0	0	0	0	0	0.14	0.14	0
p,p - DDT	0	0	0	0	0	0	0	0	0.30	0.30	0
HI	na	67	na	na	105	151	136	32	146	146	85
(weight of evidence)	na	a	na	na	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE E-4b
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Round Lake

Sample Locations	RL11	RL12	RL13	RL14	RL15	RL16.A	RL16.B	RL17.A	RL17.B	RL18	RL19	RL20
Silver	0	0	0	0	0	0	0	0	0	0	0	0
Aluminum	77.29	117.27	111.89	172.00	14.07	78.29	78.29	59.28	92.90	144.08	140.73	20.66
Barium	0.30	0.40	0.38	0.48	0.04	0.31	0.31	0.27	0.38	0.40	0.35	0.04
Cadmium	0	0	0	4.37	0	0	0	0	0	9.63	0	0
Cobalt	0	0	0.01	0.01	0	0	0	0	0	0	0	0
Chromium	0.24	0.26	0.14	0.20	0.01	0	0	0.04	0.07	0.61	0.51	0.02
Copper	0.27	0.31	0.15	0.13	0	0	0	0	0.04	0.28	0.25	0
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0.00	0	0	0	0	0	0	0	0.44	0.38	0
Vanadium	1.74	2.83	2.43	3.87	0.31	2.50	2.50	1.91	2.87	0	0	0.43
Zinc	0.03	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.07	0.06	0.01
Mercury	0	0	0	0.12	0	0	0	0	0	0	0	0
p,p - DDD	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDE	0	0	0	0	0	0	0	0	0	0	0	0
p,p - DDT	0	0	0	0	0	0	0	0	0	0	0	0
HI	80	121	115	181	14	81	81	62	96	156	142	21
(weight of evidence)	a	a	a	a	a	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-5
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Sunfish Lake

Sample Locations	SFL01	SFL02	SFL03	SFL04.A	SFL04.B	SFL05	SFL06.A	SFL06.B	SFL07	SFL08	SFL09.A	SFL09.B	SFL10
Silver	0	0	0	*	0	0	*	0	*	0	0	0	0
Aluminum	*	*	*	*	*	*	*	*	*	*	*	*	*
Barium	*	*	*	*	*	*	*	*	*	*	*	*	*
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0
Chromium	*	*	*	*	*	*	*	*	*	*	*	*	*
Copper	*	*	*	*	*	*	*	*	*	*	*	*	*
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	5.0E-06	3.8E-06	3.8E-06	4.0E-06
Vanadium	*	*	*	*	*	*	*	*	*	*	*	*	*
Zinc	*	*	*	*	*	*	*	*	*	*	*	*	*
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	*	0	*	0	0	0	0
Acetone	0	0	0	0	0	0	0	0	0	0	0	0	0
Methylethyl ketone	0	0	--	--	0	*	0	0	*	*	*	*	*
HI	0	0	0	0	0	0	0	0	0	0.00	0.01	0.01	0.00
(weight of evidence)	c	c	c	c	c	c	c	c	c	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-6
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Sunfish Lake

Sample Locations	SFL01	SFL02	SFL03	SFL04.A	SFL04.B	SFL05	SFL06.A	SFL06.B	SFL07	SFL08	SFL09.A	SFL09.B	SFL10
Silver	0	0	0	*	0	0	*	0	*	0	0	0	0
Aluminum	2.48	1.81	2.03	1.88	1.87	1.80	1.77	1.78	1.82	1.14	1.53	1.76	1.50
Barium	0.21	0.15	0.16	0.14	0.14	0.15	0.14	0.15	0.15	0.14	0.20	0.20	0.16
Cadmium	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0
Cobalt	*	0	*	*	*	*	*	*	0	0	*	*	*
Chromium	3.44	2.82	2.75	1.47	1.40	3.96	3.75	3.75	2.75	0.57	0.64	0.65	0.52
Copper	0.03	0.03	0.03	0.02	0.02	0.04	0.03	0.03	0.03	0.01	0.01	0.02	0.01
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0.75	0.50	0.52	0.41	0.43	0.79	0.52	0.52	0.56	0.34	0.30	0.34	0.41
Vanadium	0.08	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.03	0.06	0.07	0.05
Zinc	2.11	2.34	2.04	2.18	2.17	1.84	2.06	1.69	2.10	2.05	2.19	2.29	2.46
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	*	0	*	0	0	0	0
Acetone	0	0	*	*	0	0	0	0	0	0	0	0	*
Methylethyl ketone	0	0	*	*	0	*	0	0	*	*	*	*	*
HI	9	8	8	6	6	9	8	8	7	4	5	5	5
(weight of evidence)	b	a	b	b	b	b	b	b	b	a	b	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(–) = a non-contaminant

TABLE D-7
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Sunfish Lake

Sample Locations	SFL01	SFL02	SFL03	SFL04.A	SFL04.B	SFL05	SFL06.A	SFL06.B	SFL07	SFL08	SFL09.A	SFL09.B	SFL10
Silver	0	0	0	*	0	0	*	0	*	0	0	0	0
Aluminum	3.97	2.89	3.24	3.00	2.98	2.87	2.82	2.82	2.91	1.72	2.23	2.60	2.15
Barium	0.31	0.21	0.22	0.18	0.17	0.20	0.20	0.20	0.20	0.17	0.25	0.25	0.20
Cadmium	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0
Cobalt	*	0	*	*	*	*	*	*	0	0	*	*	*
Chromium	5.54	4.55	4.43	2.36	2.26	6.39	6.05	6.05	4.43	0.92	1.03	1.05	0.84
Copper	0.09	0.08	0.07	0.06	0.06	0.12	0.08	0.08	0.10	0.04	0.04	0.04	0.03
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	1.21	0.80	0.84	0.66	0.69	1.27	0.84	0.84	0.91	0.52	0.46	0.52	0.64
Vanadium	0.13	0.09	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.05	0.10	0.11	0.08
Zinc	0.55	0.48	0.57	0.40	0.38	0.56	0.57	0.57	0.47	0.19	0.67	0.84	0.38
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	*	0	*	0	0	0	0
Acetone	0	0	*	*	0	0	0	0	0	0	0	0	*
Methylethyl ketone	0	0	*	*	0	*	0	0	*	*	*	*	*
HI	12	9	9	7	7	12	11	11	9	4	5	5	4
(weight of evidence)	b	a	b	b	b	b	b	b	b	a	b	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-8
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Sunfish Lake

Sample Locations	SFL01	SFL02	SFL03	SFL04.A	SFL04.B	SFL05	SFL06.A	SFL06.B	SFL07	SFL08	SFL09.A	SFL09.B	SFL10
Silver	0	0	0	0.00	0	0	0.00	0	0.00	0	0	0	0
Aluminum	201.22	146.48	164.35	152.06	150.95	145.35	143.12	143.17	147.59	87.52	114.02	133.01	110.40
Barium	0.58	0.39	0.42	0.35	0.33	0.38	0.37	0.37	0.38	0.32	0.49	0.49	0.38
Cadmium	0	0	0	0	0	0	0	0	0	0	1.29	1.69	0
Cobalt	0.01	0	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0.01	0.01	0.00
Chromium	0.82	0.67	0.65	0.35	0.33	0.94	0.89	0.89	0.65	0.14	0.15	0.15	0.12
Copper	0.07	0.07	0.06	0.05	0.05	0.10	0.07	0.07	0.08	0.03	0.03	0.04	0.02
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0.28	0.19	0.19	0.15	0.16	0.30	0.20	0.20	0.21	0.12	0.11	0.12	0.15
Vanadium	3.78	2.72	3.34	3.07	3.13	2.95	2.93	2.93	2.72	1.49	2.78	3.30	2.21
Zinc	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.01	0.03	0.04	0.02
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	796.10	0	796.10	0	0	0	0
Acetone	0	0	0.03	0.03	0	0	0	0	0	0	0	0	0.01
Methylethyl ketone	0	0	*	*	0	*	0	0	*	*	*	*	*
HI	207	151	169	156	155	150	944	148	948	90	119	139	113
(weight of evidence)	a	a	a	a	a	a	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-9
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Rice Creek

Sample Locations	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.A	RCK06.B	RCK07	RCK08.A	RCK08.B	RCK09	RCK10
Silver	0	0	0	0	*	0	0	0	0	0	0	0
Aluminum	*	*	*	*	*	*	*	*	*	*	*	*
Barium	*	*	*	*	*	*	*	*	*	*	*	*
Cobalt	0	0	0	0	0	0	0	0	0	0	0	0
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Lead	0	0	0	0	0	0	0	0	0	0	0	0
Vanadium	*	*	*	*	--	*	*	*	*	*	*	*
Zinc	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor epoxide	*	0	0	0	0	0	0	0	0	0	0	0
HI	0	0	0	0	0	0	0	0	0	0	0	0
(weight of evidence)	c	c	c	c	c	c	c	c	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-10
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Rice Creek

Sample Locations	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.A	RCK06.B	RCK07	RCK08.A	RCK08.B	RCK09	RCK10
Silver	0	0	0	0	*	0	0	0	0	0	0	0
Aluminum	0.11	0.10	0.11	0.12	0.58	0.10	0.11	0.08	0.25	0.27	0.08	0.29
Barium	0.07	0.06	0.07	0.07	0.13	0.07	0.07	0.07	60.90	0.10	0.07	0.07
Cobalt	0	0	0	0	0	0	*	0	*	*	0	*
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Lead	0	0	0	0	0	0	0	0	0	0	0	0
Vanadium	0.00	0.00	0.00	0.00	0	0.01	0.01	0.00	0.01	0.01	0.00	0.01
Zinc	1.95	2.48	2.08	2.98	2.51	0.02	0.01	2.05	2.21	3.65	2.31	2.78
Heptachlor epoxide	*	0	0	0	0	0	0	0	0	0	0	0
HI	2	3	2	3	3	0	0	2	63	4	2	3
(weight of evidence)	a	a	a	a	b	a	b	a	b	b	a	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-11
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Rice Creek

Sample Locations	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.A	RCK06.B	RCK07	RCK08.A	RCK08.B	RCK09	RCK10
Silver	0	0	0	0	*	0	0	0	0	0	0	0
Aluminum	0.05	0.05	0.05	0.06	0.33	0.06	0.06	0.05	0.15	0.15	0.05	0.15
Barium	0.00	0.00	0.01	0.01	0.04	0.01	0.01	0.00	0.04	0.02	0.00	0.01
Cobalt	0	0	0	0	0	0	*	0	*	*	0	*
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Lead	0	0	0	0	0	0	0	0	0	0	0	0
Vanadium	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Zinc	0.02	0.02	0.03	0.02	0.01	0.03	0.02	0.02	0.06	0.06	0.02	0.06
Heptachlor epoxide	*	0	0	0	0	0	0	0	0	0	0	0
HI	0	0	0	0	0	0	0	0	0	0	0	0
(weight of evidence)	a	a	a	a	b	a	b	a	b	b	a	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-12
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Rice Creek

Sample Locations	RCK01	RCK02	RCK03	RCK04	RCK05	RCK06.A	RCK06.B	RCK07	RCK08.A	RCK08.B	RCK09	RCK10
Silver	0	0	0	0	0.00	0	0	0	0	0	0	0
Aluminum	14.34	12.76	14.55	15.50	90.21	15.97	17.20	12.29	40.32	40.47	13.51	41.57
Barium	0.07	0.05	0.08	0.07	0.42	0.09	0.07	0.05	19.03	0.22	0.05	0.09
Cobalt	0	0	0	0	0	0	0.00	0	0.00	0.00	0	0.00
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	--	--	--	--
Lead	0	0	0	0	0	0	0	0	0	0	0	0
Vanadium	0.34	0.36	0.29	0.38	0	0.62	0.58	0.31	0.94	0.94	0.22	0.72
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
Heptachlor epoxide	0.53	0	0	0	0	0	0	0	0	0	0	0
HI	15	13	15	16	91	17	18	13	60	42	14	42
(weight of evidence)	a	a	a	a	a	a	a	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-13
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
B Wetlands

Sample Locations	**B01**	**B02**	**B03.A**	**B03.B**
Aluminum	*	*	*	*
Arsenic	0	0	0	0
Barium	*	*	*	*
Beryllium	0	*	0	0
Cobalt	0	0	0	0
Chromium	*	*	*	*
Copper	*	*	*	*
Magnesium	--	--	--	--
Manganese	--	--	--	--
Nickel	*	*	*	*
Lead	0	0	0	2.9E-06
Vanadium	*	*	*	*
Zinc	*	*	*	*
Mercury	0	0	0	0
p,p - DDD	0	0	0	0
p,p - DDE	*	0	0	0
p,p - DDT	0	0	0	0
HI	0	0	0	3E-06
(weight of evidence)	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major
(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-14
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
B Wetlands

Sample Locations	**B01**	**B02**	**B03.A**	**B03.B**
Aluminum	**0.51**	**1.30**	**0.41**	**0.40**
Arsenic	**0**	**0**	**0**	**0**
Barium	**0.11**	**0.16**	**0.11**	**0.10**
Beryllium	**0**	**0**	**0**	**0**
Cobalt	*	*	*	*
Chromium	**0.07**	**0.27**	**0.13**	**0.13**
Copper	**0.00**	**0.00**	**0.00**	**0.00**
Magnesium	--	--	--	--
Manganese	--	--	--	--
Nickel	**0**	**0**	**0**	**0**
Lead	**0**	**0.05**	**0**	**0.01**
Vanadium	**0.01**	**0.04**	**0.02**	**0.02**
Zinc	**1.6**	**1.6**	**1.6**	**1.5**
Mercury	**0**	**0**	**0**	**0**
p,p - DDD	**7E+06**	**3E+05**	**0**	**0**
p,p - DDE	**3E+05**	**0**	**0**	**0**
p,p - DDT	**2E+06**	**1E+05**	**0**	**0**
HI	**9762277**	**430129**	**2**	**2**
(weight of evidence)	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major
(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-15
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
B Wetlands

Sample Locations	**B01**	**B02**	**B03.A**	**B03.B**
Aluminum	**0.50**	**2.46**	**0.61**	**0.61**
Arsenic	**0**	**0**	**0**	**0**
Barium	**0.03**	**0.19**	**0.05**	**0.05**
Beryllium	**0**	*	**0**	**0**
Cobalt	*	*	*	*
Chromium	**0.14**	**0.53**	**0.26**	**0.26**
Copper	**0.00**	**0.00**	**0.00**	**0.00**
Magnesium	--	--	--	--
Manganese	--	--	--	--
Nickel	**0**	**0.01**	**0**	**0**
Lead	**0**	**0.04**	**0**	**0**
Vanadium	**0.03**	**0.08**	**0.03**	**0.03**
Zinc	**0.17**	**0.69**	**0.22**	**0.22**
Mercury	**0**	**0**	**0**	**0**
p,p - DDD	**9E+07**	**4E+06**	**0**	**0**
p,p - DDE	**5E+06**	**0**	**0**	**0**
p,p - DDT	**3E+07**	**2E+06**	**0**	**0**
HI	**1E+08**	**6E+06**	**1**	**1**
(weight of evidence)	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major
(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-16
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
B Wetlands

Sample Locations	**B01**	**B02**	**B03.A**	**B03.B**
Aluminum	**42.92**	**201.42**	**50.74**	**50.66**
Arsenic	**0**	**0**	**0**	**0**
Barium	**0.12**	**0.60**	**0.17**	**0.17**
Beryllium	**0**	**0.02**	**0**	**0**
Cobalt	**0.00**	**0.01**	**0.00**	**0.00**
Chromium	**0.03**	**0.13**	**0.06**	**0.06**
Copper	**0.01**	**0.03**	**0.01**	**0.01**
Magnesium	--	--	--	--
Manganese	--	--	--	--
Nickel	**0.00**	**0.01**	**0.00**	**0.00**
Lead	**0**	**0.05**	**0**	**0.00**
Vanadium	**1.25**	**3.60**	**1.49**	**1.49**
Zinc	**0.00**	**0.01**	**0.00**	**0.00**
Mercury	**0**	**0**	**0**	**0**
p,p - DDD	**1.44**	**0.06**	**0**	**0**
p,p - DDE	**0.11**	**0**	**0**	**0**
p,p - DDT	**0.28**	**0.01**	**0**	**0**
HI	**46**	**206**	**52**	**52**
(weight of evidence)	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major
(*) data gap in toxicity information, potential risk
(--) a non-contaminant

TABLE D-17
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Pond G

Sample Locations	G01	G02	G03	G04.A	G04.B
Aluminum	*	*	*	*	*
Barium	*	*	*	*	*
Cobalt	0	0	0	0	0
Chromium	*	*	*	*	*
Magnesium	--	--	--	--	--
Manganese	--	--	--	--	--
Lead	0	0	0	0	0
Vanadium	*	*	*	*	*
Zinc	*	*	*	*	*
PCB 254	0	0	0	0	0
p,p - DDD	0	0	0	0	0
p,p - DDE	0	0	*	0	0
p,p - DDT	0	0	0	0	0
HI	0	0	0	0	0
(weight of evidence)	c	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

'(--) a non-contaminant
(*) data gap in toxicity information, potential risk

TABLE D-18
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Pond G

Sample Locations	**G01**	**G02**	**G03**	**G04.A**	**G04.B**
Aluminum	**0.28**	**0.64**	**0.86**	**0.44**	**0.35**
Barium	**0.06**	**0.08**	**0.13**	**0.07**	**0.06**
Cobalt	*	*	*	*	*
Chromium	**0.06**	**0.16**	**0.19**	**0.10**	**0.08**
Magnesium	--	--	--	--	--
Manganese	--	--	--	--	--
Lead	**0**	**0.11**	**0.14**	**0**	**0**
Vanadium	**0.01**	**0.02**	**0.03**	**0.02**	**0.01**
Zinc	**1.31**	**1.41**	**1.42**	**1.33**	**1.32**
PCB 254	**0**	**8E+03**	**9E+04**	**0**	**0**
p,p - DDD	**0**	**0**	**2E+06**	**0**	**0**
p,p - DDE	**0**	**0**	**1E+05**	**0**	**0**
p,p - DDT	**0**	**1E+05**	**9E+05**	**0**	**0**
HI	**2**	**1E+05**	**3E+06**	**2**	**2**
(weight of evidence)	b	a	a	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

'(--) a non-contaminant
(*) data gap in toxicity information, potential risk

TABLE D-19
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Pond G

Sample Locations	**G01**	**G02**	**G03**	**G04.A**	**G04.B**
Aluminum	**0.49**	**1.20**	**1.62**	**0.81**	**0.63**
Barium	**0.07**	**0.10**	**0.19**	**0.08**	**0.05**
Cobalt	*	*	*	*	*
Chromium	**0.12**	**0.31**	**0.38**	**0.19**	**0.16**
Magnesium	--	--	--	--	--
Manganese	--	--	--	--	--
Lead	**0**	**0.09**	**0.11**	**0**	**0**
Vanadium	**0.02**	**0.04**	**0.06**	**0.03**	**0.02**
Zinc	**0.16**	**0.69**	**0.76**	**0.24**	**0.22**
PCB 254	**0**	**8E+04**	**8E+05**	**0**	**0**
p,p - DDD	**0**	**0**	**2E+07**	**0**	**0**
p,p - DDE	**0**	**0**	**2E+06**	**0**	**0**
p,p - DDT	**0**	**2E+06**	**1E+07**	**0**	**0**
HI	**1**	**2E+06**	**4E+07**	**1**	**1**
(weight of evidence)	b	a	a	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

'(--) a non-contaminant
(*) data gap in toxicity information, potential risk

TABLE D-20
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Pond G

Sample Locations	**G01**	**G02**	**G03**	**G04.A**	**G04.B**
Aluminum	**40.97**	**99.61**	**134.23**	**67.22**	**51.80**
Barium	**0.21**	**0.31**	**0.59**	**0.25**	**0.16**
Cobalt	**0.00**	**0.01**	**0.01**	**0.00**	**0.00**
Chromium	**0.03**	**0.07**	**0.09**	**0.05**	**0.04**
Magnesium	--	--	--	--	--
Manganese	--	--	--	--	--
Lead	**0**	**0.10**	**0.12**	**0**	**0**
Vanadium	**1.01**	**1.98**	**2.66**	**1.60**	**1.16**
Zinc	**0.00**	**0.01**	**0.01**	**0.00**	**0.00**
PCB 254	**0**	**1.64**	**16.91**	**0**	**0**
p,p - DDD	**0**	**0**	**0.37**	**0**	**0**
p,p - DDE	**0**	**0**	**0.04**	**0**	**0**
p,p - DDT	**0**	**0.01**	**0.11**	**0**	**0**
HI	**42**	**104**	**155**	**69**	**53**
(weight of evidence)	a	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

'(--) a non-contaminant
(*) data gap in toxicity information, potential risk

TABLE D-21
Hazard 1
ESTIMATED HAZARDS FOR AMPHIBIANS
Marsden Lake

Sample Locations	ML01.A	ML01.B	ML02	ML03	ML04	ML05.A	ML05.B
Aluminum	*	*	na	*	*	*	*
Barium	*	*	na	*	*	*	*
Cobalt	0.08	0.07	na	0	0.03	0.00	0.00
Copper	*	*	na	*	*	*	*
Magnesium	--	--	na	--	--	--	--
Manganese	--	--	na	--	--	--	--
Nickel	0	0	na	0	*	0	0
Lead	0.00	0.00	na	0	0	9.1E-06	9.1E-06
Vanadium	0	0	na	0	0	0	0
Zinc	0	0	na	0	0	0	0
p,p - DDD	0	0	na	0	0	0	0
p,p - DDE	0	0	na	0	*	0	*
p,p - DDT	0	0	na	0	0	0	0
HI	0.08	0.07	na	0.00	0.03	0.00	0.00
(weight of evidence)	c	c	na	c	c	c	c

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential risk
(--) = a non-contaminant

TABLE D-22
Hazard 2
ESTIMATED HAZARDS FOR WADING BIRDS
Marsden Lake

Sample Locations	ML01.A	ML01.B	ML02	ML03	ML04	ML05.A	ML05.B
Aluminum	5.26	3.33	na	0.45	0.63	0.90	0.79
Barium	1.34	1.09	na	0.09	0.13	0.16	0.15
Cobalt	*	*	na	0	*	*	*
Copper	0.32	0.19	na	0	0.00	0.00	0.00
Magnesium	--	--	na	--	--	--	--
Manganese	--	--	na	--	--	--	--
Nickel	0.01	0	na	0	0.00	0	0
Lead	1.03	0.38	na	0	0.05	0.04	0.04
Vanadium	0.19	0.14	na	0.01	0.02	0.02	0.02
Zinc	4.98	3.65	na	2.39	2.16	2.68	2.69
p,p - DDD	2.36E+05	2.36E+05	na	1.63E+05	4.89E+05	2.17E+05	2.54E+05
p,p - DDE	0	0	na	0	2.03E+05	0	9.53E+04
p,p - DDT	0	0	na	0	0	2.14E+05	7.94E+05
HI (total)	2E+05	2E+05	na	2E+05	7E+05	4E+05	1E+06
(weight of evidence)	a	a	na	a	a	a	a
HI (w/o pesticides)	13	9	na	3	3	4	4
(weight of evidence)	b	b	na	b	b	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential ris
(--) = a non-contaminant

TABLE D-23
Hazard 3
ESTIMATED HAZARDS FOR WATERFOWL
Marsden Lake

Sample Locations	ML01.A	ML01.B	ML02	ML03	ML04	ML05.A	ML05.B
Aluminum	1.31	1.30	na	0.67	0.93	0.88	0.72
Barium	0.13	0.13	na	0.08	0.07	0.11	0.09
Cobalt	*	*	na	0	*	*	*
Copper	0.00	0.00	na	0	0.00	0.00	0.00
Magnesium	--	--	na	--	--	--	--
Manganese	--	--	na	--	--	--	--
Nickel	0.00	0	na	0	0.00	0	0
Lead	0.14	0.14	na	0	0.03	0.00	0.00
Vanadium	0.04	0.04	na	0.02	0.03	0.03	0.03
Zinc	0.71	0.71	na	0.16	0.23	0.55	0.58
p,p - DDD	2.36E+06	2.36E+06	na	1.63E+06	4.90E+06	2.18E+06	2.54E+06
p,p - DDE	0	0	na	0	2.03E+06	0	9.55E+05
p,p - DDT	0	0	na	0	0	2.14E+06	7.95E+06
HI (total)	2E+06	2E+06	na	2E+06	7E+06	4E+06	1E+07
(weight of evidence)	a	a	na	a	a	a	a
HI (w/o pesticides)	2	2	na	1	1	2	1
(weight of evidence)	b	b	na	a	b	b	b

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential ris
(--) = a non-contaminant

TABLE D-24
Hazard 4
ESTIMATED HAZARDS FOR AQUATIC MAMMALS
Marsden Lake

Sample Locations	ML01.A	ML01.B	ML02	ML03	ML04	ML05.A	ML05.B
Aluminum	178.60	162.36	na	72.93	101.64	98.46	81.15
Barium	0.91	0.83	na	0.32	0.31	0.47	0.37
Cobalt	0.00	0.00	na	0	0.01	0.01	0.01
Copper	0.04	0.03	na	0	0.02	0.01	0.01
Magnesium	--	--	na	--	--	--	--
Manganese	--	--	na	--	--	--	--
Nickel	0.00	0	na	0	0.00	0	0
Lead	0.21	0.20	na	0	0.04	0.00	0.00
Vanadium	3.58	3.32	na	1.33	2.02	2.10	2.01
Zinc	0.02	0.02	na	0.01	0.01	0.01	0.01
p,p - DDD	0.20	0.20	na	0.14	0.42	0.19	0.22
p,p - DDE	0	0	na	0	0.26	0	0.12
p,p - DDT	0	0	na	0	0	0.11	0.40
HI	184	167	na	75	105	101	84
(weight of evidence)	a	a	na	a	a	a	a

(a) conservative estimate of risk
(b) uncertain estimate of risk, toxicity gaps are minor
(c) uncertain estimate of risk, toxicity gaps are major

(*) = data gap in toxicity information, potential ris
(--) = a non-contaminant

APPENDIX E

BENTHIC MACROINVERTEBRATE EVALUATION

BENTHIC MACROINVERTEBRATE EVALUATION
Twin Cities Army Ammunition Plant
New Brighton, Minnesota
28 June - 3 July, 1993

1. Aquatic Evaluation.

1.1 Benthic Macroinvertebrates.

1.1.1 Biological Rationale. It is widely recognized that biota accurately reflect the quality of their environment. Many biological indices/indicator organisms have been used to evaluate pollutional stress (References 1, 2, 3, 4, 5, 6, and 7). The usefulness of biota as indicators of environmental quality results from a number of biological characteristics.

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

1.1.3 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 are forced to 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.

1.1.4 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 more abundant. These tolerant or sensitive organisms can indicate either healthy or polluted conditions, e.g., certain species of mayflies indicate healthy conditions and tubifex worms indicate polluted conditions.

1.1.5 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 (high diversity) in a given species. Diversity can be quantified using a diversity formula. Formula values determine the extent of impact of environmental stress upon the ecosystem. This comparative use of community diversity quantifies pollutional impact.

2. Methods.

2.1 Sampling Plan.

2.1.1 Rice Creek. Macroinvertebrate samples were taken along the bank from three stations on Rice Creek. A triangular dipnet with a 30 mesh screen was used to sweep grassy vegetation along the bank. Sweeps were made along the stream-vegetation interface. Three 30-foot sections were sampled at each station. The locations of the stations are shown in Figure E-1.

2.1.2 Round Lake. Benthic macroinvertebrates were taken from four stations in Round Lake using a 6" X 6" Ekman grab sampler. Three samples were taken at each station. The location of the stations are shown in Figure E-1.

2.1.3 Sunfish Lake. Benthic macroinvertebrates were taken at four stations in Round Lake using a 6" X 6" Ekman grab sampler. Three samples were taken at each station. The location of the stations are shown in Figure E-1.

2.1.4 Snail Lake. Snail Lake was investigated during the survey as a possible reference lake with which to compare Round Lake and Sunfish Lake. Benthic macroinvertebrate were taken at two stations in Snail Lake using a 6" x 6" Ekman grab sampler. Three samples were taken at each station. The samples collected at the second Snail Lake station broke during shipment and could not be recovered. The location of the stations are shown in Figure E-1.

2.2 Field Conditions and Station Descriptions.

2.2.1 Field Conditions. It had rained in the area for 2 weeks prior to sampling, with some locations recording 3 inches of precipitation on some days. Rice Creek was 2 to 4 feet higher than its banks during this survey. However, the velocity of the water among the grass was minimal. The lakes seemed to be at a full, normal level based on shore vegetation and shoreline markings. All lake samples were taken at a depth of approximately 5 feet, except where noted.

2.2.2 Station Descriptions.

2.2.2.1 Rice Creek.

2.2.2.1.1 Rice Creek 1 was located just downstream of the installation's boundary fence and patrol road where Rice Creek enters the post. Flat, grassy fields with 5-foot grass on both sides of Rice Creek were flooded to a depth of 4 feet.

2.2.2.1.2 Rice Creek 2 was onpost, downstream of the sewer outfall from Site K. The grassy field, also with 5-foot grass, was flooded to a depth of 3 feet.

2.2.2.1.3 Rice Creek 3 was offpost, downstream of the Interstate 35W bridge. A concrete pad under the overpass acted as a shelf from which Rice Creek fell and became well mixed. Rice Creek flowed along a steep hill, but the bank immediately next to the creek was flooded to a depth of 2 feet.

2.2.2.2 Round Lake. Samples were taken in Round Lake near the outfalls, off-shore of a construction debris landfill (Reference 8), and at the outlet (Figure Map). The depth of the water was approximately five feet; and there was abundant submerged aquatic vegetation.

2.2.2.3 Sunfish Lake. Samples were taken in Sunfish Lake (formerly named Ryan Lake) at the inlet, off-shore of the landfill and at the outlet (Figure E-1). Canadian geese were observed swimming, feeding, and nesting on and around the lake, and goose droppings were common along the shore.

2.2.2.3.1 At the inlet (Sunfish Lake 1), the benthos was largely composed of sand, and there was abundant submerged aquatic vegetation.

2.2.2.3.2 At Sunfish Lake 2, samples were taken from a depth of approximately 5 feet, and submerged aquatic vegetation was present.

2.2.2.3.3 At Sunfish Lake 3, there was filamentous algae growing on submerged aquatic vegetation nearby but not at the sample site.

2.2.2.4 Snail Lake. Samples were taken in Snail Lake in the event that it would prove similar enough to be used as a reference lake. The sample stations were located in a small cove off-shore of a wooded area (Figure E-1). Samples were taken at a depth of approximately 5 feet. There was abundant submerged aquatic vegetation. The benthos was composed of soft mud with abundant fine particles of plant material present.

2.3 Species Analysis. Each sample was evaluated for the presence or absence (or gradation) of sensitive or indicator species.

2.4 Diversity.

2.4.1 The diversity ($\bar{H}$) was calculated according to Brillouin's (Reference 9) Diversity Index as modified by Patten (Reference 10), incorporating Stirling's approximation for logarithms of factorials, in order to minimize the bias resulting from rare species (Reference 11).

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

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

2.4.2 This treatment results in diversity values ranging from zero to 3.321928 log N (Reference 12), where numbers $\bar{H} > 3$ generally represent clean water streams; $1 < \bar{H} < 3$, intermediate quality; and $\bar{H} < 1$, polluted streams (Reference 13).

2.4.3 Community measures at each station.

2.4.3.1 Diversity was calculated for the combination of three samples at each station.

2.4.3.2 No calculations were made with a compromised sample. Instead, one unrecoverable sample at Rice Creek 2 was assumed to be the average of the two intact samples. The recreated sample was combined with the other two so that each station would be comparable (three samples).

3. Findings.

3.1 Benthic Macroinvertebrates.

3.1.1 Rice Creek. Rice Creek is below average in stream quality as it enters the Twin Cities Army Ammunition Plant (TCAAP). It remains so throughout its course and as it exits post. One species, the chironomid, *Glyptotendipes loberiferus*, dominated all stations, accounting for approximately 75 to 80 percent of all individuals. High numbers of this species are often indicative of organic pollution by sewage waste. Diversity ranged from 1.18 to 1.44 (see Tables 3 and 4).

3.1.1.1 Rice Creek 1. At Rice Creek 1, the diversity, 1.44, was moderately low. A total of 1,710 individuals from 20 taxa were found. However, 75 percent of those individuals were the chironomid, *Glyptotendipes loberiferus*. The second most common species, 11 percent, was the amphipod, *Crangonyx gracilis*.

3.1.1.2 Rice Creek 2. The macroinvertebrate community found at Rice Creek 2 was almost identical to that found at Rice Creek 1.

3.1.1.3 Rice Creek 3. Rice Creek 3 was very similar to Rice Creek 1 and 2, with one exception. *Glyptotendipes loberiferus* still dominated, but the second most common species was *Simulium* sp.

3.1.2 Round Lake. Species found in Round Lake are typical of a eutrophic pond. They are common or widespread in distribution. The species present possess a mix of tolerance to organic enrichment or adverse water quality conditions. No single species dominated the community, and the diversity was moderate to moderately high, 1.86 to 2.76 (see Tables 5 and 6).

3.1.2.1 Round Lake 1. Five species were abundant at Round Lake 1 (10 to 14 percent each). They are widespread in distribution and/or are tolerant. The diversity was moderately high.

3.1.2.2 Round Lake 2. Five different species were abundant (10 to 31 percent) at Round Lake 2. They are widespread, indifferent to water quality, or moderately tolerant. The diversity was moderate.

3.1.2.3 Round Lake 3. Round Lake 3 was somewhat similar to Round Lake 2. Six different species were common or abundant (9 to 24 percent). They are widespread, indifferent to water quality, or moderately tolerant. The diversity was moderate.

3.1.2.4 Round Lake 4. There were fewer species and fewer individuals at Round Lake 4 than at any of the other Round Lake stations. There were no aquatic worms or chironomids, and few amphipods. The species present are not known to be indicative of water quality. The diversity was moderately low.

3.1.3 Sunfish Lake. Sunfish Lake is a eutrophic lake bordering on overenrichment. Species found in Sunfish Lake are common, and the predominant ones are moderately to very tolerant of organic overenrichment. Diversity is moderately low to moderate.

3.1.3.1 Sunfish 1. Sunfish 1 is dominated by the aquatic worm, *Aulodrilus americanus*, which is moderately tolerant of organic enrichment. Other species either require an organic environment or are tolerant of adverse water quality conditions. The diversity was moderately low (see Tables 5 and 6).

3.1.3.2 Sunfish 2. The three most numerous species are all tolerant of an organically rich environment. Other species are present but are rare. The diversity was moderate.

3.1.3.3 Sunfish 3. The two of the three most numerous species are both very tolerant of adverse water quality conditions. The diversity was moderate.

3.1.4 Snail Lake. Half the individuals at Snail Lake 1 are an amphipod, which is widespread and requires an organic environment. The next five most numerous species are typical of organic environments. The diversity was moderate (see Tables 5 and 6).

4. Discussion.

4.1 Uncertainty. Care was taken to sweep only the grass growing on the bank of Rice Creek. However, it was difficult to ascertain the exact base of the grass plant even though they were all growing vertically. Some sweeps included parts of the side bank. The same situation existed at all stations.

4.2 Station Round Lake 4.

4.2.1 Two of the three most common species at Round Lake 4, the trichoptera, *Hesperophylax designatus*, and the snail, *Menetus dilatus*, feed on diatoms and vascular plant material. Plant material was collected and was growing at this station located at the lake's outlet.

4.2.2 The third species, the clam *Sphaerium*, is an obligate benthic species, and its presence confirms that the benthos was definitely sampled.

4.2.3 The chironomid and oligochaete species, even those that are tolerant of adverse water quality or organic pollution, were totally absent. In addition, only one amphipod specimen was found. These taxa were found in other parts of the lake under apparently similar environmental conditions. The reason for the absence, or near absence, of three major groups of benthic macroinvertebrates that would be expected to be found here is not obvious.

4.2.4 One possible explanation is that there is a collection of toxic material in the sediment that affects oligochaetes, amphipods, and most benthic insect larva, but not mollusks and gastropods. However, insecticide levels in the sediment were not elevated. Toxicity can be confirmed by performing acute sediment toxicity tests on chironomids and amphipods.

4.3 Reference Lake.

4.3.1 Although it was similar in some respects, Snail Lake was larger and deeper than both Round and Sunfish lakes. The maximum depth of Snail Lake is 25 feet compared to 8 feet for Round Lake.

4.3.2 Sunfish Lake is even smaller than Round Lake, and shallow enough that fish are killed over the winter. The U.S. Fish and Wildlife Service uses it to store hatchling or fingerling fish in spring and summer. The deeper water in Snail Lake might be expected to act as a cool water reservoir and keep the whole lake cooler year round. This would make it more like a cold water lake than a shallow water pond.

4.4 Weather. Although this survey was conducted at the beginning of the Midwest Flood of 1993, TCAAP was on the northern edge.

4.4.1 The grasses that were sampled on the banks of Rice Creek would not have been submerged normally. Colonization from drift probably occurred for a maximum of 2 weeks prior to the survey.

4.4.2 Other than being full, the lakes did not seem to be affected by the weather in an obvious manner.

5. Conclusions.

5.1 Benthic Macroinvertebrates.

5.1.1 Rice Creek. Rice Creek was impacted by organic pollution before it entered TCAAP. It was not affected further by current operations at TCAAP.

5.1.2 Round Lake. Round Lake locations 1, 2, and 3 are typical of a natural eutrophic pond environment. There is no readily apparent explanation for the differences at Round Lake location 4 found during the study.

5.1.3 Sunfish Lake. Sunfish Lake shows signs of stress from overeutrophication, especially at the inlet.

5.1.4 Snail Lake. Snail Lake 1 is an organically rich area of Snail Lake similar, but not identical, to Round Lake. The differences may be explained by the depth and size of Snail Lake. Snail Lake 1 can be used for some comparisons; however, a lake that matches Round Lake closer is preferable.

6. Recommendations.

6.1 Rice Creek. No further action required for Rice Creek.

6.2 Round Lake. Perform Phase II sediment toxicity testing at Round Lake.

6.3 Sunfish Lake. Reduce organic loading from source upstream of Sunfish Lake.

Our point of contact for technical questions regarding this appendix is Mr. Arthur Asaki at DSN 584-3816 or commercial (410) 671-3816.

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TABLE 1. Benthic Macroinvertebrate Species Found at TCAAP, MN, 28 June - 3 July 1993

- Phylum Platyhelminthes
  - Class Turbellaria
    - Order Tricladida
      - Family Planariidae
        - *Dugesia tigrina*
- Phylum Mollusca
  - Class Gastropoda
    - Subclass Pulmonata
      - Order Basommatophora
        - Family Physidae
          - *Physella gyrina*
        - Family Lymnaeidae
          - *Fosaria parva*
        - Family Planorbidae
          - *Mentus dilatus*
          - *Planorbula armiger*
  - Class Bivalvia (=Pelecypoda)
    - Order Heterodonta
      - Family Spaeridae
        - *Sphaerium* sp.
- Phylum Annelida
  - Class Oligochaeta
    - Order Plesiopora
      - Family Tubificidae
        - *Aulodrilus americanus*
    - Order Prosopora
      - Family Lumbriculidae
        - *Lumbriculus variigatus*
  - Class Hirudinea
    - Order Rhynchobdellida
      - Family Glossiphoniidae
        - *Glossiphonia complanata*
    - Order Pharyngobdellida
      - Family Erpobdellidae
        - *Erpobdella punctata*

Phylum Arthropoda
- Class Crustacea
  - Order Isopoda
    - Family Asellidae
      - *Asellus* sp.
  - Order Amphipoda
    - Family Gammaridae
      - *Crangonyx gracilis*
  - Order Decapoda
    - Family Astacidae
      - *Oronectes* sp.
- Class Insecta
  - Order Ephemeroptera
    - Family Baetidae
      - *Baetis* sp.
    - Family Caenidae
      - *Caenis amica*
    - Family Ephemeridae
      - *Hexagenia bilineata*
  - Order Hemiptera
    - Family Corixidae
      - *Hesperocorixa* sp.
      - *Sigara* sp.
    - Family Pleidae
      - *Plea striola*
  - Order Trichoptera
    - Family Hydropsychidae
      - *Hydropsyche betteni*
    - Family Hydroptilidae
      - *Hydroptila consimilus*
    - Family Limnephilidae
      - *Hesperophylax designatus*
    - Family Phryganeidae
      - *Agrypnia vestita*
  - Order Coleoptera
    - Family Haliplidae
      - *Peltodytes lengi*
      - *Haliplus immaculicollis*
      - *Haliplus* sp. larva

Haliplus sp. (not *H. immaculicollis*)
Family Dytiscidae
Hydroporus sp. larva
Agabus sp.
Coptotomus sp. larva
Hydaticus modestus
Family Hydrophilidae
Berosus sp. larva
Tropisternus lateralis
Tropisternus sp. larva
Hydrochus sp.
Family Helodidae
Family Elmidae
Dubiraphia sp. larva
Order Diptera
Family Chaoboridae
Chaoborus punctipennis
Family Ceratopogonidae
Culicoides sp.
Dasyhelea grisea
Family Chironomidae
Ablabesmyia mallochi
Natarsia baltimoreus
Procladius sublettei
Chironomus decorus
Chironomus riparus
Cryptochironomus fulvus
Harnischia sp.
Glypototendipes lobiferus
Tanytarsus sp.
Family Simuliidae
Simulium sp.
Family Stratiomiidae
Strotiomys sp.
Family Empidae
Hemerodromia sp.

TABLE 2. Community Parameters for Benthic Macroinvertebrates (Creek and Lake), TCAAP, MN, 28 June - 3 July 1993

	Taxa Richness (No. of Species)	No. of Individuals	Diversity ($\bar{H}$)
Rice Creek 1	20	1710	1.44
Rice Creek 2	18	2106	1.34
Rice Creek 3	22	965	1.18
Round Lake 1	16	113	2.76
Round Lake 2	9	77	2.58
Round Lake 3	9	80	2.67
Round Lake 4	7	44	1.86
Sunfish Lake 1	11	136	1.67
Sunfish Lake 2	9	67	2.25
Sunfish Lake 3	8	75	2.29
Snail Lake 1	11	93	2.10

TABLE 3. Benthic Macroinvertebrates, Rice Creek, 28 Jun - 3 Jul 93, Composite Samples

Species	Rice 1 (raw)	Rice 1 (%)	Rice 2┼ (raw)	Rice 2 (%)	Rice 3 (raw)	Rice 3 (%)
Dugesia tigrina	0	0.0%	3	0.1%	0	0.0%
Physella gyrina	34	2.0%	37.5	1.8%	7	0.7%
Fosaria parva	5	0.3%	4.5	0.2%	0	0.0%
Aulodrilus americanus	5	0.3%	0	0.0%	1	0.1%
Lumbriculus variigatus	4	0.2%	0	0.0%	0	0.0%
Asellus sp.	8	0.5%	94.5	4.5%	11	1.1%
Crangonyx gracilis	190	11.1%	237	11.3%	33	3.4%
Baetis sp.	28	1.6%	6	0.3%	1	0.1%
Caenis amica	2	0.1%	4.5	0.2%	0	0.0%
Hesperocorixa sp.	0	0.0%	0	0.0%	1	0.1%
Sigara sp.	0	0.0%	0	0.0%	10	1.0%
Plea striola	0	0.0%	1.5	0.1%	1	0.1%
Hydropsyche betteni	6	0.4%	7.5	0.4%	12	1.2%
Peltodytes lengi	0	0.0%	0	0.0%	2	0.2%
Haliplus immaculicollis	0	0.0%	0	0.0%	1	0.1%
Haliplus sp. *	0	0.0%	0	0.0%	1	0.1%
Hydroporus sp. larva	1	0.1%	0	0.0%	1	0.1%
Hydaticus modestus	0	0.0%	0	0.0%	2	0.2%
Berosus sp. larva	11	0.6%	10.5	0.5%	1	0.1%
Tropisternus lateralis	0	0.0%	0	0.0%	1	0.1%
Tropisternus sp. larva	0	0.0%	1.5	0.1%	1	0.1%
Hydrochus sp.	0	0.0%	0	0.0%	1	0.1%
Family Helodidae	11	0.6%	34.5	1.6%	0	0.0%
Dubiraphia sp. larva	1	0.1%	0	0.0%	0	0.0%
Culicoides sp.	1	0.1%	0	0.0%	0	0.0%
Natarsia baltimoreus	17	1.0%	4.5	0.2%	17	1.8%
Harnischia sp.	6	0.4%	6	0.3%	2	0.2%
Glypototendipes lobiferus	1287	75.3%	1617	76.8%	787	81.6%
Tanytarsus sp.	4	0.2%	0	0.0%	0	0.0%
Simulium sp.	87	5.1%	33	1.6%	71	7.4%
Strotiomys sp.	2	0.1%	1.5	0.1%	0	0.0%
Hemerodromia sp.	0	0.0%	1.5	0.1%	0	0.0%
Number of Species	20		18		22	
Number of Individuals	1710		2106		965	
Diversity ($\bar{H}$)	1.44		1.34		1.18	

* not Haliplus immaculicollis
┼ includes extrapolation

TABLE 4. Benthic Macroinvertebrates, Rice Creek, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Rice 1A	Rice 1B	Rice 1C	Rice 1 (raw)	Rice 1 (%)
Dugesia tigrina	0	0	0	0	0.0%
Physella gyrina	16	14	4	34	2.0%
Fosaria parva	0	1	4	5	0.3%
Aulodrilus americanus	1	4	0	5	0.3%
Lumbriculus variigatus	4	0	0	4	0.2%
Asellus sp.	7	0	1	8	0.5%
Crangonyx gracilis	137	50	3	190	11.1%
Baetis sp.	3	12	13	28	1.6%
Caenis amica	1	1	0	2	0.1%
Hesperocorixa sp.	0	0	0	0	0.0%
Sigara sp.	0	0	0	0	0.0%
Plea striola	0	0	0	0	0.0%
Hydropsyche betteni	1	2	3	6	0.4%
Peltodytes lengi	0	0	0	0	0.0%
Haliplus immaculicollis	0	0	0	0	0.0%
Haliplus sp. *	0	0	0	0	0.0%
Hydroporus sp. larva	0	0	1	1	0.1%
Hydaticus modestus	0	0	0	0	0.0%
Berosus sp. larva	8	2	1	11	0.6%
Tropisternus lateralis	0	0	0	0	0.0%
Tropisternus sp. larva	0	0	0	0	0.0%
Hydrochus sp.	0	0	0	0	0.0%
Family Helodidae	11	0	0	11	0.6%
Dubiraphia sp. larva	0	0	1	1	0.1%
Culicoides sp.	1	0	0	1	0.1%
Natarsia baltimoreus	10	2	5	17	1.0%
Harnischia sp.	0	0	6	6	0.4%
Glypototendipes lobiferus	520	625	142	1287	75.3%
Tanytarsus sp.	1	3	0	4	0.2%
Simulium sp.	7	29	51	87	5.1%
Strotiomys sp.	0	1	1	2	0.1%
Hemerodromia sp.	0	0	0	0	0.0%
Number of Species	15	13	14	20	
Number of Individuals	728	746	236	1710	
Diversity ($\bar{H}$)	1.39	1.00	1.81	1.44	

* not Haliplus immaculicollis

TABLE 4. (cont.) Benthic Macroinvertebrates, Rice Creek, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Rice 2A	Rice 2B	Rice 2C (extra-polated)	Rice 2 (raw incl extra-polation)	Rice 2 (%)
Dugesia tigrina	2	0	1.0	3	0.1%
Physella gyrina	11	14	12.5	37.5	1.8%
Fosaria parva	2	1	1.5	4.5	0.2%
Aulodrilus americanus	0	0	0.0	0	0.0%
Lumbriculus variigatus	0	0	0.0	0	0.0%
Asellus sp.	23	40	31.5	94.5	4.5%
Crangonyx gracilis	54	104	79.0	237	11.3%
Baetis sp.	1	3	2.0	6	0.3%
Caenis amica	1	2	1.5	4.5	0.2%
Hesperocorixa sp.	0	0	0.0	0	0.0%
Sigara sp.	0	0	0.0	0	0.0%
Plea striola	1	0	0.5	1.5	0.1%
Hydropsyche betteni	5	0	2.5	7.5	0.4%
Peltodytes lengi	0	0	0.0	0	0.0%
Haliplus immaculicollis	0	0	0.0	0	0.0%
Haliplus sp. *	0	0	0.0	0	0.0%
Hydroporus sp. larva	0	0	0.0	0	0.0%
Hydaticus modestus	0	0	0.0	0	0.0%
Berosus sp. larva	3	4	3.5	10.5	0.5%
Tropisternus lateralis	0	0	0.0	0	0.0%
Tropisternus sp. larva	1	0	0.5	1.5	0.1%
Hydrochus sp.	0	0	0.0	0	0.0%
Family Helodidae	23	0	11.5	34.5	1.6%
Dubiraphia sp. larva	0	0	0.0	0	0.0%
Culicoides sp.	0	0	0.0	0	0.0%
Natarsia baltimoreus	2	1	1.5	4.5	0.2%
Harnischia sp.	3	1	2.0	6	0.3%
Glypototendipes lobiferus	729	349	539.0	1617	76.8%
Tanytarsus sp.	0	0	0.0	0	0.0%
Simulium sp.	12	10	11.0	33	1.6%
Strotiomys sp.	1	0	0.5	1.5	0.1%
Hemerodromia sp.	1	0	0.5	1.5	0.1%
Number of Species	18	11	18	18	
Number of Individuals	875	529	702	2106	
Diversity ($\bar{H}$)	1.09	1.52	1.31	1.34	

* not Haliplus immaculicollis

TABLE 4. (cont.) Benthic Macroinvertebrates, Rice Creek, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Rice 3A	Rice 3B	Rice 3C	Rice 3 (raw)	Rice 3 (%)
Dugesia tigrina	0	0	0	0	0.0%
Physella gyrina	0	7	0	7	0.7%
Fosaria parva	0	0	0	0	0.0%
Aulodrilus americanus	1	0	0	1	0.1%
Lumbriculus variigatus	0	0	0	0	0.0%
Asellus sp.	6	0	5	11	1.1%
Crangonyx gracilis	12	10	11	33	3.4%
Baetis sp.	0	1	0	1	0.1%
Caenis amica	0	0	0	0	0.0%
Hesperocorixa sp.	0	1	0	1	0.1%
Sigara sp.	0	10	0	10	1.0%
Plea striola	0	1	0	1	0.1%
Hydropsyche betteni	7	1	4	12	1.2%
Peltodytes lengi	0	2	0	2	0.2%
Haliplus immaculicollis	0	1	0	1	0.1%
Haliplus sp. *	0	1	0	1	0.1%
Hydroporus sp. larva	0	1	0	1	0.1%
Hydaticus modestus	1	1	0	2	0.2%
Berosus sp. larva	0	0	1	1	0.1%
Tropisternus lateralis	0	1	0	1	0.1%
Tropisternus sp. larva	0	1	0	1	0.1%
Hydrochus sp.	0	1	0	1	0.1%
Family Helodidae	0	0	0	0	0.0%
Dubiraphia sp. larva	0	0	0	0	0.0%
Culicoides sp.	0	0	0	0	0.0%
Natarsia baltimoreus	13	2	2	17	1.8%
Harnischia sp.	2	0	0	2	0.2%
Glypototendipes lobiferus	594	65	128	787	81.6%
Tanytarsus sp.	0	0	0	0	0.0%
Simulium sp.	28	17	26	71	7.4%
Strotiomys sp.	0	0	0	0	0.0%
Hemerodromia sp.	0	0	0	0	0.0%
Number of Species	9	18	7	22	
Number of Individuals	664	124	177	965	
Diversity ($\bar{H}$)	0.71	2.27	1.30	1.18	

* not Haliplus immaculicollis

TABLE 5. Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Composite Samples

Species	Round Lake 1 (raw)	Round Lake 1 (%)	Round Lake 2 (raw)	Round Lake 2 (%)	Round Lake 3 (raw)	Round Lake 3 (%)	Round Lake 4 (raw)	Round Lake 4 (%)
Dugesia tigrina	0	0%	0	0%	0	0%	0	0%
Physella gyrina	4	4%	4	5%	0	0%	0	0%
Mentus dilatus	11	10%	13	17%	7	9%	6	14%
Planorbula armiger	0	0%	0	0%	0	0%	0	0%
Sphaerium sp.	2	2%	9	12%	19	24%	10	23%
Aulodrilus americanus	8	7%	8	10%	11	14%	0	0%
Lumbriculus variigatus	0	0%	0	0%	0	0%	0	0%
Glossiphonia complanata	1	1%	0	0%	0	0%	1	2%
Erpobdella punctata	2	2%	0	0%	0	0%	0	0%
Crangonyx gracilis	40	35%	5	6%	16	20%	1	2%
Oronectes sp.	0	0%	0	0%	0	0%	0	0%
Caenis amica	2	2%	0	0%	2	3%	0	0%
Hexagenia bilineata	0	0%	0	0%	0	0%	0	0%
Hesperocorixa sp.	0	0%	0	0%	0	0%	0	0%
Hydroptila consimilus	0	0%	0	0%	0	0%	1	2%
Hesperophylax designatus	16	14%	0	0%	7	9%	20	45%
Agrypnia vestita	1	1%	3	4%	0	0%	0	0%
Haliplus sp. larva	1	1%	0	0%	0	0%	0	0%
Coptotomus sp. larva	0	0%	0	0%	0	0%	0	0%
Chaoborus punctipennis	1	1%	3	4%	7	9%	5	11%
Culicoides sp.	1	1%	0	0%	0	0%	0	0%
Dasyhelea grisea	0	0%	0	0%	0	0%	0	0%
Ablabesmyia mallochi	11	10%	0	0%	4	5%	0	0%
Natarsia baltimoreus	0	0%	0	0%	0	0%	0	0%
Procladius sublettei	0	0%	8	10%	0	0%	0	0%
Chironomus decorus	11	10%	24	31%	7	9%	0	0%
Chironomus riparus	0	0%	0	0%	0	0%	0	0%
Cryptochironomus fulvus	1	1%	0	0%	0	0%	0	0%
Tanytarsus sp.	0	0%	0	0%	0	0%	0	0%
Number of Species	16		9		9		7	
Number of Individuals	113		77		80		44	
Diversity ($\bar{H}$)	2.76		2.58		2.67		1.86	

TABLE 5. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Composite Samples

Species	Sun-fish Lake 1 (raw)	Sun-fish Lake 1 (%)	Sun-fish Lake 2 (raw)	Sun-fish Lake 2 (%)	Sun-fish Lake 3 (raw)	Sun-fish Lake 3 (%)	Snail Lake 1 (raw)	Snail Lake 1 (%)
Dugesia tigrina	0	0%	0	0%	0	0%	1	1%
Physella gyrina	4	3%	12	18%	14	19%	0	0%
Mentus dilatus	5	4%	0	0%	0	0%	0	0%
Planorbula armiger	2	1%	0	0%	7	9%	0	0%
Sphaerium sp.	0	0%	1	1%	0	0%	2	2%
Aulodrilus americanus	89	65%	10	15%	4	5%	7	8%
Lumbriculus variigatus	0	0%	0	0%	0	0%	7	8%
Glossiphonia complanata	1	1%	2	3%	0	0%	0	0%
Erpobdella punctata	0	0%	0	0%	0	0%	0	0%
Crangonyx gracilis	19	14%	0	0%	2	3%	51	55%
Oronectes sp.	2	1%	0	0%	0	0%	0	0%
Caenis amica	0	0%	0	0%	0	0%	0	0%
Hexagenia bilineata	0	0%	0	0%	0	0%	7	8%
Hesperocorixa sp.	0	0%	1	1%	0	0%	0	0%
Hydroptila consimilus	0	0%	0	0%	0	0%	1	1%
Hesperophylax designatus	0	0%	0	0%	0	0%	0	0%
Agrypnia vestita	0	0%	0	0%	0	0%	0	0%
Haliplus sp. larva	0	0%	0	0%	0	0%	0	0%
Coptotomus sp. larva	1	1%	0	0%	0	0%	0	0%
Chaoborus punctipennis	0	0%	17	25%	13	17%	0	0%
Culicoides sp.	0	0%	0	0%	0	0%	1	1%
Dasyhelea grisea	0	0%	0	0%	0	0%	7	8%
Ablabesmyia mallochi	0	0%	0	0%	0	0%	0	0%
Natarsia baltimoreus	0	0%	0	0%	0	0%	2	2%
Procladius sublettei	1	1%	3	4%	4	5%	0	0%
Chironomus decorus	10	7%	20	30%	28	37%	0	0%
Chironomus riparus	0	0%	1	1%	3	4%	0	0%
Cryptochironomus fulvus	2	1%	0	0%	0	0%	0	0%
Tanytarsus sp.	0	0%	0	0%	0	0%	7	8%
Number of Species	11		9		8		11	
Number of Individuals	136		67		75		93	
Diversity ($\bar{H}$)	1.67		2.25		2.29		2.10	

TABLE 6. Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Round Lake, TCAAP, MN

Species	Round 1A	Round 1B	Round 1C	Round Lake 1 (raw)	Round Lake 1 (%)
Dugesia tigrina				0	0%
Physella gyrina	1	2	1	4	4%
Mentus dilatus	4	0	7	11	10%
Planorbula armiger				0	0%
Sphaerium sp.	1	1	0	2	2%
Aulodrilus americanus	6	2	0	8	7%
Lumbriculus variigatus				0	0%
Glossiphonia complanata	0	1	0	1	1%
Erpobdella punctata	0	1	1	2	2%
Crangonyx gracilis	32	6	2	40	35%
Oronectes sp.				0	0%
Caenis amica	0	1	1	2	2%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus				0	0%
Hesperophylax designatus	5	10	1	16	14%
Agrypnia vestita	0	0	1	1	1%
Haliplus sp. larva	0	0	1	1	1%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	1	0	0	1	1%
Culicoides sp.	0	1	0	1	1%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi	5	4	2	11	10%
Natarsia baltimoreus				0	0%
Procladius sublettei				0	0%
Chironomus decorus	8	1	2	11	10%
Chironomus riparus				0	0%
Cryptochironomus fulvus	1	0	0	1	1%
Tanytarsus sp.				0	0%
Number of Species	10	11	10	16	
Number of Individuals	64	30	19	113	
Diversity ($\bar{H}$)	2.12	2.36	2.23	2.76	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Round 2A	Round 2B	Round 2C	Round Lake 2 (raw)	Round Lake 2 (%)
Dugesia tigrina				0	0%
Physella gyrina	0	2	2	4	5%
Mentus dilatus	0	10	3	13	17%
Planorbula armiger				0	0%
Sphaerium sp.	2	4	3	9	12%
Aulodrilus americanus	0	1	7	8	10%
Lumbriculus variigatus				0	0%
Glossiphonia complanata				0	0%
Erpobdella punctata				0	0%
Crangonyx gracilis	0	2	3	5	6%
Oronectes sp.				0	0%
Caenis amica				0	0%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus				0	0%
Hesperophylax designatus				0	0%
Agrypnia vestita	3	0	0	3	4%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	1	0	2	3	4%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus				0	0%
Procladius sublettei	3	2	3	8	10%
Chironomus decorus	2	15	7	24	31%
Chironomus riparus				0	0%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.				0	0%
Number of Species	5	7	8	9	
Number of Individuals	11	36	30	77	
Diversity ($\bar{H}$)	1.67	1.91	2.37	2.58	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Round 3A	Round 3B	Round 3C	Round Lake 3 (raw)	Round Lake 3 (%)
Dugesia tigrina				0	0%
Physella gyrina				0	0%
Mentus dilatus	3	2	2	7	9%
Planorbula armiger				0	0%
Sphaerium sp.	17	0	2	19	24%
Aulodrilus americanus	3	1	7	11	14%
Lumbriculus variigatus				0	0%
Glossiphonia complanata				0	0%
Erpobdella punctata				0	0%
Crangonyx gracilis	2	0	14	16	20%
Oronectes sp.				0	0%
Caenis amica	2	0	0	2	3%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus				0	0%
Hesperophylax designatus	4	1	2	7	9%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	2	4	1	7	9%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi	3	1	0	4	5%
Natarsia baltimoreus				0	0%
Procladius sublettei				0	0%
Chironomus decorus	2	0	5	7	9%
Chironomus riparus				0	0%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.				0	0%
Number of Species	9	5	7	9	
Number of Individuals	38	9	33	80	
Diversity ($\bar{H}$)	2.22	1.48	1.95	2.67	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Round 4A	Round 4B	Round 4C	Round Lake 4 (raw)	Round Lake 4 (%)
Dugesia tigrina				0	0%
Physella gyrina				0	0%
Mentus dilatus	2	4	0	6	14%
Planorbula armiger				0	0%
Sphaerium sp.	1	2	7	10	23%
Aulodrilus americanus				0	0%
Lumbriculus variigatus				0	0%
Glossiphonia complanata	1	0	0	1	2%
Erpobdella punctata				0	0%
Crangonyx gracilis	0	0	1	1	2%
Oronectes sp.				0	0%
Caenis amica				0	0%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus	1	0	0	1	2%
Hesperophylax designatus	7	5	8	20	45%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	0	5	0	5	11%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus				0	0%
Procladius sublettei				0	0%
Chironomus decorus				0	0%
Chironomus riparus				0	0%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.				0	0%
Number of Species	5	4	3	7	
Number of Individuals	12	16	16	44	
Diversity ($\bar{H}$)	1.33	1.56	1.05	1.86	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Sunfish Lake, TCAAP, MN

Species	Sun 1A	Sun 1B	Sun 1C	Sunfish Lake 1 (raw)	Sunfish Lake 1 (%)
Dugesia tigrina				0	0%
Physella gyrina	2	2	0	4	3%
Mentus dilatus	4	1	0	5	4%
Planorbula armiger	0	1	1	2	1%
Sphaerium sp.				0	0%
Aulodrilus americanus	19	26	44	89	65%
Lumbriculus variigatus				0	0%
Glossiphonia complanata	0	1	0	1	1%
Erpobdella punctata				0	0%
Crangonyx gracilis	8	9	2	19	14%
Oronectes sp.	0	1	1	2	1%
Caenis amica				0	0%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus				0	0%
Hesperophylax designatus				0	0%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva	1	0	0	1	1%
Chaoborus punctipennis				0	0%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus				0	0%
Procladius sublettei	1	0	0	1	1%
Chironomus decorus	3	5	2	10	7%
Chironomus riparus				0	0%
Cryptochironomus fulvus	1	0	1	2	1%
Tanytarsus sp.				0	0%
Number of Species	8	8	6	11	
Number of Individuals	39	46	51	136	
Diversity ($\bar{H}$)	1.90	1.69	0.74	1.67	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Sun 2A	Sun 2B	Sun 2C	Sunfish Lake 2 (raw)	Sunfish Lake 2 (%)
Dugesia tigrina				0	0%
Physella gyrina	6	6	0	12	18%
Mentus dilatus				0	0%
Planorbula armiger				0	0%
Sphaerium sp.	0	0	1	1	1%
Aulodrilus americanus	1	7	2	10	15%
Lumbriculus variigatus				0	0%
Glossiphonia complanata	1	0	1	2	3%
Erpobdella punctata				0	0%
Crangonyx gracilis				0	0%
Oronectes sp.				0	0%
Caenis amica				0	0%
Hexagenia bilineata				0	0%
Hesperocorixa sp.	0	0	1	1	1%
Hydroptila consimilus				0	0%
Hesperophylax designatus				0	0%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	4	4	9	17	25%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus				0	0%
Procladius sublettei	0	1	2	3	4%
Chironomus decorus	11	5	4	20	30%
Chironomus riparus	1	0	0	1	1%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.				0	0%
Number of Species	6	5	7	9	
Number of Individuals	24	23	20	67	
Diversity ($\bar{H}$)	1.67	1.80	1.83	2.25	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Sun 3A	Sun 3B	Sun 3C	Sun-fish Lake 3 (raw)	Sun-fish Lake 3 (%)
Dugesia tigrina				0	0%
Physella gyrina	3	2	9	14	19%
Mentus dilatus				0	0%
Planorbula armiger	3	4	0	7	9%
Sphaerium sp.				0	0%
Aulodrilus americanus	1	0	3	4	5%
Lumbriculus variigatus				0	0%
Glossiphonia complanata				0	0%
Erpobdella punctata				0	0%
Crangonyx gracilis	0	2	0	2	3%
Oronectes sp.				0	0%
Caenis amica				0	0%
Hexagenia bilineata				0	0%
Hesperocorixa sp.				0	0%
Hydroptila consimilus				0	0%
Hesperophylax designatus				0	0%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis	2	3	8	13	17%
Culicoides sp.				0	0%
Dasyhelea grisea				0	0%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus				0	0%
Procladius sublettei	0	2	2	4	5%
Chironomus decorus	0	4	24	28	37%
Chironomus riparus	0	0	3	3	4%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.				0	0%
Number of Species	4	6	6	8	
Number of Individuals	9	17	49	75	
Diversity ($\bar{H}$)	1.39	1.99	1.83	2.29	

TABLE 6. (cont.) Benthic Macroinvertebrates in Lakes, TCAAP, MN, 28 June - 3 July 1993, Raw Data

Species	Snail 1A	Snail 1B	Snail 1C	Snail Lake 1 (raw)	Snail Lake 1 (%)
	Snail Lake, TCAAP, MN				
Dugesia tigrina	1	0	0	1	1%
Physella gyrina				0	0%
Mentus dilatus				0	0%
Planorbula armiger				0	0%
Sphaerium sp.	1	1	0	2	2%
Aulodrilus americanus	1	3	3	7	8%
Lumbriculus variigatus	3	2	2	7	8%
Glossiphonia complanata				0	0%
Erpobdella punctata				0	0%
Crangonyx gracilis	29	15	7	51	55%
Oronectes sp.				0	0%
Caenis amica				0	0%
Hexagenia bilineata	2	2	3	7	8%
Hesperocorixa sp.				0	0%
Hydroptila consimilus	1	0	0	1	1%
Hesperophylax designatus				0	0%
Agrypnia vestita				0	0%
Haliplus sp. larva				0	0%
Coptotomus sp. larva				0	0%
Chaoborus punctipennis				0	0%
Culicoides sp.	1	0	0	1	1%
Dasyhelea grisea	2	3	2	7	8%
Ablabesmyia mallochi				0	0%
Natarsia baltimoreus	1	0	1	2	2%
Procladius sublettei				0	0%
Chironomus decorus				0	0%
Chironomus riparus				0	0%
Cryptochironomus fulvus				0	0%
Tanytarsus sp.	2	5	0	7	8%
Number of Species	11	7	6	11	
Number of Individuals	44	31	18	93	
Diversity ($\bar{H}$)	1.67	1.89	1.85	2.10	

APPENDIX E REFERENCES

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APPENDIX F
ACID VOLATILE SULFIDE ANALYSIS

UNIVERSITY OF WISCO[illegible]

Superior
1893-19

LAKE SUPERIOR RESEARCH INSTITUTE
BARSTOW HALL, ROOM 4
1800 GRAND AVENUE
SUPERIOR, WISCONSIN 54880-2898
(715) 394-8315

April 13, 1994

[illegible] 18
[illegible]A. Ground
[illegible] Solid Waste

Mark L. Ferrey
Minnesota Pollution Control Agency
520 Lafayette Rd. N.
St. Paul, MN 55155-4194

Post-it™ Fax Note 7671	Date 1-18-95	# of pages ▸ 7
To Matt McAtee	From Mark Ferrey	
Co/Dept. U.S. Army Chpm.	Co. MPCA	
Phone # 410 612-8552	Phone # 612 296 7775	
Fax # 410 671 5237	Fax # 612 296 9707	

Dear Mark:

Enclosed please find the report for the analysis of the sediment core samples from Round Lake and Sunfish Lake. I hope the report will provide you with the additional information you were interested in obtaining about these sediment samples. I have enjoyed working with you on this project and if I can be of further assistance please don't hesitate to contact me.

Sincerely,

Thomas P. Markee

Thomas P. Markee
Associate Scientist

Enclosure

Ground Water & Solid Was[te] Site Response Secti[on]
Site Name
Category
Subcategory
Initials

Sample Receipt and Processing

The Minnesota Pollution Control Agency sent eight sediment core samples to the Lake Superior Research Institute to be analyzed for acid volatile sulfide (AVS) and simultaneously extractable metals (SEM). Six of the core samples were from Round Lake and the other two were from Sunfish Lake. The core samples were received on Friday, March 18, 1994. At the time of arrival, the core samples were frozen. They were removed from the cooler, inspected and placed in a freezer until the following Monday.

On Monday, March 21, 1994, the samples were removed from the freezer and allowed to thaw. Core processing was conducted in a glove bag under a nitrogen atmosphere. The processing involved removing and discarding the top inch of sediment from the core sample. The core segment between one and six inches in depth in the core tube was transferred into a teflon beaker and stirred to homogenize the sediment sample. Two portions of the homogenized sample were transferred into plastic zip-lock bags, sealed, and then removed from the glove bag. One portion of the sample was to be analyzed while the other was a duplicate to be used in case any problems were encountered with the analysis of the original sediment sample. Samples from Round Lake sites #3 and #4 consisted of two cores (A + B) each. The cores from these sites were processed in the same manner as previously described except for the following change. The one through six inch segments that were saved from both cores were combined and mixed to give a composite sample for each site from the two cores. The sediment samples in the zip-lock bags were frozen until they were analyzed.

Sample Analyses

Acid volatile sulfide analysis was conducted on March 22 and March 23, 1994. The procedure used followed the EPA's "Draft Analytical Method for Determination of Acid Volatile Sulfide in Sediment". The method involves the conversion of the AVS in the sediment sample to hydrogen sulfide by acidification of the sample with hydrochloric acid. The hydrogen sulfide was purged from the sample and transferred to a silver nitrate trapping solution by bubbling nitrogen through the AVS apparatus. The mass of silver sulfide precipitate formed was determined and the original AVS concentration calculated.

The simultaneously extractable metals were liberated from the sediment along with the AVS by the acidification of the sample with hydrochloric acid. After the hydrogen sulfide formed by the acidification was purged from the reaction flask, the acid solution in the reaction flask was filtered to remove sediment particles and the solution saved for the analysis of metal concentrations. The SEM samples were analyzed for cadmium, copper, lead, mercury, nickel and zinc. Quantification of metal concentrations was done by flame atomic absorption for all the metals except mercury which was analyzed by cold vapor technique.

Quality Control

Quality control samples were processed along with the AVS and SEM samples and included a laboratory reagent blank, laboratory fortified blanks, spikes, duplicates and a standard reference material. The laboratory reagent blank consisted of deionized water to which hydrochloric acid was added. Several fortified blanks were analyzed. They included a blank to which a known amount of sulfide was added, a blank to which known amounts of the metals to be analyzed were added and a blank to which both sulfide and metals were added. For all the metals analyses, two samples were spiked with known amounts of the analyte to determine the spike recovery efficiency. Round Lake composite sample #4A + 4B was analyzed in duplicate for each of the parameters determined. A standard reference material was analyzed for cadmium, copper, nickel and zinc. No standard reference is currently available for the AVS determination, nor did we have an appropriate reference available for lead or mercury.

Results and Discussion

The simultaneously extractable metal concentrations are provided in Table 1. These concentrations are reported in μmoles of metal per gram of dry sediment. The values have been recovery corrected based on the average spike recovery found for the spiked samples. The total umoles of simultaneously extractable metals (Σ [Metals]) was calculated by summing the individual μmole contributions for each metal. A value equal to the detection limit was used in the summation in each instance where a reported value was less than the detection limit.

Zinc contributed between 70 and 85% of the total μmoles of SEM for each of the sediment samples. Mercury and cadmium contributions were near or below the detection limit for all samples. Round Lake sample #2 had a copper concentration significantly higher than any of the other copper levels. Lead and nickel made intermediate contributions to the total SEM value.

The acid volatile sulfide and percent dry weight values are given in Table 2. The AVS values ranged from less than 0.9 μmoles per gram of dry sediment for the Sunfish Lake sample #2 to 4.9 μmoles per gram in the Round Lake #3A + 3B sample. The percent dry weight was similar for all samples except the Round Lake #2 sample which had approximately twice as much solids as the other samples.

Table 2 also provides a ratio of the μmoles of SEM to the μmoles of AVS. This ratio is important because if the molar ratio of toxic metals measured by SEM to AVS exceeds one, the metals are potentially bioavailable. At the time these samples were analyzed, only Round Lake site #2 had a SEM to AVS ratio greater than one. This would indicate that the metals at this site could potentially be toxic to aquatic organisms. A ratio for Sunfish Lake sample #2 could not be calculated because the AVS value was found to be below the detection limit of the method used.

Seasonal variation in AVS concentrations has been found by a number of researchers. AVS levels increase during anoxic periods and decrease if oxygen levels are replenished. For this reason, it is possible that toxic metals could become bioavailable at some of the other sites studied in this project. The data would seem to indicate that Round Lake site #3 would be the most likely location for this to occur.

Data from the quality control analyses are presented in Table 3. The laboratory reagent blank was found to have levels of all measured parameters below the detection limit for those parameters. The two sulfide fortified lab blanks were found to have an average sulfide recovery of 89.5%. This recovery falls within the expected range for the AVS determination and was used to correct the AVS concentrations for all samples.

The SEM spike recoveries for the sulfide plus metals fortified lab blank ranged from less than 2% for mercury to 105% for zinc. The recoveries of mercury and copper were quite low and for that reason a second metals only fortified lab blank was prepared and analyzed. The recoveries of mercury (80.6%) and copper (100.4%) were much better for this fortified blank. The sulfides of mercury and copper are much less soluble than the sulfides of the other simultaneously extractable metals and this is believed to have resulted in the substantially lower recoveries in the lab blank fortified with both metals and sulfide. This would seem to indicate that in actual samples containing measurable AVS levels the sulfides of mercury and copper would be only slightly to partially soluble reducing the likelihood of finding high levels of these metals being bioavailable.

The mean spike recoveries of the metals ranged from 92.6% to 107.3%. These values are all within the range our quality assurance plan indicates as acceptable. All reported metal concentrations have been corrected for the average spike recovery for that metal. The duplicate agreement of the metals concentrations ranged from 88.3% to 100% and that of the AVS analysis was 70.8%. These values fall within the range of agreements that we have previously found for AVS and SEM samples.

A metals reference standard (Environmental Resource Associates, Lot #3402) was analyzed for cadmium, copper, nickel and zinc. The analytical values obtained were all well within the advisory range provided for the reference standard.

Table 1. Simultaneously Extractable Metals (SEM) Concentrations found in Sediment Core Samples Collected from Round Lake and Sunfish Lake. The Concentrations Reported are in μmoles of Metal per Gram of Dry Sediment.

Sample	Cadmium	Copper	Mercury	Nickel	Lead	Zinc	Σ [Metals]
Round Lake 1	<0.0041	0.0164	<0.0002	0.0686	0.0322	0.4148	0.5363
Round Lake 2	0.0023	0.2445	<0.0001	0.0919	0.0596	2.4348	2.8332
Round Lake 3A+3B	0.0059	0.0166	<0.0003	0.1376	0.0817	1.4072	1.6493
Round Lake 4A+4B	<0.0040	0.0160	<0.0002	0.0669	0.0212	0.2815	0.3898
Round Lake 4A+4B Dup.	<0.0040	0.0138	<0.0002	0.0662	0.0230	0.2769	0.3841
Sunfish Lake 1	<0.0051	<0.0081	<0.0003	0.0531	0.0527	0.5861	0.7054
Sunfish Lake 2	<0.0040	<0.0064	<0.0002	0.0793	0.0282	0.3290	0.4471

Table 2. Summary of Analytical Data Obtained from the Analysis of Sediment Core Samples Collected from Round Lake and Sunfish Lake. The Concentrations Reported are Recovery Corrected Concentrations.

Sample	% Dry Weight	AVS (µmole/g)	Σ[Metals] µmol/g	Ratio (Σ[Metals]/AVS)
Round Lake 1	28.88	3.7	0.5363	0.14
Round Lake 2	57.34	2.1	2.8332	1.35
Round Lake 3A+3B	24.18	4.9	1.6493	0.34
Round Lake 4A+4B	29.66	2.4	0.3898	0.16
Round Lake 4A+4B Dup.	29.86	1.7	0.3841	0.23
Sunfish Lake 1	24.54	1.5	0.7054	0.47
Sunfish Lake 2	28.85	<0.9 0.3	0.4471	-

Table 3. Results of Quality Control Samples for Simultaneously Extractable Metals and Acid Volatile Sulfide. Metal Concentrations are Reported in μg/L and AVS in μmoles/g for the Laboratory Reagent Blank.

Quality Control Sample	Cd	Cu	Hg	Ni	Pb	Zn	AVS
Laboratory Reagent Blank	<7.7	<6.9	<0.8	<14	<65	<4	<0.9
Laboratory Fortified Blank Recovery-Sulfide Added (%)							90.6
Laboratory Fortified Blank Recovery-Sulfide + Metals Added (%)	102.3	49.7	<2.0	104.3	103.8	105.0	88.3
Laboratory Fortified Blank Recovery-Metals Added (%)	-	100.4	80.9	101.9	102.5	-	
Mean Spike Recovery (%)	93.4	98.3	98.2	92.6	107.3	98.4	
Duplicate Agreement (%)	100	86.3	100	99.0	92.2	98.4	70.8
Metals Reference Standard							
LSRI Analyzed Value	91.6	133.3	*	442	*	547	*
Certified Value	87.7	130		429		571	

* Appropriate reference standard not available.

APPENDIX G

MPCA SAMPLING OF RICE CREEK

Minnesota Pollution Control Agency

December 23, 1993

Mr. Art Asaki
Water Quality
U.S. Army Environmental Hygiene Agency
Aberdeen Proving Ground, Maryland 21010-5422

Attention: HSHB-ME-W

Dear Mr. Asaki:

Please find enclosed the results of the October 1992, Minnesota Pollution Control Agency sampling of Rice Creek that we discussed last week.

Two samples each of surface water and sediment were taken from Rice Creek. The locations of these samples are as follows:

SW refers to surface water sample;

SE refers to sediment sample;

01 refers to samples taken approximately 30 feet downstream of the upper Site K outfall;

02 refers to samples taken approximately 100 feet upstream of the upper Site K outfall;

C refers to samples tested for cyanide; and

M refers to samples tested for metals.

Please feel free to contact me at (612) 296-7775 should you have any questions about this data.

Sincerely,

Mark L. Ferrey
Soil Scientist/Technical Analyst
Response Unit I
Site Response Section
Ground Water and Solid Waste Division

MLF:ch

Enclosure

Discussion

Routine Braun Intertec QA/QC was followed. No anomalies were encountered in the analysis of these samples.

We appreciate the opportunity to meet your analytical needs. If you have any questions or need additional information, please call Cynthia Weber at (612) 942-4812.

Sincerely,

Cynthia H. Weber
Project Manager

Anne L. Ochs
Laboratory Manager

chw/alo:prg

Attachments
Chain of Custody

Minnesota Pollution Control Agency
520 Lafayette Road, St. Paul, MN 55155-4194

MARK L. FERREY
Soil Scientist/Research Analyst
Response Unit I, Site Response Section
Ground Water and Solid Waste Division
(612) 296-7775 Fax (612) 296-9707

BRAUN℠
INTERTEC

Braun Intertec Environmental, Inc.
6875 Washington Avenue South
P.O. Box 39108
Minneapolis, Minnesota 55439-0108
612-941-5600 Fax: 942-4844

Project No: CMXX-91-033L
Report No: 92-2417

November 6, 1992

Mr. Luke Charpentier
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155

Dear Mr. Charpentier:

Re: Project No: 835652/PL
TCAAP - New Brighton

Braun Intertec Environmental, Inc. (Braun Intertec) received the following samples on October 9, 1992 for chemical analyses.

Braun Intertec I.D.	Client Sample I.D.	Sample Matrix
92-2417-02	SW 01 C	Liquid
92-2417-03	SW 01 M	Liquid
92-2417-04	SW 02 C	Liquid
92-2417-05	SW 02 M	Liquid
92-2417-06	SE 01 MC	Solid
92-2417-07	SE 02 MC	Solid

Results

Analytical results are summarized on the following laboratory report.

Methodology

The samples were analyzed following Braun Intertec standard operating procedures based on the methods listed below.

Parameters	Method	Date Analyzed
Cyanide, Total	EPA 335.2	10/12/92
Arsenic, Total	EPA 206.2	10/12/92
Barium, Total	EPA 200.7	10/22/92
Beryllium, Total	EPA 210.2	10/26/92
Copper, Total	EPA 220.2	10/14/92
Cadmium, Total	EPA 213.2	10/13/92
Chromium, Total	EPA 218.2	10/12/92
Lead, Total	EPA 239.2	10/15/92
Mercury, Total	EPA 245.1	10/23/92
Manganese, Total	EPA 200.7	10/22/92
Antimony, Total	EPA 204.2	10/20/92
Zinc, Total	EPA 200.7	10/22/92
Cyanide, Total	SW 846 9010	10/21/92
Arsenic, Total	SW 846 7060	10/16/92
Barium, Total	SW 846 6010	10/19/92
Beryllium, Total	SW 846 7090	10/28/92
Copper, Total	SW 846 6010	10/19/92
Cadmium, Total	SW 846 7130	10/20/92
Chromium, Total	SW 846 6010	10/19/92
Lead, Total	SW 846 6010	10/19/92
Mercury, Total	SW 846 6010	10/19/92
Manganese, Total	SW 846 6010	10/19/92
Antimony, Total	SW 846 7040	10/28/92
Zinc, Total	SW 846 6010	10/19/92

Minnesota Pollution Control Agency
20 Lafayette Road

St. Paul, MN 55155

PROJECT: CVXX-91-033L
COLLECTED: Client
RECEIVED: 09-OCT-92

PARAMETER	Braun Intertec ID:	92-2417-02		92-2417-03		92-2417-04		92-2417-05	
	Client ID:	SW 01 C		SW 01 M		SW 02 C		SW 02 M	
	Matrix:	Liquid		Liquid		Liquid		Liquid	
	Collect Date:	09-OCT-92		09-OCT-92		09-OCT-92		09-OCT-92	
Cyanide, Total		<0.01	mg/L	-		<0.01	mg/L	-	
Antimony, Total		-		<6.0	ug/L	-		<6.0	ug/L
Arsenic, Total		-		<2.0	ug/L	-		<2.0	ug/L
Barium, Total		-		0.06	mg/L	-		0.06	mg/L
Beryllium, Total		-		<0.2	ug/L	-		<0.2	ug/L
Cadmium, Total		-		<0.2	ug/L	-		<0.2	ug/L
Chromium, Total		-		<0.5	ug/L	-		<0.5	ug/L
Copper, Total		-		<1.0	ug/L	-		<1.0	ug/L
Lead, Total		-		<2.0	ug/L	-		<2.0	ug/L
Mercury, Total		-		0.8	ug/L	-		0.6	ug/L
Manganese, Total		-		0.13	mg/L	-		0.13	mg/L
Zinc, Total		-		<0.02	mg/L	-		<0.02	mg/L

< = less than: compound not detected at or above indicated detection limit
\- = Analysis not required

Quality control data reviewed: WRU

06-NOV-92

BRAUN INTERTEC REPORT NO: 922417

PROJECT: CVXX-91-033L
COLLECTED: Client
RECEIVED: 09-OCT-92

Minnesota Pollution Control Agency
) Lafayette Road

St. Paul, MN 55155

PARAMETER	Braun Intertec ID: 92-2417-06		92-2417-07	
	Client ID: SE 01 MC		SE 02 MC	
	Matrix: Solid		Solid	
	Collect Date: 09-OCT-92		09-OCT-92	
Cyanide, Total	<0.2	mg/Kg	<0.2	mg/Kg
Antimony, Total	<50	mg/Kg	<50	mg/Kg
Arsenic, Total	<2.0	mg/Kg	<2.0	mg/Kg
Barium, Total	20	mg/Kg	10	mg/Kg
Beryllium, Total	<0.5	mg/Kg	<0.5	mg/Kg
Cadmium, Total	<0.5	mg/Kg	<0.5	mg/Kg
Chromium, Total	3.8	mg/Kg	1.9	mg/Kg
Copper, Total	4.6	mg/Kg	1.4	mg/Kg
Lead, Total	7.6	mg/Kg	<3.4	mg/Kg
Mercury, Total	0.02	mg/Kg	0.02	mg/Kg
Manganese, Total	130	mg/Kg	49	mg/Kg
Zinc, Total	17	mg/Kg	5.5	mg/Kg

< = less than: compound not detected at or above indicated detection limit
- = Analysis not required

Quality control data reviewed: URO

APPENDIX H

RESPONSE TO REGULATOR COMMENTS ON THE JULY 1996 VERSION

Comments by the U.S. Environmental Protection Agency

1. Section 4.3.2, Page 13, Paragraph 1. This paragraph states that three unknown chemicals were discovered in Sunfish Lake. It is unclear if "unknown" indicates that the laboratory was not able to identify the chemicals or if the chemicals are not included in the list of compounds that the laboratory scanned for and therefore identification of the chemicals was not attempted. An explanation clarifying this issue should be provided.

Response: Yes, three unknown chemicals were discovered in Sunfish Lake sediments. These were discovered at SFL03SE, SFL08SE, and SFL10SE. They were identified as unknowns 069 (400μg/g), 091 (0.05μg/g), and 092 (0.04μg/g), respectively. These unknown chemicals were not labeled as tentatively identified compounds (TICs) because their analysis outcomes did not meet the necessary criteria. These substances were labeled as "unknowns" because no match was found in the mass spectral library. The substances would have been labeled TICs if they were at least 10% of the response of the mearest internal standard and were matched against the library (Smith 1994). We presume that the lab examined the 30 largest peaks in the volatile run for TICs and the 30 largest peaks in each extractable run that fit the criteria. Because these substances did not satisfy this criteria for being selected as TICs, they are not considered further in this risk assessment.

This text has been placed in this draft in section 4.3.2 on page 15.

2. Section 6.5, Page 43, Paragraph 3. This paragraph states that the toxicological reference values (TRV) were determined using the data presented in Section 6.4, and then were "adjusted or scaled to compensate for uncertainties inherent in these extrapolations." The uncertainties are identified in this paragraph, but the methods used to apply these uncertainties to the numerical TRVs developed in Section 6.4 are not provided. These methods should be numerically presented in Section 6.5 of the risk assessment.

Response: Within each subsection of 6.4 (July 1996 draft), the specific uncertainty factors used in the development of the toxicological reference values were identified. Uncertainty factors are multiplied with the study value to produce a lower, more conservative value. Generally, the factors are:

- 0.1 for deriving a chronic exposure value from subchronic or acute data, and

- 0.1 for deriving a NOAEL from LOAEL, EC50, or LD50 data.

The issue is clarified in the last paragraph of Section 6.1 on page 40.

Based upon the ERA Update Conference Call on 17 December 1996, two additional issues arose. First, it was agreed that a specific example of a derivation calculation for a toxicological reference value be presented in the text of the report.

Response: An example is provided in this draft in section 6.4 on page 43.

Based upon this same conference call another issue has been addressed. Steve Hennes (MPCA) and Matt McAtee (CHPPM) discussed some of the recent scientific investigations in regard to toxicological scaling factors for avian species and how preliminary studies have shown them to be different from mammalian scaling factors (the approach used in the July 1996 draft). Due to the limited number of studies completed on the issue it was agreed that CHPPM would consider the issue (specifically a paper provided by Steve—Mineau et al. 1996). However, the consensus during the call was that we are not *yet* compelled to change the avian scaling factor for the TCAAP investigation.

Response: Based upon a CHPPM review of the paper which Steve provided, this draft incorporates an avian scaling factor for use in extrapolation of toxicity characteristics between species of birds. Refer to section 6.4, page 43 for more detail. This change has altered some of the toxicological reference values, but has no overall impact on the conclusions.

3. Section 7, Page 45, Paragraph 6. This paragraph states that hazard index (HI) is used as the decision point for determining if further "effort" is required, but Section 4.2.1, Page 10, Paragraph 4 states that a sediment contaminant of concern (COC) was not used in the HI evaluation when an Ontario standard lowest effect level (OSLEL) or a National Oceanic and Atmospheric Administration (NOAA) standard for the COC was unavailable. This process will screen out some COCs from further evaluation regardless of their detected concentration or spatial distribution on site. The risk assessment should consider alternative screening methods for COCs lacking OSLELs and NOAA standards (for example, the September 1994 *Interim Sediment Quality Assessment Values* from the Ecosystem Conservation Directorate of Environment Canada).

Response: It is important to note that several of the substances which the comment refers to are nutrients, such as calcium, potassium, and sodium. These substances do not have background comparative criteria, are not likely to be hazardous, nor are they likely to be TCAAP waste. On page 10 (July 1996 draft), the report states that: "calcium, potassium, and sodium were excluded as COCs in sediment [because they are essential nutrients]." A discussion regarding their significance occurs in Section 6. The tables in Appendix B in this draft have been revised and these nutrients will not be considered as COCs (see Tables 2 and 3 of this draft.

The sediment COCs (i.e., non-nutrients) without screening values are addressed in a new section in the March 1997 draft (section 8.8). In this section, Tables 13 and 14 address issues of uncertainty inherent in the use of the screening values. Based upon the discussion during the ERA Update Conference Call on 17 December 1996, we did not compare concentrations to the referenced *Interim Sediment Quality Assessment Values* of Environment Canada (EC), because the MPCA had made the comparisons and the EC document provided no additional insight into the interpretation of potential effects. Steve Hennes (MPCA) faxed the EC document to Matt McAtee (CHPPM) for informational purposes.

4. Section 7, Page 46, Paragraph 1. This paragraph states that HIs in this risk assessment will be interpreted as follows:

$HI \leq 1$ = a safe location
$1 < HI \leq 10$ = area of potential concern
$HI > 10$ = area of probable adverse effects

A HI of 1 should not be considered indicative of a safe location because it typically represents contaminant concentration that presents an unacceptable risk. The text should be changed to state that only HI values of less than 1 represent safe locations.

Response: We do not necessarily agree with the assessment that an HI of 1 does not represent a "safe" situation. It is important to understand that for the selected receptors (amphibian, heron, mallard, and muskrat) the hazards are representative of no-effect levels. For these receptors, an HI of 1, by definition, means 'no effect'. However, for the water and sediment criteria we confer to the recommendation provided. This change does not alter the conclusions of the current assessment.

5. Section 9.3, Page 61, Paragraph 3. This paragraph states that the higher concentrations detected during the first round of surface water sampling compared to the second round of surface water sampling indicates that the concentrations detected during the first round were elevated due to laboratory error; however, no explanation is provided to support the assumption that laboratory error rather than seasonal variation or sampling errors caused the different concentrations detected in the two rounds. A discussion justifying the assumption of laboratory error should be provided. Also, no explanation is provided to support the assumption that first round results indicate laboratory error rather than second round results. This paragraph also states that because results from both sampling events were used to determine ecological risk, the risk to aquatic organisms may be overestimated; however, if seasonal variation accounts for the differences between the two sampling events, risk may be underestimated if COC concentrations are highest during the more vulnerable life cycles stages of aquatic organisms. The possibility of seasonal variation in surface water concentrations and its potential impact on risk to aquatic organisms should be discussed in the risk assessment.

This paragraph also states that data from both sampling rounds were used to determine ecological risk, but the risk assessment does not explain how the two sets of data were combined to determine the ecological risk. An explanation of how both sets of data were used should be included in the risk assessment.

> Response: No documented information was identified by CHPPM in the data reports and QA/QC write-ups in the Mongomery Watson, Inc. 1994 Draft OU-2 Feasibility Study to support a rejection of the first round of sampling data from the database. The database for surface water was re-evaluated and expanded to include data from the 1994 and 1995 Annual TCAAP Monitoring Study. Refer to the new section in this draft (section 7.11 on page 61) and Tables B-11 through B-16 for this additional evaluation.
>
> The annual monitoring data has been able to assist in the evaluations of zinc, lead, and mercury only. Aluminum is not an analyte which is monitored. Some organics are monitored, however only PCBs are risk assessment COCs. Annual monitoring report data for PCBs (no detections) does not affect the conclusions of the risk assessment.
>
> Monitoring data for both lead and mercury in surface waters are consistent with the database within this risk assessment. However, zinc concentrations in both the 1994 and 1995 monitoring reports were much less than the concentrations found during the OU-2 FS first round of sampling (October 1992), and closer by comparison to the concentration levels detected in the second round (June 1993). This data provides indication that the zinc detections during October 1992 are suspect. This is important because it is these October data which are forcing the high risk modeling estimates from zinc at these sites.

End of U.S. EPA Comments

Comments by the Minnesota Pollution Control Agency

General Comments

1. The issue of the zinc and aluminum exceedances of surface-water standards must be resolved. Is there any evidence that the results from the second round of sampling are more accurate than the first round? If not, further sampling may be required. This should be included in recommendations at the end of the risk assessment. This matter is important, because as it stands, the risk assessment shows exceedances of promulgated state standards, which are applicable or relevant and appropriate requirements, requiring corrective action.

Response: Refer to the response provided to U.S. EPA comment number 5. In addition, rRecommendations to address these exceedances are provided in section 10 and are based upon the weight of evidence for potential risk as evaluated in the refined risk assessment.

2. It would be preferable not to sum hazard quotients (HQs). The assumption that all of the contaminants of concerns (COCs) would act additively across a variety of endpoints and broad range of organisms is not supportable, and adds considerable conservatism to an already conservative (except for amphibian risk) screening assessment, virtually assuring hazard indexes greater than one when there are several COCs. Although summing HQs is convenient for data presentation, it would be preferable to present individual HQs and discuss the potential impacts of the inability to address exposure to multiple chemicals in the uncertainty analysis. Could the risk figures in Appendix F be modified to show the COCs with HQ greater than one at each location?

Response: The use of the HI as a screening tool within this risk assessment has proven to be very useful and has not added excessive conservativism to the assessment. The CHPPM does agree that the assumption that *all* of the COCs act additively across various toxicological endpoints is not supportable. However, the assessment only makes this assumption to "screen out" those scenarios not likely to be adversely impacted. The assessment does not assume that the risk to any particular receptor is defined by the HI value.

In order to eliminate this confusion, Tables 5, 6, 7, and 8 of the July 1996 draft have been replaced by the new Tables 10 and 11, which do not rely on the reader to interpret the HI values. Refer to Appendices C and D (March 1997 draft) where all of the individual HQs and additive HIs are presented.

Lastly, the maps presented in Appenidx F of the July 1996 draft have been eliminated and replaced with other maps (Figures 2-7), as agreed upon during the ERA Update Meeting on 8 October 1996.

3. Include and discuss the organic carbon data that were collected to aid in interpretation of the risks due to persistent organic contaminants in sediments.

Response: This data was provided by Mark Ferrey and incorporated into the exposure and effects assessment.

4. Many of the calculations for the mean, standard deviation, and confidence levels in Appendix B using the sediment background data appear incorrect: all of the standard deviations appear incorrect, and for many of the metals, the 95 percent confidence level appears to be low, leading to a very conservative estimate of background by which to compare to site concentrations. A review of these calculations is necessary as well as resolution on the method by which the 95 percent confidence interval is calculated.

Response: The background sediment concentrations have been recalculated using a different methodology as recommended by the MPCA during the 8 October ERA Update Meeting at TCAAP. The background value has been calculated by utilizing the following algorithm:

$$[background] = \bar{x} + (t_{95\%} * SD)$$

where, x-bar is the mean background substance concentration, $t_{95\%}$ is the t-value based upon the degrees of freedom and the 95% confidence interval, and SD is the standard deviation of the background sample set.

The background sediment screening values are now presented in Table 1, page 11.

5. Mink should have been included as a species to model in addition to the muskrat because of: 1) its higher potential exposure to bioaccumulative contaminants; 2) its sensitivity to polychlorinated biphenyls (PCBs) and mercury; and 3) the fact that mink sign was observed on the site.

Response: The muskrat was specificaly chosen by the USEPA, MPCA, Army, and the USFWS due to its significance in the systems evaluated during the scoping of the risk assessment revisions in late 1994 and early 1995. Based upon this concern and the agreement during the ERA Update Meeting on 8 October 1996, the risk assessment process will utilize the mink during all future analyses (i.e., Tier II).

6. Tables of Ontario Ministry of the Environment sediment quality numbers and State the Federal Water Quality numbers must be included for review and reference.

Response: The revised report includes tables which present the Ontario and AWQS values. Refer to Tables 7 and 8 in this draft.

7. In the recommendations section, there is no mention of the two studies under development to address data gaps in the risk assessment, i.e., the sediment toxicity evaluation of Round Lake and the sediment metal bioavailabity study at Round and Sunfish Lakes. Descriptions of these studies and what data gaps they should address should be included.

Response: The revised report refers to and describes the two current studies in section 11 in this draft. In addition the revised recommendations now discuss these studies.

Specific Comments

8. The report must be dated.

Response: The report was dated July 1996. The revised report is dated 20 June 1997.

9. The Background section must include a detailed explanation of why the sediments and surface waters were split from the Operable Unit 2 (OU2) portion of the Twin Cities Army Ammunition Plant (TCAAP) Site. This will include:

a. A reference to the September 5, 1995, meeting at TCAAP at which Army, U.S. Environmental Protection Agency (EPA), and Minnesota Pollution Control Agency (MPCA) agreed to a separation of the surface water and sediment sites from the other TCAAP sites;

b. Clarification that the investigations into Round Lake, Sunfish Lake, Marsden Lake, Rice Creek, Site G sediments, and Site B sediments and surface waters are proceeding under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act and the National Contingency Plan and part of the remedial investigation/feasibility study process; and

c. Reference to the Federal Facilities Agreement between the Army, EPA, and MPCA that provides the framework for investigations and remedial decisions at TCAAP.

Response: This version of the report contains a more detailed representation of the separation of the surface water and sediment sites from Operable Unit 2, the Federal Facilities Agreement which provides the framework for the investigations, and the authority of the Comprehensvie Environmental Response, Compensation, and Liability Act. Please refer to sections 1 and 2 of the revised document.

10. Page 3, paragraph 2, Section 2.2: Change "Canadian" Geese to "Canada" Geese here and throughout rest of report.

Response: 'Canadian' Geese has been changed to 'Canada' Geese.

Sections 2.2 - 2.7, History and Ecology of Water Bodies: Include and refer to maps showing the features, habitats, etc., mentioned in these sections.

Response: Site maps are provided in Figures 1-8.

11. Page 3, paragraph 4, Section 2.2: Include reference to the U.S. Fish and Wildlife jurisdiction over Round Lake.

Response: The jurisdication of the U.S. Fish and Wildlife Service over Round Lake is acknowledged.

12. Page 5, paragraph 1, Section 2.4: Include reference to the Trumpeter Swans released by the Minnesota Department of National Resources (DNR) onto Marsden Lake.

Response: Reference is now made to the Trumpeter Swans released onto Marsden Lake.

13. Page 5, paragraph 2, Section 2.4: Replace "Minnesota Highway 96" with "Lexington Ave."

Response: Minnesota Highway 96 has been re-named in the revised report.

14. Page 9, paragraph 2, Section 4.1.2: Change "total organic compounds" to "total organic carbon" and "TOCs" to "TOC."

Response: The spelling error of total organic carbon has been corrected.

15. Page 10, paragraph 1, Section 4.2.1 and Table B-52: The UCL is actually lower than the mean plus two standard deviations in most cases, but appears otherwise in Table B-52 because of errors in the standard deviation calculation.

Response: Revisions to the use of the UCL for background sediments has been addressed in response to comment number 4.

16. Page 10, paragraph 3, Section 4.2.1: The Ontario and NOAA sediment values should be referred to as guidelines, not standards. Also, the Ontario guideline value for nickel is 16 parts per million (ppm).

Response: The Ontario and NOAA sediment values are now refered to as guidelines and not as standards. The Ontario value for nickel of 16 ppm is now utilized.

17. Page 12, paragraph 1, Section 4.3.1: PCB was also found at RL02SE, RL05SE, and RL10SE.

Response: The data set was cooperatively reviewed by Mark Ferrey (MPCA) and Matt McAtee (CHPPM) to locate any missing or mispresented data. All data should now be correctly incorporated.

18. Page 13, paragraph 1, Section 4.3.2: Clarify the significance of the three unknown chemicals. Are they semivolatile TICs? Tentative identification? Are they at high concentrations or at trace levels?

Response: Refer to the response to U.S. EPA comment number 1.

19. Page 13, paragraph 2, Section 4.3.2: Lead was also found at SFL08 at 2.5 ppb.

Response: Lead in surface water sample SFL08SW was detected at 2.5 ppb and the text has been revised to reflect this.

20. Page 16, paragraph 1, Section 4.4: The reference to paragraph 5.2 is incorrect; please change to the correct paragraph number. Do not eliminate the unknown chemicals completely from the assessment, but discuss these as components of the uncertainty section, especially if they occur in high concentrations. Also discuss whether further investigation is required to determine their identity.

Response: The correct paragraph reference in this section is to paragraph 4.2. Please refer to the response to comment 18 for a discussion of how the unknown chemicals are handled.

21. Page 19, paragraph 1, Section 5.3.1: Clarify whether the equation found in Menzie et al. (1992), used to estimate BAFs for plant uptake, is equally valid for animals and plants.

Response: A more appropriate plant uptake algorithm was researched, but an updated or better model was not found. This draft continues to use the original algorithm and the uncertianty of its use for plant uptake is relatively minor.

22. Page 24, Section 5.5.2, and Appendix E: It would make sense, if assuming that waterfowl range over the entire waterbody (e.g., Round Lake, Sunfish Lake, Marsden Lake), to sum the HQs for individual contaminants across sampling locations to derive a waterbody HQ for each contaminant, in addition to the sampling location HQs.

Response: This comment has merit, however the risk assessment did consider the range of waterfowl when estimating exposures. Refer to page 22 Section 5.4 (third paragraph) of the draft report and Table 3. The waterfowl hazard quotients in the assessment (Appendix D) represent these considerations and, in fact, show the risk at each location as a porportion of the waterbody as a whole.

23. Page 31, paragraph 1, Section 6.1: It is unclear to what the "bold faced TRV types" is referring.

Response: This is a typo and the sentence refering to bold-faced text has been re-written.

24. Page 31, Section 6.2: Are there any COCs for which there was a Federal Ambient Water Quality Criteria (AWQC) and not a Minnesota standard? If not, then eliminate the Federal AWQC, since the Minnesota standards would apply since they are always either the same or lower than the Federal AWQC. This approach would greatly simplify the tables in Appendix 5 and allow elimination of several maps in Appendix F.

Response: The revised report only utilize the Minnesota water quality standards, except in cases where only a Federal criteria value exists. However, upon brief inspection there does not seem to be a case where the Federal criteria will need to be invoked. Additional benchmarks are used for substances which do not have Minnesota or Federal standards—refer to Table 7 in this draft.

25. Page 32, paragraph 1, Section 6.4: The Oak Ridge "Toxicological Benchmarks for Wildlife" document was revised in 1995 (ORNL 1995). Some of the toxicity reference values (TRVs) were changed, and a few new one were added, e.g., boron. Use the most recent TRV values.

Response: At the time when the draft report manuscript was being prepared the 1994 version of the Oak Ridge toxicity benchmarks were the most up-to-date. The revised report contains toxicity values derived from the most current sources. The comments recommend the use of the 1995 Oak Ridge updates; however, the 1996 updates have been recently published and the revised report utilizes values from the 1996 update.

26. Page 34, Boron: ORNL (1995) contains an avian chronic no observable adverse effect level (NOAEL) of 28.8 milligrams per kilogram (mg/kg)/day for the mallard.

Response: Refer to response 25.

27. Page 36, Cadmium: The mammalian NOAEL was revised in ORNL (1995) to 0.008 mg/kg-day.

Response: Refer to response 25.

28. Page 36, Copper: The avian NOAEL was revised in ORNL (1995) to 47 mg/kg-day.

Response: Refer to response 25.

29. Page 38, Mercury: ORNL (1995) contains a NOAEL for the mink of 0.015 mg/kg-day. This is more appropriate than the rat NOAEL because the mink is a potential receptor at the site.

Response: Refer to response 25.

30. Page 41, Aroclor 1254: The mammalian NOAEL was revised in ORNL (1995) to 0.068 mg/kg-day.

Response: Refer to response 25.

31. Page 41, DDT: ORNL (1995) contains an avian NOAEL of 0.0028 mg/kg-day for the brown pelican.

Response: Refer to response 25.

32. Page 42, Benzene Hexachloride: ORNL (1995) contains a NOAEL for the mink of 0.014 mg/kg-day, which

would be more appropriate than the rat value.

Response: Refer to response 25.

33. Page 43, Heptachlor epoxide: The mammalian NOAEL was revised in ORNL (1995) to 0.1 mg/kg-day, based on the mink.

Response: Refer to response 25.

34. Page 43, Methylethyl ketone: ORNL (1995) contains a mammalian NOAEL of 1771 mg/kg-day.

Response: Refer to response 25.

35. Page 45, last paragraph, Section 7: In the last sentence, change the reference to paragraph 6.2 to the correct section.

Response: The report has been revised.

36. Page 51, paragraph 1, Section 7.6: The Report may add that, in a subsequent sampling, MPCA was unable to detect the same contaminants at comparable levels at Area B.

Response: The revised report considers the data which the MPCA collected in Area B and those findings are discussed.

37. Page 57, paragraph 3, Section 8.2: Modify the text to clarify that the risk posed by the pesticides is not particular to the TCAAP site or past disposal practices.

Modify the last sentence to read, "Thus, risks to aquatic organisms by inorganics may be over estimated."

Response: The text has been revised as recommended.

38. Page 58, paragraph 4, Section 9: MPCA also collected total organic carbon data from Round, Sunfish, and Marsden Lakes that may be included in the discussion under *Supporting Investigations*.

Response: The organic carbon data for Round, Sunfish, and Marsden Lakes are included in the revised report and their affect on conclusions are considered.

39. Page 60, paragraph 1, Section 9.1: Reference the AVS/SEM data that will be forthcoming from USACHPPM as well.

Response: References to the two forthcoming studies have been inserted into a section 11 in the March 1997 draft.

40. Page 63, paragraph 3, Section 10.2: Discuss results from the benthic population and diversity survey.

Response: The results of the benthic population and diversity survey are clarified in the Conclusions (Section 10) of the revised report.

41. Page 65, Section 11.3: Add that the Blandings turtle population is currently being monitored by the Minnesota DNR.

Response: Information regarding the current monitoring studies of the Blandings Turtle by the Minnestoa DNR will be included in the revised report. More specific recommendations on how to incorporate the monitoring data into the risk assessment will be addressed in any Tier II study, if warranted.

42. Page B-3, Table B-2: Add PCB 1248 at 0.145 ppm and PCB 1254 at 0.429 ppm.

Response: With the help of Mark Ferrey (MPCA) our team has re-evaluated the data packages to ensure that any missrepresented data have been corrected.

43. Page B-7, Table B-6: Add PCB 1248 at 1.28 ppm and PCB 1254 at 0.24 ppm.

Response: Refer to response 42.

44. Page B-51, Table B-50: Add DDD at 0.135, DDE at 0.077, and DDT at 0.258 ppm.

Response: Refer to response 42.

45. Page B-67, Table B-80: Change barium to 27.2 ppb.

Response: Refer to response 42.

46. Page B-69, Table B-84: No HPCLE was detected in SFL09SW.

Response: Refer to response 42.

47. Page B-71, Table B-86: Change barium to 70.6 ppb.

Response: Refer to response 42.

48. Page C-14, Table C-19: Add a footnote explaining that the drivers to risk are by default due to the fact that the risk levels are all below detection limits. Mercury, beryllium, silver, and cadmium were not detected in the surface waters to generate the indicated HIs.

Response: The data tables in Appendices B and C have been revised during a second data review. The COCs which drive the estimated risks have been assessed again to more accurately reflect the data quality. In addition, section 8.8 addresses detection limit problems and their potential affect on the assessment.

49. Appendix B, Tables B-1 through B-50: Show the actual detection limits (e.g., < 0.05) rather than BDL in all data tables. Also include the sediment guideline values for all the chemicals in the tables, so the reader can see how they compare with background, and whether the detection limits were above or below the guideline values.

Where background exceed the sediment guideline value (e.g., copper and nickel) calculate the HQ using the background value (i.e., background become the guideline value) and indicate in a footnote where this has been done.

Final Report, Tier I Screening Risk Assessment of Aquatic Ecosystems No. 39-EJ-1393-97, Twin Cities Army Ammunition Plant, MN, Oct 92 - Jul 93

Response: The tables in Appendix B have been revised and presented in a more useful format. The suggested recommendations have been addressed by incorporating a more comprehensive COC selection process explained in section 4.2 of the March 1997 draft.

End of the MPCA Comments

Final Report, Tier I Screening Risk Assessment of Aquatic Ecosystems No. 39-EJ-1393-97, Twin Cities Army Ammunition Plant, MN, Oct 92 - Jul 93

Comments by the U.S. Department of the Interior, Fish and Wildlife Service

Review Comments

1. The transmittal memorandum for the subject report references "two studies are under development which address some of the data gaps identified in the enclosed report." These two studies may significantly add to risk assessment conclusions at Round Lake; however, they are not referenced within the context of the report (see review comments below). We recommend the final screening risk assessment include these studies.

Response: The two studies currently ongoing (Sediment-metal Bioavailability Study and Sediment Toxicity Evaluation) are more clearly referenced in the revised report, specifically in Section 11. These studies will be completed after the finalization of the Tier I Screening Risk Assessment. As these two studies are not screening-level assessments but more detailed risk evaluations, they will be incorporated into the Tier II Risk Assessment. The final risk assessment product will contain both the Tier I and Tier II assessments. The Tier II assessment better defines and evaluates the potentially unacceptable risks identified in the Tier I assessment.

2. Paragraph 1, Purpose: It is misleading for this report to state that "This risk assessment was performed upon request..." In fact, the aquatic sites included in this screening risk assessment have been identified within the Remedial Investigations and Feasibility Studies for the TCAAP as a site listed on the National Priorities List (Superfund) under the Comprehensive Environmental Response, Compensation, and Liability Act. Further, Round Lake has been formally administered as part of TCAAP Operable Unit 2. The Service believes it is critical for the applicable statutory requirements and associated administrative processes be fully recognized and referenced by the Department of the Army in all assessments of Round Lake in order to most effectively design and implement any necessary remediation due to TCAAP-related contamination.

Response: The purpose of this report is more clearly represented in the revised version.

3. Paragraph 2.1, ERA Framework: The Service concurs with the outlined structure of the Ecological Risk Assessment (ERA). However, we also advise that effects of contaminants on individuals may indeed be significant at Round Lake because of its unique status as an unit of the National Wildlife Refuge System. The National Wildlife Refuge System Administration Act of 1966 provides directives for determining compatible uses for all areas in the system, and may affect final interpretation of the ecological risk assessment at Round Lake.

Response: The Army requests that the compatable use directives of the FWS at Round Lake be forwarded to CHPPM, especially if these directives conflict with the current assumptions in the risk assessment in terms of estimating potential exposures and effects. During the ERA Update Conference Call on 17 December 1996, Mr. Dave Warburton indicated that contact was being made with the refuge manager, Rick Schultz, and that the specific documentation for the USFWS position will be forwarded to the Army. Mr. Warburton and Mr. Matt McAtee (CHPPM) agreed that this issue was not necessarily relevant to the Tier I screening evaluations and that it will be appropriate to speak to this issue (and documented) during the Tier II assessment reports. The Army emphasizes the need for these USFWS guidelines to be communicated more explicitly to the Army, USEPA, and MPCA.

4. Paragraph 2.2, History and Ecology of Round Lake: Please revise the second sentence, first paragraph, as follows: "This lake is currently managed as a unit of the Minnesota Valley National Wildlife Refuge by the U. S. Fish and Wildlife Service." We also advise that the reference in this paragraph to Round Lake receiving "contaminated runoff from urban non-point sources (including highway runoff)" be appropriately documented or

qualified; any such reference should be inserted after the text describing TCAAP sources of pollutants.

Response: Recommended text revisions has been performed. The sentence refering to non-point sources has been removed and replaced with: " Round Lake may also have received contamination by unknown sources which are out of the Army's control".

5. Paragraph 3, Problem Formulation: The Service concurs with the approach as described.

Response: Noted.

6. Paragraph 4.2, Methodology and Section 5 Exposure Assessment: The Service defers review comments of the methodology and modeling used to evaluate data collected at Round Lake to the Minnesota Pollution Control Agency due to the multiple aquatic sites involved in this screening risk assessment, and the need for consistency in methodology. One noted exception: Paragraph 4.2 specifies that sediment samples from Black Dog Lake, Pond C, and Blue Lake are not used as background locations; therefore, please delete Pond C data from Table B-51.

Response: Pond C data is no longer included in the review of sediment background levels. The tables in Appendix B will be revised to provide a more clear presentation of the data.

7. Paragraph 6, Characterization of Ecological Effects: The Service concurs with the methodologies and qualifications as described.

Response: Noted. Several changes have been made however, based upon other review comments, particularly by the MPCA.

8. Paragraph 8.4, Toxicological Data and Population Level Effects: Reference our review comment under Paragraph 2.1 regarding individual versus population level effects.

Response: Noted.

9. Paragraph 9.3, Second Round Surface Water Sampling: Further evaluation of quality assurance/quality control data for the first round of surface watersampling appears warranted. If "laboratory error" in first round analyses can in fact be demonstrated, then we recommend the risk assessment screen utilize only second round data to avoid possible overestimation of ecological risk.

Response: Refer to the response to U.S. EPA comment number 5.

10. Paragraph 10.1, Conclusions, Round Lake: The ecological risk to benthic organisms may be unnecessarily overestimated in the subject report based on the findings of the benthic macroinvertebrate evaluation, as presented in Appendix G. The Service notes that the "Sediment Toxicity Evaluation of Round Lake" study (in progress) referenced in the report's transmittal memorandum may provide the data necessary to finalize this aspect of the ecological risk assessment. Therefore, we recommend the conclusion of risk to benthic organisms be qualified or reserved pending the results and interpretation of the referenced study.

Response: The current data and risk estimates are not consistent for Round Lake, hence the impetus to investigate further. The conlusions of the report will be revised to better reflect the benthic evaluations and the need for further evaluation in the Tier II effort, of which two studies are already under way. Refer to section 11 in the March 1997 draft.

11. Paragraph 10.7, Data Gaps and Limitations: Please reference our first review comment. The two studies indicated in the subject report's transmittal memorandum as "under development" should be cited in this section with further explanation as to their relevance to the limitations and conclusions of the screening risk assessment.

Response: The Data Gaps and Limitations section have been revised and clarified based upon the revisions to the report. The future studies, as a part of Tier II, are now underway.

12. Paragraph 11, Recommendations: The Service notes there is no direct reference to Round Lake in this section. Given the potential for chemical impacts and population-level risks to occur at Round Lake (Paragraph 10.1), there should be clear and specific recommendations for further assessment at Round Lake necessary to finalize the evaluation of ecological hazard due to the release of TCAAP-related contaminants (Service review comment re: Paragraph 10.7 is also applicable here). Are evaluations described in Recommendations 11.4 and 11.5 intended to be applied at Round Lake? How is the need for investigation of community level risks at Round Lake identified in Paragraph 7.2 intended to be fulfilled?

Response: Conclusions, uncertainties, and recommendations for Round Lake are defined more explicitly in the revised report.

13. Paragraph 12, Remediation Considerations: The general issues presented in this section are acknowledged by the Service. However, we note that TCAAP-related contamination also exists outside the "boundaries of the TCAAP". Therefore, we request that this section includes reference to potential remediation activities at Round Lake as a management unit included in the National Wildlife Refuge System.

Response: Refer to response to comment number 12.

End of FWS Comments

APPENDIX I

RESPONSE TO REGULATOR COMMENTS ON THE DRAFT FINAL VERSION (JUNE 1997)

Final Report, Tier I Screening Risk Assessment of Aquatic Ecosystems No. 39-EJ-1393-97, Twin Cities Army Ammunition Plant, MN, Oct 92 - Jul 93

Comment by the U.S. Environmental Protection Agency

The Final Draft, Tier I Screening Risk Assessment adequately addresses the previous EPA comments. However, the document contains a discrepancy between the text and the tables. Specifically, Section 4.3.1 states that polychlorinated biphenyl (PCB) contamination was identified at sampling location RL09SE in Round Lake, and Section 9.1 discusses PCB contamination in Round Lake. However, the information in Table 2 and Table B-1 does not reflect the PCB contamination in Round Lake. This discrepancy should be addressed.

Response: Yes, there is a discrepancy to be resolved. First, the data presented in Table B-1 is wrong for sample RL09SE (0-1 ft). After attempting to verify this data in the 1994 OU-2 Feasibility Study Data Package prepared by Montgomery Watson, Inc., we found the error. The correct data should be as follows:

PCB 1248	1.280 μg/g	R
PCB 1254	0.240 μg/g	R

These detections were flagged with an "R" descriptor by the analyzing laboratory. This flag means that the data is rejected, or deemed unusable. This finding has two implications for the risk assessment. First, Table B-1 has been changed to reflect the actual analytical finding, as shown above. Second, the text in Sections 4.3.1 and 9.1 has been modified to reflect this correction. Table 2 has remained unchanged.

End of U.S. EPA Comments

Comments by the Minnesota Pollution Control Agency

1. Total Organic Carbon Data: Although the report indicates that the sediment organic carbon data was incorporated into the exposure and effects assessment, the organic carbon data itself is not presented. Please tabulate this data in the Final Report.

Response: Yes this tabulation would add value to the report. Table B-17 (Appendix B) presents this data.

2. Table 7. Water Quality Screening Benchmarks: The Minnesota water quality standards used were for the wrong water classification. The class 2B standards should have been used rather than the 2A standards. The correct values are as follows:

aluminum:	chronic=125; acute=1072
lead:	no change
mercury:	chronic=0.0007; acute=2.4
nickel:	no change
silver:	chronic=1; acute=2
zinc:	no change
heptachlor epoxide:	chronic=0.0005; acute 0.27

The Minnesota chronic standards should be used as benchmarks instead of the USEPA Tier II chronic values for mercury, silver, and heptachlor epoxide. These chronic values were used in the previous draft; why were they changed in this version? The above changes will affect some of the hazard quotients for aquatic organisms, i.e., aluminum HQs will all be lower than currently indicated, with some of them changing to zero; mercury HQs will increase, and some change from zero to positive numbers; silver HQs will decrease; and some heptachlor epoxide HQs will change from zero to positive numbers.

In addition, MPCA has calculated water quality criteria (not yet promulgated standard) for manganese (chronic=491; acute=4643) which should be used instead of the USEPA Tier II values (it was an oversight that these manganese criteria were not provided to USACHPPM previously). While this correction is not necessary for approval of the Report, it will substantially reduce all of the manganese HQs and probably eliminate manganese as a chemical of further concern from Round Lake and Rice Creek.

Response: We recognize that the final draft report used some of the wrong MWQS's and this final report incorporates the appropriate values. The suggested mercury chronic standard (0.0007 μg/L) is an order of magnitude more stringent than the actual MWQS (0.007 μg/L). Note also that the mercury benchmark is below the detection limit of the OU-2 Feasibility Study.

Tables 7 and 13 have been revised to reflect these issues. The relevant tables in Appendix C have also been revised to correct the mistakes.

3. Section 6.2, page 39, paragraph 2: Discussion of hardness adjustments to surface water standards: The first sentence indicates that cadmium, chromium, and copper are contaminants of concern (COCs) for surface water. However, cadmium, chromium, and copper are not listed as COCs for surface water in Table 3, surface water standards for these chemicals are not listed in Table 7, and HQs are not calculated for them in the risk characterization. These contaminants were detected in some surface water samples presented in Appendix B. Please correct these inconsistencies in the Final Report.

Response: These substances were not included as COCs because they did not appear to satisfy the selection criteria described in Section 4.2.2. Note that only the OU-2 Feasibility Study database was used to estabilish COCs and the annual monitoring data was not used in this capacity. However, chromium and copper were actually detected in one Marsden Lake sample (ML01SE). Therefore, chromium and copper should have been included in the list of COCs for this site. It is noted that all three of these metals were detected within the annual monitoring database.

Even in light of this error, the outcome of the risk assessment will not significantly change. The report recommends more investigation at potential Marsden Lake source areas, to include the area where sample ML01SE was taken. The analytical suite for these recommended samples will include chromium and copper and they will be evaluated further to determine if they should be considered COCs during the Tier II assessment. The only revision warranted is to include cadmium and copper in Table 13.

4. Data concerning PCBs in Round Lake sediment below one foot was, as previously agreed, omitted from the risk assessment. Future management activities at Round Lake may benefit, however, from the knowledge that this contamination exists at depth. Please include reference to this fact either in this report or in the Tier II assessment.

Response: The final draft report may not have sufficiently identified the presence of contamination found at depth in the subsurface sediments. This final report identifies this issue in Section 8 with the following subsection:

8.9 Contamination in Deep Sediments in Round Lake. The assessment documents a process used to define potential ecological effects which may be occurring in the systems previously identified. Because of this scope, the assessment only evaluated surficial sediment contamination, that is, contaminants within the 0 to 1 foot depth interval. This evaluation defines "current" risks, where the deep sediments are not significantly disturbed. The potential for contaminants presently in the deep sediments at Round Lake (deeper than 1 foot below the surface) to become biologically available in the future (due to disturbances) has not been critically examined. This situation limits the risk information available to assist in the management of the lake over the long term. Appendix I presents the comments which identify this limitation.

End of the MPCA Comments

Comments by the U.S. Fish and Wildlife Service

1) The Service recognizes and appreciates the responses of Army to Service review comments of the previous (July 1996) draft, and the applicable changes made to the current Tier I report.

Response: Noted.

2) The Executive Summary (2.7) references that risks from sediment contamination of PCBs cannot be adequately assessed; but, that organic carbon data collected by the Minnesota Pollution Control Agency (MPCA) indicates that PCBs are not likely to be bioavaliable. The Service notes that this organic carbon data is apparently not presented in the report, and recommends that this data be included in the Tier II assessment with specific reference to Round Lake sites (also see Service Comments 3, 5, and 6, below).

Response: See response to MPCA comment no. 1.

3) The Service recognizes that potentially contaminated sediment at depths greater than 1 foot are not included in the risk assessment methodology due to the assumption of biological unavalability. However, the Service believes it is important to maintain a record of such analytical results in the Tier II evaluation so that final risk assessment conclusions may include the necessary precautions, such as recommendations against disturbing underlying sediments. Such documented precautions (if warranted) are critical for Service land managers who may consider water level manipulation, sediment excavation, or other physical operations in the management of Round Lake for fish and wildlife habitat.

Response: See reponse to MPCA comment no. 4. During the planning process for the Tier II risk assessment at Round Lake, the conditions in the sediments at depths below 1 foot will be discussed and the issue will be addressed during the conduct of the Tier II assessment.

4) The Service notes that "the northern portion of the [Round] lake located just south of the urban runoff inflow [which] has the most contaminated sediment" (Section 4.3.1), is also in the area of the stormwater outfall to the lake through which hazardous wastes released from TCAAP had a documented pathway to Round Lake (Section 2.2). The Service believes this distinction should be included in subsequent references within the Tier II assessment.

Response: Noted.

5) The Service acknowledges the lack of uniformity in risk assessment values for Round Lake resources. However, the Service remains concerned in particular about potential "hot spot" contamination. Such contamination may not only limit Service management action (reference Service Comment 3, above), but may also represent a [as yet incompletely defined] degree of ecological concern. The Service believes the Tier I risk assessment conclusion of hot spot contamination of DDT and its metabolites, PCBs, and mercury being "unlikely to be causing any significant effects" (Section 9.1) may be premature considering the scope of the Tier I assessment and the data presented. Further, consideration of adverse impacts to Refuge resources as defined by regulations administering the Service's management of Round Lake (see discussion below) remains to be addressed for Round Lake and should be included in the Tier II assessment.

Response: Please note the correction made to Section 9.1 in regards to PCBs, as a response to the USEPA comment. In regards to mercury, the data used in the assessment showed that this substance was not detected in any of the 20 surficial sediments and in only 1 of 20 surface water samples collected at the lake. In addition, the final draft report showed that the detection limits for mercury were not above the screening benchmarks for effects used — hence, the conclusion that this mercury contamination is unlikely to be causing any significant effects may have been justifiable. In reponse to MPCA comment no. 2, it became apparent that the final mercury benchmark (0.007 μg/L) is below the detection limit (0.74 μg/L) used in the OU-2 Feasibility Study. Due to this revision, Section 9.1 and Table 13 have been updated. In addition, mercury monitoring has been added to the recommendations.

In regards to DDT and its metabolites, the data used in the assessment showed that these substances were detected in only 1 of the 20 surficial sediment samples and were not detected in any of the 20 surface water samples collected at the lake. We maintain that the detections of DDT and its metabolites are unlikely to be causing any significant effects.

6) The Service does not fully understand Tier I conclusions for potential ecological risk at Round Lake from PCBs. The Tier I assessment is admittedly limited by inadequate analytical detection limits; however, the basis for obviating potential ecological concern from PCB exposure in Round Lake remains incomplete. The Service recommends this issue be addressed and explained in greater detail in the Tier II assessment, including reference to related Service comments, above.

Response: The issue to PCB contamination of Round Lake sediments (especially at depths greater than one foot) will be discussed and addressed during the Tier II assessment. Please note, however, that a correction in Table 13 was made. The old table indicated that PCB detection limits were 1.0 μg/g, and above the toxicity benchmark. This was a mistake. In fact, the detection limit for PCBs was 0.040 μg/g, and less than the toxicity benchmark. Therefore that final report does not state that the conclusions are limited by inadequate analytical detection limits for PCBs.

7) The Service appreciates the progress of Army and CHPPM to complete the two preliminary Tier II studies (sediment toxicity and sediment-metal bioavalability). The Service believes these studies will significantly contribute to further evaluating ecological risk at Round Lake, and looks forward to completed reports in the near future.

Response: Noted.

Comment regarding the National Wildlife Refuge System Administration Act

Lastly, as referenced in previous Service review comments and discussions, we take this opportunity to clarify the

Service's position regarding the effect of regulations promulgated under the authority of the National Wildlife Refuge System Administration Act on ecological risk assessment conclusions at Round Lake. The regulations which govern the general administration of National Wildlife Refuges are found in 50 CFR Parts 25-37; we believe Part 25 and particularly Part 27 apply to evaluating ecological risk at Round Lake. As part of the National Wildlife Refuge System, Round Lake resources include "all lands, waters, and interests therein administered by the U.S. Fish and Wildlife Service... for the protection and conservation of fish and wildlife" (50CFR 25.12(a)). 50 CFR 25.11 (b) identifies that "refuges are established for the restoration, preservation, development and management of wildlife and wildlands ... to obtain maximum benefit from these resources" (emphasis added). 50 CFR 27.51 provides regulations prohibiting "disturbing, injuring, spearing, poisoning, destroying, collecting ... any plant or animal on any national wildlife refuge" (emphasis added). Finally, 50 CFR 27.94 (a) prohibits "the draining or dumpling of oil, acids, pesticide wastes, poisons, or any other types of chemical wastes in, or otherwise polluting any waters, water holes, streams or other areas within any national wildlife refuge".

We believe these regulations provide the basis for an evaluation of ecological risk at Round Lake that takes into account the potential for any "injury" to "any plant or animal" due to releases of hazardous wastes from TCAAP. We recognize that available remedial technologies and measures that may be necessarily considered subsequent to ecological risk assessment conclusions must also take into account the best interests of the public, including the expenditure of public funds. However, at this point in the evaluation, we believe it necessary for the Service to strictly maintain its regulated responsibility of obtaining "maximum benefit from these resources" at Round Lake. Therefore, localized "hotspot" contamination (including depths greater than 1 foot) should be identified and maintained in the Tier II ecological rick assessment. Conclusions and recommendations related to the Tier II assessment should further take into account any limitations placed on the Service in the management of Round Lake as an unit of the National Wildlife Refuge System.

Response: The Army has previously requested that the management plans for the lake and the compatable use directives be forwarded to the risk managers and to USACHPPM (see response to comment no. 3 on page H-13). The Army emphasizes the need for these USFWS guidelines to be communicated more explicitly to the Army, USEPA, and MPCA.

As discussed in responses to the Services' comments numbers 3, 5, and 6, during the planning process for the Tier II risk assessment at Round Lake, the conditions in the sediments equilivent to "hot spots" and at depths below 1 foot will be discussed and the issues will be addressed during the conduct of the Tier II assessment. It is important to point out that the Tier II assessment endpoints will be defined by Army, USEPA, MPCA, USFWS, and other stakeholders *together* and it will be at this time that the Service can ensure that its concerns will be addressed during the Tier II analsis.

End of the USFWS Comments