W92194F

FINAL
REMEDIAL INVESTIGATION REPORT

VOLUME I OF IV

NYANZA OPERABLE UNIT III - SUDBURY RIVER STUDY MIDDLESEX COUNTY, MASSACHUSETTS

NUS Corporation

EPA Work Assignment No. 02-1L15
Contract No. 68-W8-0117
NUS Project No. 0214

May 1992

NUS
CORPORATION
A Halliburton Company

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EXECUTIVE
SUMMARY

1.0 EXECUTIVE SUMMARY

A Remedial Investigation Feasibility Study (RI/FS) of Nyanza Operable Unit III, the Sudbury River, Middlesex County, Massachusetts is being conducted by the NUS Corporation under the ARCS I contract for the Region I U.S. Environmental Protection Agency (EPA). The RI was conducted from October 1989 through February 1992. Results of the RI are presented in this report. The Feasibility Study report will be presented in a separate document.

The RI was conducted to assess contaminants in the Sudbury River basin in the vicinity and downriver of the Nyanza Chemical Waste Dump Site in order to: determine the nature and extent of contamination in the River; evaluate public health and ecological risks associated with observed contamination; provide data to develop general response objectives and cleanup standards focusing on sediment cleanup; and provide data to develop and evaluate remedial alternatives to mitigate the defined risks.

The Nyanza Chemical Waste Dump Site occupies a 35-acre parcel of land located in the town of Ashland, Massachusetts. Beginning in 1917 the property has been occupied by several companies involved in the manufacture of various dye and chemical products. Nyanza, Inc., for whom the Site is named, was the most recent dye manufacturing company to occupy the Site. Nyanza, Inc. appears to have ceased operations at the Site in 1978. Documentation indicates that several types of organic and inorganic chemical wastes were disposed in various locations at the Site. These wastes included partially treated process wastewater and sludge, solid process wastes, solvent distillation residues, off specification dyes, intermediate dye products acids and non-recyclable products.

As early as 1967, the Commonwealth of Massachusetts began enforcement activities in connection with Nyanza Inc's wastewater and sludge disposal practices. Later investigations conducted by contractors for the EPA detected elevated levels of mercury and other chemicals linked to the Nyanza Site in sediments, biota, and water in the Sudbury River.

In 1982, the Nyanza Site was classified by the EPA as a National Priority List Site. An RI/FS for the Site was completed in 1985 leading to the signing of the Record of Decision (ROD) in September 1985. The ROD divided the Agency's remedial response into Operable Units for the purpose of addressing distinct problems. Operable Unit I dealt with the consolidation of on-Site and off-Site metallic sludge deposits, and the construction of a cap to secure Site related sludges on-Site. The construction was completed in November 1991.

Operable Unit II is addressing groundwater contamination at the Site. An RI/FS has been completed. Results indicate that a groundwater plume containing organic contaminants has migrated 0.5 miles downgradient of the Site in a northeasterly direction to the vicinity of the Sudbury River. The FS proposed remedial alternatives and the EPA has selected an Interim Groundwater Cleanup Plan to mitigate this plume.

Operable Unit III was established in 1987 to address surface water and sediment contamination in the Sudbury River and its tributaries (Figure ES-1). Field investigation activities for the RI began in 1989 and include the following:

- o Collection of surface water and sediment samples throughout the Study Area to determine the nature and extent of contamination in each medium. Sampling activities were conducted during two major events.
- o Collection of fish and invertebrate biota throughout the Study Area in two major events.
- o Completion of a soil boring program in the Eastern Wetlands area adjacent to the Nyanza Site for the purpose of delineating the nature and extent of contamination in this area.
- o Collection of water quality samples on a monthly basis to define seasonal water quality fluctuations. Data was evaluated to determine if aquatic organisms are seasonally more vulnerable to toxic contaminants.

The RI resulted in the following conclusions:

1) Nature and Extent of Contamination

- o Chlorobenzene, dichlorobenzene, trichloroethene, and dichloroethene were detected in sediments and soils within the Eastern Wetlands at concentrations in the range of 10^4 parts per billion (ppb). These compounds were detected immediately downstream of the Wetlands, but were not detected in the Sudbury River.
- o The highest concentrations of mercury in surface sediments were detected in the Eastern Wetlands. The maximum concentration detected is 424 parts per million (ppm). Mercury concentrations generally decrease in the Sudbury River to the confluence of the Assabet River in Concord, where concentrations were comparable to background levels detected upstream of the Nyanza Site.

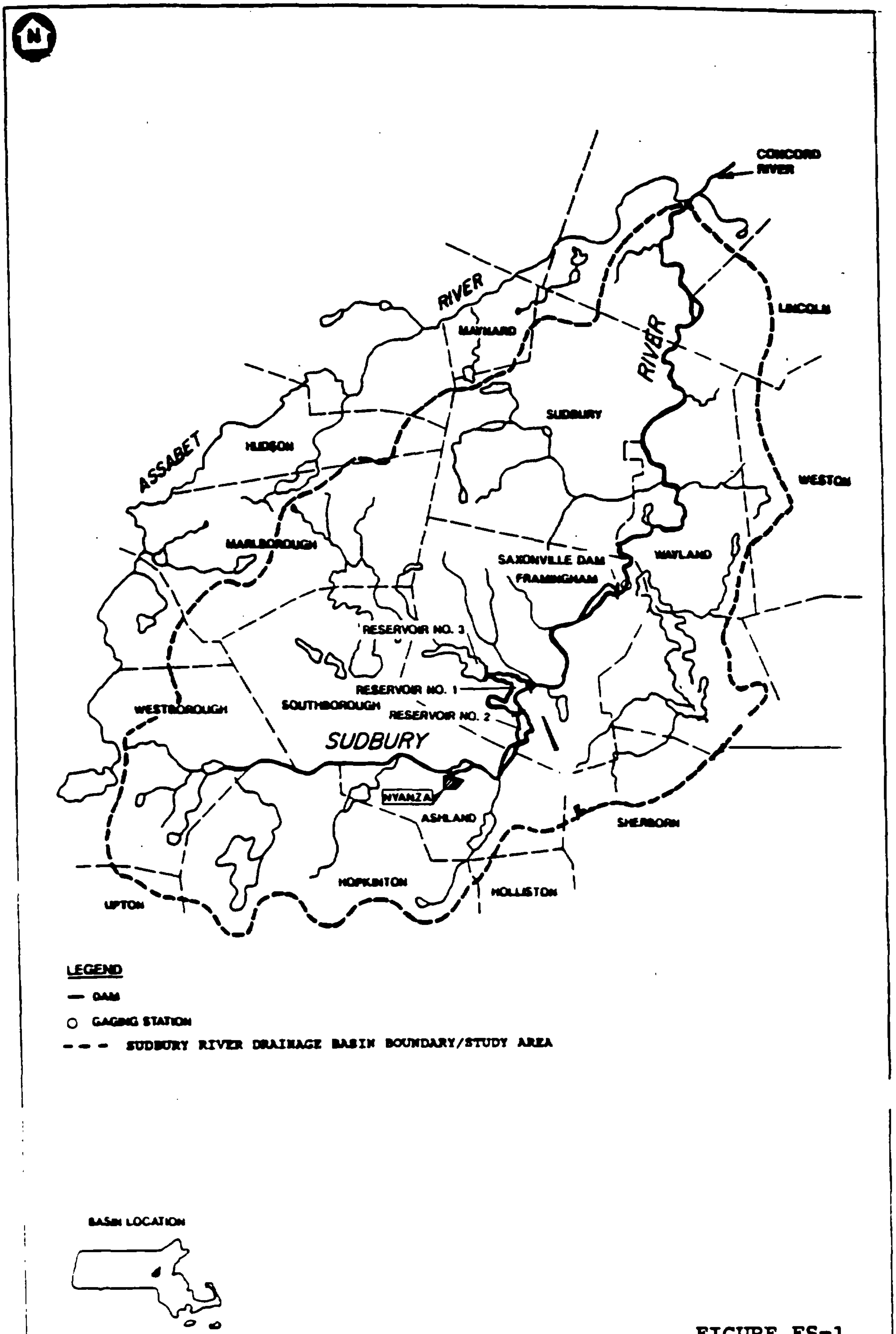

FIGURE ES-1

STUDY AREA MAP
NYANZA III - SUDBURY RIVER STUDY
MIDDLESEX CO., MASSACHUSETTS

- Mercury and chromium were detected in River sediments throughout the Study Area downgradient of the Nyanza Site. Concentrations of these metals are higher in depositional areas (reservoirs and impoundments) and are lower in channelized river areas. The highest concentrations of mercury in the River sediments occur in Reservoir 2 where over 90 percent of the samples collected detected mercury at an average of 17.43 ppm. The highest concentration detected in Reservoir 2 was 54.6 ppm.

- Mercury and chromium were detected in surface water samples in the Eastern Wetlands and several River water samples, but at low concentrations.

- Fish samples collected throughout the Study Area revealed the presence of mercury and methylmercury in the tissues of Largemouth Bass and Yellow Perch. While concentrations of these compounds depended mainly on age of the fish, capture location was also a factor. Fish collected from Reservoir 2 showed the highest concentrations of mercury, and fish collected from upstream locations (background), showed less, as did those from Fairhaven Bay. Pesticides and PCBs were also bioaccumulated by fish.

- Site specific organic compounds used in the Nyanza dye manufacturing process, including aniline, napthalamines, benzidine and related compounds, were not detected in the Study Area.

- A variety of non Site-related contaminants were detected in River sediments including pesticides, polynuclear aromatic hydrocarbons, volatile organic contaminants, phthalate compounds, and metals.

- Many point and non-point sources of contaminants, which may contribute to contamination in the Sudbury River, are present throughout the Study Area.

2) Fate and Transport of Contaminants

An analysis of the fate and transport of contaminants found in the Study Area has revealed the following:

- Contaminant transport is provided mainly by the physical transport of contaminated sediment in surface water bodies. Contaminants which adsorb to particulate matter will be transported in flowing waters and deposited in bed sediments.

- Contaminants in sediments are expected to continue to impact surface waters in the Eastern Wetlands if chemical conditions allow transfer. Heavy metals such as mercury and chromium are not readily desorbed from sediments in the Sudbury River as evidenced by TCLP and ACOE extraction analyses which model environments which would leach contaminants from sediments.

- Contaminated finer grained sediments tend to be wide spread in the reservoirs and impoundments where low water velocities allow deposition of the sediment.

3) Public Health Risk Assessment

- There are two categories of individuals which are susceptible to health effects of contaminants found in the Study Area. These individuals are those who regularly consume fish caught in the Study Area and those who use parts of the Study Area for wading and swimming.

- Hazard quotients and hazard indices calculated for recreational and residential sediment exposure scenarios do not exceed unity. The exception is in the Eastern Wetlands, where unity is approached if the receptor is a small child.

- Accidental ingestion hazard quotients and hazard indices exceed those for dermal absorption. The hazard index for bordering wetlands exceeds unity when maximum concentrations are considered and the receptor is a small child.

- Maximum or average mercury concentrations detected in fish tissue throughout the Study Area exceed the Food and Drug Administration action level for mercury in fish. The only exception is fish caught in Southville Pond (in a Background area).

- Adverse noncarcinogenic health effects are anticipated for sports and subsistence fishermen who consume fish caught in the Study Area.

4) Ecological Risk Assessment

- The toxicity hazards associated with Site-related contaminants are minimal compared to the hazards of contamination bioaccumulation in the food chain.

- Mercury is the only Site-related contaminant which contributes significantly to bioaccumulation in the food chain.

- Mean estimated whole body concentrations of total mercury in Largemouth Bass and Yellow Perch collected throughout the Study Area exceed values (established by the Fish and Wildlife Service) that are considered to be protective of predators that consume fish.

LIST OF ACRONYMS AND ABBREVIATIONS

AAWQC	Acute Ambient Water Quality Criteria
ABS	Absorption rate
ACL	Alternate Concentration List
ACOE	U.S. Army Corps of Engineers
ACR	Acute to Chronic Ratio
ACRe	Estimated Acute to Chronic Ratio
ADC	Average Detected Concentration
am	Before noon
AOC	Area of Concern
APA	Air pathway analysis
ARARs	Applicable or relevant and appropriate requirements. A law or regulation that should be applied in a NPL site cleanup.
ARCS	Alternative Remedial Contracting Strategy
ASTM	American Society of Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AVG	Number of years over which an exposure is averaged
AWQC	Ambient Water Quality Criteria
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BDL	Below Detection Limits
BNAs	Base-neutral and acid compounds
BOD	Biochemical Oxygen Demand
Btu	British Thermal Unit
BW	Receptor body weight

C	Measured/estimated media concentration
^{0}C	degree Centigrade (Celsius)
CAA	Clean Air Act
CAWPC	Chronic Ambient Water Quality Criteria
cc	cubic centimeters
CERCLA	The Comprehensive Environmental Response, Compensation and Liability Act of 1980. Amended by SARA in 1986. Also called the Superfund law.
CF	Volumetric Conversion Factor
cf	cubic feet
cfm	cubic feet per minute
cfs	cubic feet per second
CLP	(EPA) Contract Laboratory Program
cm	Centimeter
CNS	Central Nervous System
COC	Chemicals of Concern
COD	Chemical Oxygen Demand
CR	Contact Rate or Cancer Risks
cm/sec	centimeters per second
CSF	Carcinogenic Slope Factor
CWA	Clean Water Act
cy	cubic yard
D	Deposition rate
dB	decibel
DCB	Dichlorobenzene
DCE	Dichloroethene
DDD	1,1^{1}-(2,2-Dichloroethylidene)-bis/4-chlorobenzene/
DDE	1,1^{1}-(2,2-Dichloroethenylidene)-bis/4-chlorobenzene/

DDT	1,11-(2,2,2-Trichloroethylidene)-bis/4-chlorobenzene/
DEP	Massachusetts Department of Environmental Protection (formerly DEQE)
DEQE	Massachusetts Department of Environmental Quality Engineering (now the DEP)
dia	diameter
DIUF	De-ionized ultra-filtered water
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DPH	Massachusetts Department of Public Health
DQO	Data quality objectives
DWPC	Massachusetts Division of Water Pollution Control
E	Entrainment rate
ED	Exposure duration
EEC	Estimated Environmental Concentration
EF	Exposure frequency
EPA	U.S. Environmental Protection Agency
ER	Exposure rate
ERi	Ratio of risk for each chemical/total risk
ER-L	Effects Range-Low
ER-M	Effects Range-Median
ESD	EPA's Environmental Services Division
^0F	degree Fahrenheit
FDA	U.S. Food and Drug Administration
FID	Flame Ionizing detector
FI	Fraction of consumed fish

foc	Fraction of organic carbon in sediment/soil
FOL	Field Operations Leader
fpm	feet per minute
fps	feet per second
FS	Feasibility Study. See RI/FS.
FSP	Field Sampling Plan
ft	feet
g	gram
GAC	Granulated Activated Carbon
gal	gallon
gpd	gallons per day
gph	gallons per hour
gpm	gallons per minute
GWPS	Groundwater Protection Strategy
HA	Health Advisory
HASP	Health and Safety Plan
HEAST	EPA Health Effects Assessment Summary Tables
HI	Hazard Index
HNUS	Halliburton NUS Environmental Corporation
hp	horsepower
HPLC	High Pressure Liquid Chromotography
HQ	Hazard Quotient
hr	hour
I.D.	inside diameter
IDW	Investigation-derived Waste
in.	inch
in/hr	inches per hour

IR	Ingestion Rate
IRIS	Integrated Risk Information System
^{0}K	degree Kelvin
K	Hydraulic conductivity
Kcal	Kilocalorie
Kd	Sediment or soil/water partitioning coefficient
kg	kilogram
kHz	Kilohertz
km	kilometer
Koc	Partitioning coefficient for chemical/organic carbon
Kow	Partitioning coefficient for octanol in water at STP
l	liter
lb	pound
LEC	Lowest effects concentration
LEL	Lower Explosive Limit
ln ft	linear foot
LOEC	Lowest-observed effects concentration
LOAEL	Lowest-observed adverse effects level
m	meter
u	micro (prefix)
MCL	Federal Safe Drinking Water Act maximum contaminant level. The primary MCL is health-based; the secondary is aesthetic-based.
MCLG	Federal Safe Drinking Water Act maximum contaminant level goal.
MDC	Massachusetts Metropolitan District Commission
mg	milligram
mgd	million gallons per day

mg/kg	milligram per kilogram
mg/L	milligram per liter
mi	mile
mL	milliliter
MOM	Management of Migration
mph	miles per hour
msl	mean sea level
NAAQS	National Ambient Air quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NF	Net flux
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No-observed adverse effects concentration
NOEL	No-observed effects concentration
NPDES	National Pollution Discharge Elimination System
NPL	(EPA's) National Priority List. A list of sites identified for remediation under CERCLA.
NUS	NUS Corporation (Halliburton NUS Environmental Corporation as of July 1991)
O.D.	outside diameter
O&M	Operations and Maintenance
OS	Oversight
OSHA	Occupational Safety and Health Administration
OSWER	(EPA's) Office of Solid Waste and Emergency Response
ORD	(EPA's) Office of Research and Development
OVA	Organic Vapor Analyzer
OVM	Organic Vapor Meter

oz	ounce
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated Biphenyl
PC	Permeability constant
PCDF	Polychlorinated Dibenzofuran
pCi	picocurie
PCOC	Potential Chemical of Concern
PDI	Pre-Design Investigation
PEL	Permissible Exposure Level
pH	hydrogen-ion concentration
PID	photo-ionizing detector
pm	afternoon
POTW	Publicly Owned Treatment Works
ppb	parts per billion
PPE	Personal Protection Equipment
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RAF	Absorption factor for soils/sediment
RD/RA	Remedial Design/Remedial Action
RAS	Routine Analytical Service
RCO	Regional Contracting Officer
RCRA	Resource Conservation and Recovery Act
D	Remedial Design

RfD	Reference Dose
Ri	Risk factor for a specific chemical in an environmental medium
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study. The first comprehensive phase in cleaning up an NPL site. An RI involves field work to determine the nature and extent of site contamination. The FS analyses that data and recommends strategies to clean it up.
ROD	(EPA's) Record of Decision. Documents the selection of a cost-effective Superfund remedy.
RPM	Regional Project Manager
RPO	Regional Project Officer
RQD	Rock Quality Designation
SAP	Sampling and Analysis/Quality Assurance Plan
SAS	Special Analytical Service
SARA	Superfund Amendments and Reauthorization Act of 1986. Amended CERCLA. Also known as the Superfund law.
SCBA	Self-Contained Breathing Aparatus
SCR	Soil/sediment contact rate
SCS	(U.S. Department of Agriculture) Soil Conservation Service
SDWA	Safe Drinking Water Act
Site, the	The National Priority List site, as defined by EPA.
SMO	Sampling Management Office
SMP	Site Management Plan
SOW	Statement of Work
SPHEM	Superfund Public Health Evaluation Manual
sq ft	square feet
sq in	square inch
sq yd	square yard

SSA	Contact rate
SVOC	Semi-volatile Organic Compound
$T_{1/2}$	Half-life
TAL	(CLP) Target Analtye List for metals
TBC	To Be Considered
TCE	Trichloroethene
TCL	(CLP) Target Compound List for Organics
TCLP	Toxicity Characteristic Leaching Process
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage, or Disposal under RCRA
UEL	Upper Exposure Limit
UF	Uncertainty factor
ug/kg	microgram per kilogram
ug/L	microgram per liter
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USN	U. S. Navy
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WP	Work Plan
WWTP	Wastewater treatment plant

1

1.0 INTRODUCTION

1.1 Purpose of the Report

This report presents the results of a detailed investigation of the Sudbury River and associated surficial drainage routes from the Nyanza Site (Nyanza) in the Town of Ashland, Massachusetts, to the confluence of the Sudbury with the Assabet River in Concord. This Remedial Investigation was prepared in accord with the Final Work Plan, dated August 1989, and the Sampling and Analysis Plan, dated April 1990, for the United States Environmental Protection Agency (EPA) Region I, under Work Assignment No. 02-1L15, Contract 68-W8-0117. The Feasibility Study is under development and will be submitted to the EPA under separate cover.

The Nyanza Site was included on the original National Priorities List (NPL) in 1982. To expedite remediation, the Remedial Investigation/Feasibility Study (RI/FS) for Nyanza was originally divided into separate units. Operable Unit I, for which an RI/FS has been completed, a Record of Decision (ROD) signed, and most of the remedial construction activities completed, addressed surficial deposits of sludges and sediments containing elevated levels of heavy metals, including arsenic, chromium, mercury, cadmium, and lead. A ROD has also been signed for Operable Unit II, referred to as "Nyanza II - Groundwater Study." This study addresses groundwater contamination within the former Nyanza property boundary and determines the presence of offsite migration. Operable Unit III, the focus of this Remedial Investigation, is referred to as "Nyanza III - Sudbury River Study." It addresses contamination in the Sudbury River by discharges of wastewater and sludge from the Nyanza Site.

The Nyanza III RI was conducted to determine the nature and extent of chemical contamination of surface water, sediment, and biota, and to gather sufficient information to determine the need for and extent of remedial action. To achieve these objectives, data was collected:

1. to assess the nature and distribution of contaminants in surface water, sediments, and fish
2. to perform a public health and environmental risk assessment
3. to develop response objectives
4. to support the evaluation of remedial alternatives

The data and conclusions presented in this report will be used to develop the Feasibility Study (FS), an evaluation of possible remedial alternatives to accomplish the response objectives. A detailed analysis of each alternative will be provided in the FS.

The Nyanza III - Sudbury River Study Remedial Investigation has been performed consistent with the requirements of the National Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendment and Reauthorization Act (SARA) of 1986. This Remedial Investigation report has been prepared in accord with the latest U.S. Environmental Protection Agency RI/FS Guidance (EPA, 1988) and Data Quality Objective (DQO) Guidance (EPA, 1987).

1.2 Site Background

This section describes the setting of the Site and Study Area, and outlines the Site history and previous investigations within the Study Area. In accord with the National Environmental Policy Act, Section 1500.4, Reducing Paperwork, this document minimizes redundancy of printed information through use of previous studies and reports by reference in lieu of reprinting information readily available from other sources.

1.2.1 Site Industrial History

The Nyanza Site was occupied from 1917 through 1978 by several companies involved in manufacturing textile dyes and dye intermediates. During that period large volumes of chemical wastes were disposed into burial pits, structures including "The Vault" a below ground containment structure, and lagoons at various locations throughout the Hill section and what is now the lower industrial area. Wastes include partially treated process wastewater, chemical sludge from the wastewater treatment process, solid process wastes (chemical precipitate and filter cakes), solvent recovery distillation residue, acids, numerous organic and inorganic chemicals (including mercury) and off-specification products. Process chemicals that could not be recycled or reused (phenol, nitrobenzene, and mercuric sulfate) were also disposed onsite or discharged to the Sudbury River.

Nyanza, Inc., the most recent dye manufacturer at the location, operated from 1965 until 1978, when it ceased business due to financial difficulties. The property was purchased by Edward Camille, a private citizen, in 1978. In 1981, most of the property was acquired by MCL Development Corporation, which leases a large portion of the Site to Nyacol Products, Inc. Mr. Camille and three other small property owners currently operate or lease facilities in the lower industrial area to various light industries and commercial concerns. These include Ashland Industrial Fuel Corporation, Middlesex Equipment, Ashland Excavating Co., A Auto Body, Environmental Restoration Engineering Co., and others.

1.2.2 Study Area Description

The Nyanza Superfund Site is located on Megunko Road in Ashland, Massachusetts, in Middlesex County, approximately 22 miles west of Boston. The Site was the location of chemical dye manufacturing facilities for 61 years and is currently occupied by several small industrial enterprises.

The Nyanza Operable Unit III was established as a study of the Sudbury River drainage basin (Figure 1-1) in May 1989. For purposes of this report, the term "Nyanza Site" or "Site" will refer to the 35-acre former Nyanza, Inc., Site.* The term "Study Area" will refer to the 31 miles of the Sudbury River drainage basin from the headwaters at Cedar Swamp Pond in Westborough to the confluence of the Sudbury and Assabet Rivers which form the Concord River in Concord, Massachusetts.

Also included in the Study Area are the "Raceway" (a canal serving the historic mill district in Ashland); Eastern Wetland and Trolley Brook, which drains this ponded wetland (both are recipients of surface water to the east of the Nyanza Site); Cold Spring Brook; and Chemical Brook Culvert. Chemical Brook Culvert is a recipient of flow from Trolley Brook and Chemical Brook, which are drainage routes from the Site. Refer to Figures 1-A and 1-B in Volume IV of this report for depictions of these areas.

The Sudbury River flows in a northerly direction through rolling, hilly terrain. Most of the surrounding area is suburban residential, consisting of several closely spaced urban centers connected by arterial commuting routes to Boston. The Great Meadows National Wildlife Refuge (a total of approximately 3,000 acres) in Sudbury, Wayland, Concord, and Lincoln, Massachusetts borders approximately 6 miles of the Sudbury River (Figure 1-1).

For the purposes of this report, the Study Area has been separated into ten sections termed "Reaches", which are defined by, among other parameters, changes in river configuration, impounding structures, and stream junctures. Tributaries, such as Chemical Brook Culvert, Trolley Brook and Eastern Wetland, and Cold Spring Brook are discussed separately. Reaches are numbered 1 through 10, which follow in order from upstream to downstream. The limits of each Reach are outlined below and in Figures 1-A and 1-B.

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* The Site consists of a 35-acre parcel on Megunko Road in Ashland, Massachusetts formerly owned and operated by Nyanza, Inc. (the Nyanza Property) as well as all areas that have come to be contaminated with hazardous substances emanating from the Nyanza Property.

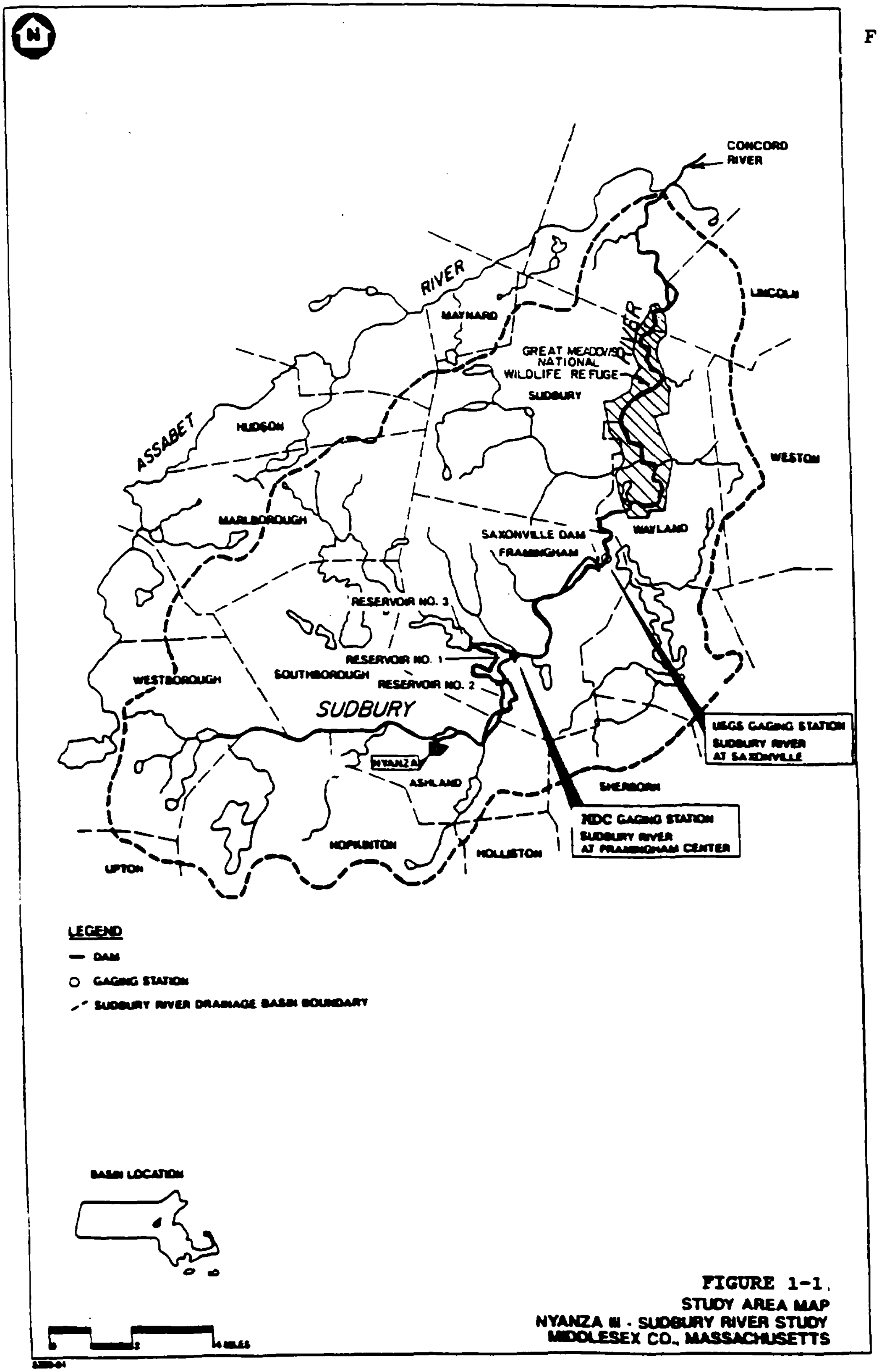

FIGURE 1-1
STUDY AREA MAP
NYANZA III - SUDBURY RIVER STUDY
MIDDLESEX CO., MASSACHUSETTS

Reach 1 extends from Cedar Swamp in Westborough, upstream of the Nyanza Site, to the small dam (referred to as the Pleasant Street Impoundment) downstream of the Pleasant St. river crossing and upstream of Mill Pond in Ashland. This area has been determined to be upgradient of Site-related surficial drainage and the groundwater plume. Reach 1 is considered a background Reach.

Reach 2 extends from the Pleasant Street impoundment to the Union Street (Route 135) bridge in Ashland. This Reach is directly impacted by Site discharges at and downstream of Mill Pond, and is geographically the most proximate of the Reaches to the Site. Mill Pond is the only impoundment where sediment carried by the River may be deposited in this Reach. Other depositional areas in Reach 2 are typically along the River's edge, behind obstructions or inside the River bends. There are fewer of these depositional areas in Reach 2 than in the reservoirs immediately downstream. Present in the geographical region, but not included in Reach 2, are Eastern Wetlands, the Chemical Brook and Cold Spring Brook Culverts, and the Raceway, which is a canal paralleling the River through Ashland. These features are not included in Reach 2 discussions and the data sets will be discussed individually later in this section.

Reach 3 includes Reservoir No. 2 and ends at Dam No. 2, which divides Reservoirs 2 and 1. Reach 3, being a relatively deep, slow moving body of water, is a primary sedimentation area directly downstream of Reach 2.

Reach 4 includes Reservoir No. 1 and is bounded by Dam No. 1 at the Winter Street crossing in Framingham. Reach 4 has characteristics similar to Reach 3, the dams act as physical barriers to upstream fish migration, although some downstream migration of contaminants may occur.

Reach 5 extends from Dam No. 1 to the Massachusetts Turnpike (Interstate 90) overpass where the River widens. The Sudbury River is typically narrow in this vicinity, with higher flow velocities than the impounded reservoirs; some channelization has occurred through developed areas. As a result, the River in Reach 5 has less depositional potential than Reservoirs 1 and 2; however, some localized depositional areas are present due to the low flow velocity and low gradient areas present.

Reach 6 extends from the Massachusetts Turnpike to the Saxonville Dam at the Central Street crossing. Reach 6 includes the depositional area of ponded water behind the Saxonville Dam.

Reach 7 extends from the Saxonville Dam downstream to the Route 20 overpass in Wayland. Downstream of the Saxonville Dam (the last impoundment), a low stream gradient (less than 1 foot per mile) results in a slow, meandering river with high depositional potential.

Reach 8 extends from the Route 20 overpass in Wayland to the area of the Route 117 overpass, prior to the inlet at Fairhaven Bay. This Reach includes the Great Meadows National Wildlife Refuge. The River's meandering course and extensive bordering swamps and marshes characterize this Reach as having high depositional potential.

Reach 9 is Fairhaven Bay, a large pond-like feature in the River. Fairhaven Bay is also a potential depositional area.

Reach 10 extends from the outlet of Fairhaven Bay to the confluence of the Sudbury and Assabet Rivers.

The RI also addresses contamination in several locations within the Study Area which are not included in the ten Reaches of the Sudbury River:

- The Eastern Wetlands are treated separately because they actually constitute a headwaters area of a small tributary of the River. They also receive surface runoff directly from the Nyanza Site (Figure 1-D).

- Chemical and Trolley Brooks were the primary surficial drainage routes from the Site and Eastern Wetlands before remedial activities were conducted under Operable Unit I. Chemical Brook was remediated under Operable Unit I. The Brooks merged and discharged through a subsurface culvert (Chemical Brook Culvert) which discharged to the Raceway, downstream of the Concord Street overpass in Ashland, and to the Sudbury River (Figure 1-A, Detail).

- The Raceway is a man-made canal which channelizes a portion of the River flow from a flow-control gate at Mill Pond into a culvert which passes beneath a large mill building. The Raceway changes to an open canal downstream of the mill. The Outfall Creek carrys water from the Chemical Brook culvert discharge and in turn, discharges to the open part of the raceway. The raceway rejoins Reach 2 of the Sudbury River downstream of the confluence with the Outfall Creek.

- A second culvert, Cold Spring Brook Culvert, is also located within Reach 2. It discharges to Cold Spring Brook, a tributary of the Sudbury River (Figure 1-A, Detail) near the Main Street crossing in Ashland. This culvert was referred to in previous reports as the Trolley Brook Wetlands Culvert.

- The Sudbury Reservoir in Southboro, Massachusetts was sampled as a background location. The reservoir is located on a tributary which discharges to the main stem of the Sudbury River, and therefore, can be used as a background location for comparison with elevated downstream levels of inorganics and organics (Figure 1-A). Data sets from this Reservoir are included with Reach 1 data sets to comprise background data sets.

- Heard Pond, located in Reach 7, is considered separate from the other features of Reach 7. The Pond is, on occasion, reportedly flooded by the River, however, the two are not otherwise linked by surface water.

1.2.3 Nyanza Previous Investigations

This section briefly describes previous investigations relevant to the Nyanza III RI/FS. Several investigations were conducted within the Nyanza III - Sudbury River Study Area by various state and federal agencies from 1972 to the present. Most of the previous studies concentrated on the Nyanza Site; however, several studies addressed, in a cursory fashion, assessments of the Sudbury River downstream of the Site. The following paragraphs present a brief overview of the investigations most relevant to this study.

1.2.3.1 Previous Investigations - Nyanza Site

Investigation of the Nyanza Site began in 1972, when the Massachusetts Departments of Public Health (DPH) and Water Pollution Control (DWPC) cited Nyanza, Inc., for several waste disposal violations. Investigations and interim groundwater remedial activities have continued to the present, with a source control remedial action (Operable Unit I) currently in progress. A summary of major events in the investigative history of the Nyanza Site includes the following:

- 1972-1977: Massachusetts DPH and DWPC cited Nyanza for several waste disposal violations.

- 1974: Camp Dresser and McKee, Inc. (CDM) completed an environmental site investigation for Nyanza, Inc. The study focused on the identification of sources of contamination found on- and off-site. A plan to control groundwater contamination was developed but not implemented.

- 1980: Massachusetts Department of Environmental Quality Engineering (DEQE) (currently called the Massachusetts Department of Environmental Protection [DEP]) performed a preliminary site assessment (SA). DEQE also released a report summarizing findings of previous studies.

- 1981: Connorstone Engineering/Carr Research Labs performed a site characterization study for MCL Development Corporation, the new Nyanza Site owners.
- 1982: The Nyanza Site was listed on the Superfund National Priorities List (NPL); CDM developed a Remedial Action Master Plan (RAMP) for EPA, emphasizing on-site source control remedial actions.
- 1984-1985: NUS performed an RI/FS on Operable Unit I (on-site surficial soils, sediments, and sludge deposits); a ROD based on this RI/FS, recommending source removal and stabilization/landfilling activities, was signed in 1985.
- 1986: CDM conducted additional on-site investigations to locate source areas and support a remedial design of the ROD-specified actions.
- 1987: EPA Region I Environmental Services Division (ESD) and DEQE performed a sludge removal action for a buried concrete tank, "the vault", at the Nyanza Site. The vault was a major source of organic chemical groundwater contamination. E.C. Jordan began RI/FS activities on Operable Unit II (a groundwater assessment study). Planning was initiated for Operable Unit III (Sudbury River Study).
- 1989: Source control measures were implemented at the Nyanza Site by the U.S. Army Corps of Engineers using Tricil Environmental Response, Inc.

These investigations and remedial activities indicated that on-site soils, sludges, and sediments were contaminated primarily with heavy metals, including mercury, chromium, lead, and cadmium. These surficial deposits were remediated as part of the Operable Unit 1 remedial action. However, a contaminated groundwater plume containing elevated levels of various organic chemicals (nitrobenzene, trichloroethylene, chlorobenzene) has been identified migrating in a northeasterly direction from the Site; it may be a source of organic compound contamination to the Sudbury River. Organic contaminants may also reach the River through surficial runoff from secondary sources such as the Eastern Wetland and Trolley Brook. A more detailed evaluation of these contaminant source transport pathways and their relationship to contamination in Sudbury River water, sediments, and biota is presented in Section 4.

1.2.3.2 Previous Investigations - Sudbury River

Previous Sudbury River contamination studies included sediment, surface water, and biota investigations at various locations from upstream of the Nyanza Site, downstream to the Concord River.

Investigations of Sudbury River contamination related to the Nyanza Site have included the following:

- o JBF Scientific, Inc.: JBF performed initial investigations addressing elevated levels of mercury in Sudbury River water, sediments, and biota in 1972. Elevated levels of mercury were detected, and were qualitatively linked to uncontrolled sludge disposal at the Nyanza property.
- o U.S. Fish and Wildlife Service (USFWS): USFWS began monitoring fish in the Sudbury River for elevated mercury levels in 1977. Sampling events continued through 1987. Several species of fish were analyzed to determine the potential for bioaccumulation of mercury. Some sampling events also included sediment sampling. Analyses of organic contaminants included concentrations in sediments of polychlorinated biphenyls (PCBs), pesticides, and polynuclear aromatic hydrocarbons (PAHs).
- o DEQE/MDC Metropolitan District Commission: DEQE performed several environmental investigations of assessments of the Sudbury River from 1980 to 1987. These studies included fish, surface water, and sediment sampling and analysis for metals, with limited additional organic analyses. The DEQE data were incorporated into an MDC Sudbury Reservoir Water Treatment Plant Draft Environmental Impact Report (1982). In addition, DEQE was involved in a cooperative biota/sediment monitoring effort with USFWS.

These studies have indicated that sediments and fish in the Sudbury River contain elevated levels of mercury and that sediments contain elevated concentrations of other metals, most notably lead and chromium. The highest elevated levels of inorganics (metals) and organic compounds were generally found in the River downstream of the Site, from Reach 2 to the Saxonville Dam, located in Reach 6. Mercury concentrations in approximately 25 percent of the fish tested exceeded the Food and Drug Administration (FDA) action level of 1 mg/kg (ppm). As a result, the DPH issued a Health Advisory in 1986 recommending that fish caught in the Sudbury River not be eaten. Organic analyses in previous investigations have been limited and do not provide a definitive basis for assessment of organic compound contamination.

A detailed discussion of the data generated during this RI concerning inorganic and organic chemical contamination in fish, surface water, and sediment in the Sudbury River is included in Section 4.0.

1.3 Specific Objectives of the Remedial Investigation

The objectives of the Nyanza III - Sudbury River Study RI are:

- Defining of the nature and extent of contamination in the sediments, surface water, and biota of the Sudbury River
- To the extent possible, determining the distribution of contamination discharged from the Nyanza Site versus contamination attributable to other sources
- Assessing the public health and ecological risks associated with the elevated levels of inorganic and organic contaminants observed in the sediments, surface water, and biota

The Feasibility Study will:

- Develop general response objectives and Site clean-up standards focusing on possible sediment remediation goals appropriate to the observed contamination
- Develop and evaluate remedial alternatives focusing on possible sediment cleanup to mitigate or eliminate the defined risks

1.4 Summary of Remedial Investigation Activities

Section 2 of this RI report presents a detailed description of the field investigation activities.

The large scale river system addressed by the Nyanza III - Sudbury River Study dictated a two-phased approach to meeting RI objectives. The phased approach provided the greatest flexibility as well as the collection of the most applicable data.

Phase I

Phase I data collection focused on preliminary characterization of the nature and distribution of contamination in the water, sediment, and biota in the River system. Phase I also included a one-year, monthly sampling program to identify trends and fluctuations in the water chemistry of the River system. Following Phase I, a Technical Directive Memorandum was issued which identified the preliminary findings of the study, as well as a preliminary qualitative assessment of the risks to public health and the ecology of the system.

Phase I included sampling 50 sediment station locations. Sediment samples were collected at the sediment surface at all the 50 stations and at a depth interval from six to twelve inches at 14 of these stations.

All 64 sediment samples were analyzed for Target Compound List (TCL) metals and methyl mercury. Twenty-two of these samples were also analyzed for additional parameters, as specified in Table 1-1. With the exceptions of SW3-101 and SW3-103, these 22 samples were collected at locations corresponding with the 22 surface water locations. SW3-101 and SW3-103 were not co-located with sedient samples because a laboratory was not available to analyze sediment samples when these water samples were collected.

Unfiltered surface water samples were collected from 22 of the 50 sediment stations. In addition, filtered surface water samples were collected from 11 of the 22 stations. Surface water samples were analyzed for the parameters presented in Table 1-2.

Biota sampling during Phase I included the collection of three species of fish from four impoundments of the River. These included Reservoirs No. 1 and 2, the Saxonville Dam impoundment, and the Sudbury Reservoir (background location). Biota sampling also included a qualitative assessment of benthic organisms at River sediment sampling locations.

Phase I work included a one-year periodic surface water sampling program (January through December 1990) which involved monthly collection of surface water samples from five locations. These samples were analyzed for metals and water quality parameters.

Phase II

Phase II of the investigation included additional sampling to further define the nature and extent of contamination. The goal of this phase was to fill data gaps identified following the completion of Phase I and to provide a more complete database to identify risks.

Phase II samples were analyzed for the parameters listed in Table 1-1 and 1-2, Section 2.0. A detailed discussion of analytical parameters is presented in the Phase II Final Sampling and Analysis Plan (SAP) Amendment No. 2, October 1990.

The Eastern Wetlands were sampled during Phase II activities to provide information on the horizontal and vertical extent of contaminants in the wetland sediments. A total of 23 locations

TABLE 1-1

SEDIMENT SAMPLING PARAMETERS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION		STATION	INORGANIC	METHYL-MERCURY	TCL ORGANICS	SITE ORGANICS	ACOE METALS	TCLP METALS	GRAIN SIZE	pH & Eh	TOC	BOD	COD	TKN	HEX.* CHROM. VI
SUDBURY RIVER	*PHASE I*	SD3-101	X	X											
		SD3-102	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-103	X	X											
		SD3-104	X	X											X
		SD3-111	X	X											
		SD3-115	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-116	X	X											
		SD3-117	X	X	X	X	X	X	X	X	X	X	X	X	X
		SD3-118	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-118+	X	X											
		SD3-119	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-120	X	X	X	X	X	X	X	X	X	X	X	X	X
		SD3-120+	X	X					X						
		SD3-121	X	X											X
		SD3-122	X	X	X	X	X	X	X	X	X	X	X	X	X
		SD3-123	X	X											
		SD3-124	X	X	X	X	X	X	X	X	X	X	X	X	X
		SD3-125	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-125+	X	X											
		SD3-126	X	X											
		SD3-127	X	X											
		SD3-128	X	X											
		SD3-129	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-130	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-130+	X	X											
		SD3-131	X	X											
		SD3-132	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-132+	X	X											
		SD3-133	X	X			X	X							
		SD3-134	X	X											
		SD3-135	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-135+	X	X											
		SD3-136	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-137	X	X											
		SD3-138	X	X											
		SD3-138+	X	X	X	X			X			X	X	X	
		SD3-139	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-140	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-140+	X	X											
		SD3-141	X	X											
		SD3-141+	X	X											
		SD3-142	X	X											
		SD3-143	X	X											
		SD3-144	X	X											
		SD3-145	X	X											
		SD3-146	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-147	X	X											
		SD3-148	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-149	X	X	X	X	X	X	X	X	X	X	X	X	

TABLE 1-1
SEDIMENT SAMPLING PARAMETERS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

LOCATION	STATION	INORGANIC	METHYL-MERCURY	TCL ORGANICS	SITE ORGANICS	ACOE METALS	TCLP METALS	GRAIN SIZE	pH & Eh	TOC	BOD	COD	TKN	HEX.* CHROM. VI
SUDBURY RIVER *PHASE I*	SD3-150	X	X	X	X	X	X	X	X	X	X	X	X	
SUDBURY RIVER *PHASE II*	SD3-152	X		X	X			X		X	X	X		
	SD3-153	X		X	X			X		X	X	X		
	SD3-153+	X		X	X			X		X	X	X		
	SD3-154	X		X	X			X		X	X	X		
	SD3-154+	X		X	X			X		X	X	X		
	SD3-156	X		X	X			X		X	X	X		
	SD3-157	X		X	X			X		X	X	X		
	SD3-158	X						X		X				
	SD3-162	X						X		X				
	SD3-163	X						X		X				
	SD3-163+	X						X		X				
	SD3-165	X						X		X				
	SD3-165+	X						X		X				
	SD3-166	X						X		X				
	SD3-166+	X						X		X				
	SD3-168	X						X		X				
	SD3-169	X						X		X				
	SD3-170	X						X		X				
	SD3-170+	X						X		X				
	SD3-171	X						X		X				
	SD3-172	X						X		X				
	SD3-173	X						X		X				
	SD3-174	X						X		X				
	SD3-175	X						X		X				
	SD3-176	X						X		X				
	SD3-177	X						X		X				
	SD3-177+	X						X		X				
	SD3-178	X						X		X				
	SD3-178+	X						X		X				
	SD3-179	X						X		X				
	SD3-180	X						X		X				
	SD3-181	X						X		X				
	SD3-182	X						X		X				
	SD3-183	X						X		X				
	SD3-183+	X						X		X				
	SD3-184	X						X		X				
	SD3-185	X						X		X				
	SD3-186	X						X		X				
	SD3-186+	X						X		X				
	SD3-187	X						X		X				
	SD3-188	X						X		X				
	SD3-188+	X						X		X				
	SD3-189	X						X		X				
	SD3-190	X						X		X				
	SD3-191	X						X		X				
	SD3-192	X						X		X				
	SD3-192+	X						X		X				
	SD3-193	X						X		X				
	SD3-194	X						X		X				

TABLE 1-1
SEDIMENT SAMPLING PARAMETERS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE THREE

LOCATION		STATION	INORGANIC	METHYL-MERCURY	TCL ORGANICS	SITE ORGANICS	ACOE METALS	TCLP METALS	GRAIN SIZE	pH & Eh	TOC	BOD	COD	TKN	HEX. * CHROM. VI
SUDBURY RIVER	PHASE II	SD3-195	X						X		X				
		SD3-195+	X						X		X				
		SD3-196	X						X		X				
		SD3-197	X						X		X				
		SD3-198	X						X		X				
		SD3-199	X						X		X				
		SD3-199+	X						X		X				
		SD3-202	X		X	X			X		X	X	X		
		SD3-203	X		X	X			X		X	X	X		
		SD3-204	X		X	X			X		X	X	X		
		SD3-207	X						X		X				
		SD3-208	X						X		X				
		SD3-209	X						X		X				
		SD3-210	X						X		X				
		SD3-242			X	X			X		X				
		SD3-242+			X	X			X		X				
		SD3-243			X	X			X		X				
		SD3-243+			X	X			X		X				
BORDERING WETLANDS	PHASE I	SD3-113	X	X											
		SD3-114	X	X											
	PHASE II	SD3-155	X						X		X				
		SD3-155+	X						X		X				
		SD3-159	X						X		X				
		SD3-159+	X						X		X				
		SD3-161	X						X		X				
		SD3-161+	X						X		X				
		SD3-167	X						X		X				
		SD3-167+	X						X		X				
RACEWAY		SD3-244	X		X	X			X		X				
		SD3-244+	X		X	X			X		X				
		SD3-245	X		X	X			X		X				
		SD3-245+	X		X	X			X		X				
COLD SPRING BROOK	PHASE I	SD3-105	X	X											
	PHASE II	SD3-160	X		X				X		X				
EASTERN WETLANDS	PHASE I	SD3-106	X	X	X	X	X	X	X	X	X	X	X	X	
		SD3-106+	X	X											
		SD3-107	X	X											
		SD3-107+	X	X											
		SD3-108	X	X											
		SD3-108+	X	X											
		SD3-109	X	X											
		SD3-109+	X	X							X	X	X	X	
		SD3-110	X	X	X	X	X	X	X		X	X	X	X	
		SD3-110+	X	X											
	PHASE II	SD3-211#	X												

TABLE 1-1
SEDIMENT SAMPLING PARAMETERS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE FOUR

LOCATION		STATION	INORGANIC	METHYL-MERCURY	TCL ORGANICS	SITE ORGANICS	ACOE METALS	TCLP METALS	GRAIN SIZE	pH & Eh --------	TOC	BOD	COD	TKN	HEX.* CHROM. VI
EASTERN WETLANDS	*PHASE II*	SD3-212 #	X		X	X									
		SD3-213 #	X												
		SD3-214 #	X												
		SD3-215 #	X												
		SD3-216 #	X		X	X									
		SD3-217 #	X												
		SD3-218	X												
		SD3-219 #	X												
		SD3-220 #	X												
		SD3-221 @	X		X	X									
		SD3-222 @	X		X	X									
		SD3-223 @	X		X	X									
		SD3-224 #	X												
		SD3-225 @	X												
		SD3-226 @	X		X	X									
		SD3-227 @	X		X	X									
		SD3-228 @	X		X	X									
		SD3-229 @	X		X	X									
		SD3-230 @	X		X	X									
		SD3-231 @	X		X	X									
		SD3-232 @	X		X	X									
		SD3-233 @	X		X	X									
		SD3-234 @	X		X	X									
		SD3-235 @	X		X	X									
		SD3-236 @	X		X	X									
		SD3-237 @	X		X	X									
		SD3-238 @	X		X	X									
		SD3-239 @	X		X	X									
		SD3-240 @	X		X	X									
		SD3-241 @	X		X	X									
		SD3-339 @	X		X	X									
CHEMICAL BROOK CULVERT	*PHASE I*	SD3-112	X	X	X	X	X	X	X	X	X	X	X	X	
	PHASE II	SD3-200	X		X	X					X	X	X		
		SD3-201	X		X	X			X		X	X	X		
		SD3-205	X		X	X			X			X	X		
		SD3-206	X		X	X			X			X	X		

Notes:
Station SD3-151 not collected - Cedar Swamp Pond sediment - 100% organic material
Station SD3-164 deleted - sample slots were used for sediment sampling at Phase II caddisfly sampling locations
Station SD3-200 Grain Size was not collected due to low available sediment volume
* = Hexavalent Chromium collected at Phase I locations during Phase II sampling round

TCL ORGANICES include volatile, PCB/Pesticides, and BNA fractions analyses
SITE ORGANICS include Benzidine, Aniline, o0Nitroclorobenzene, 1-Naphylamine, 2-Naphthylamine, o-Tolidine, o-Dianisidine
ACOE = Army Corps or Engineers Elutriate Test
TCLP = Toxicity Characteristic Leaching Procedure
TOC = Total Organic Carbon
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand

TKN = Total Kjeldahl Nitrogen
HEX CHROM VI = Hexavalent Chromium
= 2 feet total depth - two profiles collected
@ = 6 feet total depth - four profiles collected
X = Analysis was performed
\+ = 6 to 12 inch profile

TABLE 1-2

SURFACE WATER SAMPLING PARAMETERS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION		STATION	TCL ORGANICS	SITE ORGANICS	TCL INORGANICS	FILTERED INORGANICS	METHYL-MERCURY	Alkalinity-TOC-BOD-COD-TDS-TSS-TKN		pH	DO	HARDNESS (calculated)
								unfiltered	filtered	field	field	
SUDBURY RIVER	*PHASE I*	SW3-101	X	X	X		X	X		X	X	X
		SW3-102M	X	X	X		X	X		X	X	X
		SW3-107	X	X	X	X	X	X	X	X	X	X
		SW3-108M	X	X	X		X	X		X	X	X
		SW3-109	X	X	X		X	X		X	X	X
		SW3-110	X	X	X		X	X		X	X	X
		SW3-111	X	X	X		X	X		X	X	X
		SW3-112	X	X	X	X	X	X	X	X	X	X
		SW3-113M	X	X	X		X	X		X	X	X
		SW3-114	X	X	X	X	X	X	X	X	X	X
		SW3-115	X	X	X		X	X		X	X	X
		SW3-116	X	X	X		X	X		X	X	X
		SW3-117	X	X	X	X	X	X	X	X	X	X
		SW3-118	X	X	X	X	X	X	X	X	X	X
		SW3-119M	X	X	X	X	X	X	X	X	X	X
		SW3-120	X	X	X	X	X	X	X	X	X	X
		SW3-121	X	X	X	X	X	X	X	X	X	X
		SW3-122	X	X	X	X	X	X	X	X	X	X
	PHASE II	SW3-123	X	X	X	X		X	X	X	X	X
		SW3-124	X	X	X	X		X	X	X	X	X
		SW3-125	X	X	X	X		X	X	X	X	X
		SW3-126	X	X	X	X		X	X	X	X	X
		SW3-127	X	X	X	X		X	X	X	X	X
		SW3-128	X	X	X	X		X	X	X	X	X
		SW3-129	X	X	X	X		X	X	X	X	X
		SW3-130	X	X	X	X		X	X	X	X	X
		SW3-131	X	X	X	X		X	X	X	X	X
		SW3-132	X	X	X	X		X	X	X	X	X
		SW3-133	X	X	X	X		X	X	X	X	X
		SW3-134	X	X	X	X				X	X	X
		SW3-135	X	X	X	X				X	X	X
COLD SPRING BROOK	*PHASE I*	SW3-103	X	X	X		X	X		X	X	X
EASTERN WETLANDS	*PHASE I*	SW3-104	X	X	X	X	X	X	X	X	X	X
		SW3-105M	X	X	X	X	X	X	X	X	X	X
CHEMICAL BROOK CULVERT	*PHASE I*	SW3-106	X	X	X	X	X	X	X	X	X	X
RACEWAY	*PHASE II*	SW3-136	X	X	X	X				X	X	X

TCL Organics include volatiles, PCB/Pesticides and BNA fractions analyses
SITE ORGANICS include Benzidine, Aniline, o-Nitrchlorobenzene, 1-Naphthylamine, 2-Naphthylamine o-Tolidine, o-Dianisidine
TOC = Total Organic Carbon
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand

TDS = Total Dissolved Solids
TSS = Total Suspended Solids
TKN = Total Kjeldahl Nitrogen
DO = Dissolved Oxygen
X = analysis was performed
M = Monthly sampling locations

were sampled to a total depth of approximately six feet, nine samples to a total depth of approximately two feet, and one sample to a depth of six inches in a small stream feeding the south end of the wetlands. These samples were analyzed for the parameters presented in Table 1-1.

Additional sampling was conducted at five Phase I sediment sampling locations which exhibited elevated levels of total chromium. These additional samples were collected to determine the presence of the hexavalent chromium.

Biota assessments during Phase II operations consisted of two major sampling events. Caddis fly larvae were collected by EPA from five locations along the River; these were analyzed for body burden concentrations of mercury, chromium, and lead. Two species of fish were collected by USFWS and analyzed for mercury and methyl mercury as well as other organic and inorganic contaminants. Phase II fish collection was performed at all Phase I fish collection locations (with the exception of the Sudbury Reservoir) as well as at additional background and downstream locations.

1.5 Report Organization

The general outline of this RI report follows that presented in the Interim Final USEPA Guidance for Remedial Investigations and Feasibility Studies Under CERCLA (1988). However, this format includes several modifications to better reflect the nature of the project.

Because of the Study Area expanse, the investigation report has been separated into discussions of: the Sudbury River, the Eastern Wetlands, the two tributaries and the Raceway. The Sudbury River has been further divided into reaches as defined in Section 1.2.1. The length of each reach was based on its geographic location and potential applicability of individual remedial action alternatives. Each area can be evaluated separately.

The order of this report has been divided by content. An Executive Summary and a list of abbreviations and acronyms specific to the Nyanza Operable Unit III investigation have been included as reader's aids. Sections 1.0 through 7.0 contain substantive information about the Study. The Introduction and other background information is contained in Section 1.0. The remaining Sections are summarized below:

- Section 2.0 Study Area Investigation

  Section 2.0 of this report details the investigation activities performed as a part of Phase I and Phase II, including the surface water, sediments, biota sampling (fish and benthic organisms), the monthly water sampling, and the wetlands evaluation.

- Section 3.0 General Characteristics of the Study Area

  The River system, including the wetlands, culverts, and the Raceway, is described in detail. This description includes the surface water hydrology, the bathymetry, and the ecology and surficial geology of the area.

- Section 4.0 Nature and Extent of Contamination

  Section 4.0 describes the extent of contamination in the Study Area. The Sudbury River watershed has a long history of industrialization. This industrialization, as well as the population centers and transportation routes within the watershed, are likely to contribute to the contamination of the River. Therefore, Section 4.0 also presents a discussion regarding those contaminants which are likely to be specifically related to the Nyanza Site (Nyanza Site contaminants) and a discussion regarding contaminants from other sources (other Study Area contaminants).

- Section 5.0 Contaminant Fate and Transport

  Section 5.0 discusses the various pathways, transport mechanisms, and fate of contaminants in the ecosystem. These include physical transport of contaminated media, transport of contaminants through the food chain by ecological receptors, and the degradation of contaminants in the environment.

- Section 6.0 Public Health Risk Assessment

  The Public Health Risk Assessment, presented in Section 6.0, follows guidelines in EPA national and regional documents and presents quantifications of potential risks to human health by the contaminants found in the River system.

- Section 7.0 Ecological Risk Assessment

  The Ecological Risk Assessment, presented in Section 7.0, provides analyses of food chain contaminant transfer and additional assessments of risks to receptor organisms. Particular discussion will focus on the potential affect to top predators within the food chain.

2

2.0 STUDY AREA INVESTIGATION

A number of investigations and environmental monitoring activities have been conducted in the Study Area prior to this investigation, as summarized in Section 1.2.3. These investigations identified the Nyanza Site as a source area of contamination affecting the Sudbury River. This Sudbury River RI builds on these studies to determine the nature and extent of contamination in the River system and to identify the risks to human health and the environment. This section presents a description of each of the field investigation tasks performed in the Study Area to meet the objectives of the RI.

Between September 1989 and December 1989, the following field activities were conducted under Phase I.

Phase I

- Sampling and analysis of surface water and sediment from selected River locations
- Sampling and analysis of surface water and sediment from selected Chemical Brook Culvert locations
- Monthly water sampling from selected River and Trolley Brook locations to define seasonal fluctuations in water chemistry
- Sampling and analysis of fish from selected River locations
- Surveying benthic biota (population density count) in the Study Area
- Assessing wetlands in the Study Area
- Surveying bathymetry and sediment thickness in Reservoirs No. 1 and No. 2 by the United States Geological Survey (USGS)
- Sampling and analysis of sediment within the Eastern Wetlands

A number of data gaps were identified at the completion of a preliminary evaluation of Phase I. The most significant finding was the presence of elevated levels of metals in sediments at the down-river limit of sampling. A Phase II work plan was then developed. This work was conducted from September 1990 through June 1991 and included:

- Expanding the Study Area to delineate the downstream extent of mercury contamination in river sediments
- Sampling and analysis of surface water and sediment from selected River locations
- Sampling and analysis of sediment in the Eastern Wetlands
- Sampling and analysis of sediment from selected locations within the bordering wetlands of the River
- Sampling and analysis of sediment from selected locations within the Raceway which parallels the River
- Sampling and analysis of additional fish from selected River locations
- Sampling and analysis of caddis fly larvae at selected River locations
- Inspecting the Chemical Brook Culvert by remote video camera to identify areas of sediment deposition
- Sampling and analysis of sediments from the Chemical Brook Culvert

The discussion of the Study Area investigation has been separated into three sections, as described in Section 1.5. These include the Sudbury River; the Eastern Wetlands; and the source tributaries and Raceway. Each of the tasks, the sampling station locations, and the analytical parameters, are described in the following sections.

2.1 Sudbury River Study

2.1.1 Sudbury River Surface Water Sampling and Analysis

The surface water sampling and analysis program and sampling procedures described in Section 4.3.1.4 of the Final Work Plan (August 1989), Final Work Plan Amendment No. 2 (October 1990), and Final Work Plan Amendment No. 3 (June 1991), Sections 4.1.5 and 4.2.2, respectively of the Final Sampling and Analysis Plan (SAP, August 1989), and the Final SAP Amendment No. 2 (October 1990) and the Final SAP Amendment No. 3 (June 1991) address specific sampling methods. Quality control samples including field duplicates, trip blanks, and rinsate blanks were collected and analyzed for each sampling round as specified in EPA guidance (User's Guide to the Contract Laboratory Program, December 1988) and in the Final SAP and the SAP Amendment Memoranda. The analytical results for surface water sampling are discussed in Section 4.3 and are presented in Appendix A, the Data Summary Analytical Database.

Surface water sampling was conducted for the following reasons: to determine the presence of contaminants; to evaluate surface water quality and potential migration of contaminants from sediments to surface water; to gather data to evaluate the appropriateness of surface water remedial action; and to provide data for the selection and design of remedial alternatives.

2.1.1.1 Phase I and Phase II Surface Water Sampling

The Phase I sampling program included an initial round of 18 unfiltered surface water samples collected from locations numbered SW3-101 through SW3-122, as presented in Figure 1-A. In addition, filtered surface water samples were collected from nine of these 18 locations. Phase I surface water sampling locations included areas upstream of the Nyanza Site, and extended down-river to the vicinity of Heard Pond in Wayland (Reaches 1 through 7). Sample locations were chosen to correspond to sediment sample locations and to provide representative information for each geographical portion of the River.

Surface water samples collected during Phase I were not analyzed for hexavalent chromium (chromium VI), as proposed in the Final Work Plan, since a Contract Laboratory Program (CLP) laboratory could not be identified to perform this analysis.

The Phase II surface water sampling included the collection of 11 unfiltered samples from stations numbered SW3-123 through SW3-133, as presented in Figure 1-A. These included additional background samples from Cedar Swamp Pond (in the headwaters area of the River), to the area directly downstream of the Saxonville Dam. Water samples were also collected at Phase II benthic sample stations and at "fill in" sample stations to provide complete coverage in Mill Pond and the Raceway.

Water quality parameters measured in the field during Phase I and II surface water sampling included pH, temperature, specific conductivity, and dissolved oxygen. Stream flow was also measured at each location. The surface water field data summaries are presented in Table 2-1.

All samples were submitted to the CLP for analysis. All surface water samples were analyzed for the parameters presented in Table 1-2. Phase II analytical parameters were selected to target selected metals and compounds known to have been discharged from the Site (Site contaminants), or were frequently detected during Phase I sampling.

TABLE 2-1
SURFACE WATER FIELD DATA SUMMARY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

SAMPLE IDENTIFICATION	SW3-101-0701	SW3-102-0201	SW3-102-0102	SW3-102-0203	SW3-102-0104	SW3-102-0205	SW3-102-0206	SW3-102-0207
DATE SAMPLED	11/30/89	11/01/89	01/08/90	02/05/90	03/06/90	04/04/90	05/08/90	06/04/90
pH	6.70	7.00	6.84	6.40	7.90		7.30	6.82
CONDUCTIVITY	0.155	0.158	0.16		0.22	0.22	0.258	0.21
TEMPERATURE	5.0	12.3	0.0	1.0	1.2	5.0	13.0	16.0
DISSOLVED OXYGEN	12.5	8.9	14.5	13.5	12.8	12.2	9.5	9.2
VELOCITY ft/sec	NO DATA	NO DATA	0.1	0.4	NOT RECORDED	3.0	0.4	1.0

SAMPLE IDENTIFICATION	SW3-102-0108	SW3-102-0109	SW3-102-0110	SW3-102-0311	SW3-102-0212	SW3-102-0113	SW3-103-0101	SW3-104-0101
DATE SAMPLED	07/10/90	08/07/90	09/15/90	10/01/90	11/08/90	12/06/90	11/01/89	11/27/89
pH	6.76	6.60	6.68	6.75	6.17	7.45	7.90	7.10
CONDUCTIVITY	0.227	0.236	0.231	0.271	0.191	0.211	0.16	0.22
TEMPERATURE	23.4	22.6	22.5	14.6	8.9	1.9	16.5	2.0
DISSOLVED OXYGEN	7.7	7.1	7.2	6.8	14.3	12.1	7.4	
VELOCITY ft/sec	0.7	1.0	NOT TAKEN	0.2	1.0	1.2	0.0	NO DATA

SAMPLE IDENTIFICATION	SW3-105-0101	SW3-105-0302	SW3-105-0103	SW3-105-0104	SW3-105-0105	SW3-105-0106	SW3-105-0107	SW3-105-0108
DATE SAMPLED	11/27/89	01/08/90	02/05/90	03/06/90	04/04/90	05/08/90	06/04/90	07/09/90
pH	7.20	6.76	8.25	9.20		6.28	6.93	6.68
CONDUCTIVITY	2.5	0.22	0.215	0.245	0.14	0.22	0.24	0.287
TEMPERATURE	3.0	2.5	0.5	2.2	7.0	15.0	23.8	22.7
DISSOLVED OXYGEN	9.3	10.5	6.4	10.25	10.0	9.1	12.5	5.4
VELOCITY ft/sec	NO DATA	0.4	0.0	NOT RECORDED	0.7	0.3	0.4	NO DATA

SAMPLE IDENTIFICATION	SW3-105-0109	SW3-105-0110	SW3-105-0111	SW3-105-0112	SW3-105-0113	SW3-106-0101	SW3-107-0201	SW3-108-0201
DATE SAMPLED	08/07/90	09/15/90	10/01/90	11/06/90	12/06/90	11/09/90	11/09/90	11/06/89
pH	6.69	6.91	6.73	6.50	7.32			7.50
CONDUCTIVITY	0.319	0.569	0.584	0.287	0.172	0.18	0.11	0.165
TEMPERATURE	24.2	21.5	18.5	8.4	1.8	9.0	9.0	8.0
DISSOLVED OXYGEN	4.75		8.0	13.2	10.0	10.0	10.0	21.0
VELOCITY ft/sec	0.6	NOT TAKEN	0.6	NOT RECORDED	0.2	0.3	0.1	0.0

SAMPLE IDENTIFICATION	SW3-108-0202	SW3-108-0203	SW3-108-0204	SW3-108-0205	SW3-108-0106	SW3-108-0107	SW3-108-0108	SW3-108-0309
DATE SAMPLED	01/08/90	02/05/90	03/06/90	04/04/90	05/08/90	06/04/90	07/09/90	08/07/90
pH	6.92	6.33	6.60		7.00	6.75	6.80	6.64
CONDUCTIVITY	0.211	0.22	0.22	0.215	0.219	0.23	0.23	0.221
TEMPERATURE	1.8	0.0	-0.07	6.0	13.5	17.0	26.6	22.8
DISSOLVED OXYGEN	13.0	12.4	13.2	15.3	9.8	9.0	7.4	4.7
VELOCITY ft/sec	0.0	0.0	NOT RECORDED	1.0	NOT RECORDED	0.3	0.0	0.0

TABLE 2-1
SURFACE WATER FIELD DATA SUMMARY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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SAMPLE IDENTIFICATION	SW3-108-0310	SW3-108-0411	SW3-108-0212	SW3-108-0113	SW3-109-0501	SW3-110-0401	SW3-111-0801	SW3-112-1201
DATE SAMPLED	09/15/90	10/01/90	11/08/90	12/06/90	11/02/89	11/02/89	11/01/89	11/08/89
pH	8 52	6 67	6 43	7 45	6.70	5.40	7.20	9.60
CONDUCTIVITY	0 198	0 276	0 207	0.175	0.16	0.16	0.165	0.12
TEMPERATURE	22 5	16 6	8.4	4 8	11.0	16.0	12.9	7.5
DISSOLVED OXYGEN	8 15	6 9	12 6	10 4	9.2	10.0	8.6	8.6
VELOCITY ft/sec	NOT TAKEN	0.1	0.3	0.4	0.0	NO DATA	0.1	0.0

SAMPLE IDENTIFICATION	SW3-113-0101	SW3-113-0202	SW3-113-0103	SW3-113-0104	SW3-113-0205	SW3-113-0406	SW3-113-0507	SW3-113-0408
DATE SAMPLED	11/29/89	01/08/90	02/08/90	03/06/90	04/04/90	05/08/90	06/04/90	07/09/90
pH	5 71	6 96	7 50	8 02		6.25	7.19	6.93
CONDUCTIVITY	0 123	0 25	4 0	0 18	0 21	0.22	0.23	0 238
TEMPERATURE	3 0	2 0	1 7	1 9	6.0	13.5	19.0	23.4
DISSOLVED OXYGEN	12 4	13 8	13.4	9 2	12.2	9.2	9.8	6.6
VELOCITY ft/sec	NO DATA	0 0	0 0	NOT RECORDED	0.0	0.0	0.0	0.0

SAMPLE IDENTIFICATION	SW3-113-0409	SW3-113-0410	SW3-113-0911	SW3-113-0512	SW3-113-0113	SW3-114-0101	SW3-115-0201	SW3-116-0201
DATE SAMPLED	08/07/90	09/15/90	10/01/90	11/07/90	12/06/90	11/16/89	11/28/89	11/28/89
pH	6 85	6 93	7 11	6 70	7.82			
CONDUCTIVITY	0 229	0 218	0 242	0.187	0.202		250	
TEMPERATURE	24 2	22 6	20 1	9 3	5.8		3.0	
DISSOLVED OXYGEN	5 6	5 6	12.2	15.4	11.5		13.6	11.5
VELOCITY ft/sec	0 0	NOT TAKEN	0.0	0.0	0.0	NOT TAKEN	NO DATA	0.0

SAMPLE IDENTIFICATION	SW3-117-0201	SW3-118-0301	SW3-119-0301	SW3-119-0202	SW3-119-0103	SW3-119-0104	SW3-119-0205	SW3-119-0406
DATE SAMPLED	11/15/89	11/15/89	11/13/89	01/09/90	02/06/90	03/06/90	04/04/90	05/08/90
pH	7 20	7 30	7.40	6.91	6.49	7.20		5.84
CONDUCTIVITY	0 225	0 25	0 21		0.21	0.29	0.2	0.23
TEMPERATURE	0 1	10 0	7 0	1 0	1.0	1.0	6.0	13.6
DISSOLVED OXYGEN	10 5	10 5	10.2	12 6	13.2	11.2	11.2	8.1
VELOCITY ft/sec	0 1	0 0	0.0	0 0	0.0	NOT RECORDED	0.0	0.0

SAMPLE IDENTIFICATION	SW3-119-0207	SW3-119-0208	SW3-119-0309	SW3-119-0510	SW3-119-1211	SW3-119-0312	SW3-119-0313	SW3-120-0101
DATE SAMPLED	06/04/90	07/09/90	08/07/90	09/15/90	10/01/90	11/07/90	12/06/90	11/13/89
pH	7 3	6 93	6 75	6 96	7.01	7.14	8.03	7.20
CONDUCTIVITY	0 21	0 302	0 265	0 254	0.29	0.216	0.204	0.265
TEMPERATURE	20 0	23 6	24 3	20 9	19.5	9.3	5.1	8.0
DISSOLVED OXYGEN	7 1	6 1	5 6	6 4	11.1	14.5	10.7	11 6
VELOCITY ft/sec	0 0	0 0	0 0	0 0	0.5	0.0	0.0	0.0

TABLE 2-1
SURFACE WATER FIELD DATA SUMMARY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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SAMPLE IDENTIFICATION DATE SAMPLED	SW3-121-0101 11/14/89	SW3-122-0401 11/14/89	SW3-123-0111 10/04/90	SW3-124-0411 10/03/90	SW3-125-0111 10/09/90	SW3-126-0111 10/09/90	SW3-127-0111 10/08/90	SW3-128-0111 10/03/90
pH	7 60	7.10	7.10	6 83	6.82	6.99	6.69	7.16
CONDUCTIVITY	0 21	0 23	0.266	0 326	0.246	0.229	0.262	0.34
TEMPERATURE	12 0	12.0	20.4	14 0	18.1	17.6	20.7	15.0
DISSOLVED OXYGEN	7 4	10 0	5.5	12.0	6.1	9.0	12.4	15.2
VELOCITY ft/sec	0 0	NOT TAKEN	NOT RECORDED	0.0	0.1	0.0	0.0	0.5

SAMPLE IDENTIFICATION DATE SAMPLED	SW3-129-0111 10/03/90	SW3-130-0111 10/06/90	SW3-131-0111 10/09/90	SW3-132-0111 10/08/90	SW3-132-0111 10/09/90
pH	7 05	7 00	6 98	7.31	6.97
CONDUCTIVITY	0 335	0 254	0 231	0 24	0.21
TEMPERATURE	14 7	15 6	18 8	19 2	17.9
DISSOLVED OXYGEN	14 8	12 6	10.1	10.8	9.3
VELOCITY ft/sec	1 3	NOT RECORDED	0.3	2 5	0.3

2.1.1.3 Monthly Surface Water Sampling and Analysis

Water samples were collected from SW3-102, the Pleasant Street crossing; SW3-105, at the Chemical Brook Culvert intake; SW3-108, at the Route 135 crossing; SW3-113, in Reservoir No. 2; and SW3-119, immediately upstream of the Saxonville Dam. Water samples were collected from five of the original Phase I sample locations on the first week of every month from January to December 1990. Sample locations were selected in several upgradient and several downgradient points relative to the Nyanza Site. These samples were analyzed for the parameters listed in the Sampling Summary Table 1-2. The analytical results for monthly surface water sampling are discussed in Section 4.3 and Appendix L and are presented in Appendix B, the Data Summary Analytical Database.

During monthly sample collection, stream flow, pH, conductivity, dissolved oxygen, and temperature were measured using standard field techniques and apparatus. No sediment samples were collected in conjunction with the monthly sampling program.

Stream Flow Measurements

Stream flow measurements were conducted monthly at location SW3-102 (Pleasant Street overpass), at the end of Phase I sampling, and during the surface water monthly sampling (January through December 1990) to determine stream flow volumes. The collection of stream flow measurements was interrupted during the months of January through March 1990 due to severe icing conditions. Additionally, stream flow data from the Saxonville Dam was acquired from the USGS. The data presented in Table 2-2 indicates a net increase in stream flow volume from the upstream location in Reach 1 (SW3-102) to the Saxonville Dam in Reach 4. Stream flow data from the Dam No. 1 (outlet of Reservoir No. 1) is available but it cannot be correlated in sufficient detail to augment the database.

The stream flow measurement at the SW3-102 location was conducted using a vertical shaft Teledyne Gurley Current Meter. The cross-section River profile was measured at a minimum of three vertical cross-section points. Velocity measurement readings were taken at 0.6 feet of the total depth below the surface at each vertical transect location (0.6-depth method). The velocity readings were multiplied by the respective estimated area represented by the transect point and were added to compute total discharge at each location. Results of the stream flow measurements are included in Section 3-6.

TABLE 2-2
MONTHLY MONITORING FLOW DATA
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

DATE	NUS FLOW (FT3/SEC) LOCATION SW3-102	USGS FLOW (FT3/SEC) SAXONVILLE DAM
12/7/89	54	229
4/5/90	186	572
5/9/90	21	196
6/5/90	70	205
7/10/90	8	45
8/8/90	36	276
10/2/90	4	41
11/8/90	66	155
12/6/90	77	430

2.1.2 Sudbury River Sediment Sampling and Analysis

The sediment sampling and analysis program and sampling procedures are described the Final Work Plan and Work Plan Amendments and detailed in the Final Sampling and Analysis Plan and Amendments.

Quality control samples including field duplicates, trip blanks, and rinsate blanks were collected and analyzed for each sampling round as specified in EPA guidance (User's Guide to the Contract Laboratory Program) and in the Final SAP and the SAP Amendment Memoranda. The analytical parameters are presented in Table 1-1; analytical results for sediment sampling are discussed in Section 4.4 and are presented in Appendix A, the Summary Analytical Database.

Sediment sampling was conducted to determine the presence and distribution of inorganic and organic contaminants in the sediments, to gather data to evaluate the appropriateness of sediment remedial actions, and to provide data for the selection and design of remedial alternatives.

Phases I and II were purposely biased towards areas of low current velocity since silt- and clay-sized particles would be deposited in these areas. This sediment size readily adsorbs metal contaminants associated with Site-related discharges. Therefore, the extent of contamination may be determined through sampling and analysis of these sediments.

2.1.2.1 River Sediment Phase I Sampling and Analysis

The Phase I sampling program included a comprehensive initial sampling round of 50 sediment stations numbered SD3-101 to SD3-150 (Figure 1-A). Sediment samples were collected from depths of zero to six inches below the surface. At 14 of these locations, profile sediment samples were also collected at a depth of from six to 12 inches to provide information on vertical distribution of inorganic and organic contaminant concentrations. Sediment sampling locations include the River and Reservoir areas upstream and downstream of the Nyanza Site, as far as Heard Pond in Wayland. Samples were collected from expected depositional areas, such as near stream confluences, inside River bends, etc. Specific sample location rationale is discussed in detail in Sections 4.3.1.4 and 4.3.1.5 of the Final Work Plan (August 1989).

All 64 sediment samples were analyzed for TCL metals and methyl mercury. Twenty-two of these samples were also analyzed for other parameters, as specified in Table 1-1. These 22 samples were collected from locations that corresponded with the 22 surface water sampling locations, with the exceptions of SW3-102 and 103.

Analytical parameters were chosen to provide confirmation regarding the extent of contamination and contaminant transport/fate information in the ecosystem.

2.1.2.2 River Sediment Phase II Sampling and Analysis

The Phase II sediment sampling program included the collection of 59 surface sediment sample stations (0-6 inch depth), numbered SD3-152 through SD3-204, in the Sudbury River. Sediment profile samples were also collected at depths ranging from six to 12 inches at 19 of these locations to provide a vertical distribution of contaminants. In addition, sediment samples were collected at six locations to collect information on levels of hexavalent chromium in areas where elevated levels of total chromium had been detected in Phase I. Sediment sampling locations were selected in order to:

- fill in data gaps in Phase I sampling
- determine the down-river extent of elevated mercury levels in sediments
- determine if selected wetland areas adjacent to the River have been impacted by elevated metals concentrations
- provide additional background sediment samples where background fish samples were collected
- provide additional sediment samples where Phase II benthic organism samples were collected

Several sediment sampling locations were changed from those proposed in the SAP Amendment No. 2. Changes were made because of poor sample recovery and to locate sampling stations at Phase II caddis fly larvae sample locations which were planned after preparation of the SAP.

2.1.2.3 Bordering Wetlands Sediment Sampling and Analysis

Sediments from wetland areas adjacent to the Sudbury River were sampled during Phase I at two stations (SD3-113 and 114) and Phase II at four stations (SD3-155, 159, 161, and 167), as presented in Figure 1-2A. The sediments were collected to determine if these wetlands have been impacted by contamination. The Phase I locations were sampled at depths ranging from zero to six inches while the Phase II stations were sampled at two intervals, zero to six inches and from six to 12 inches. The sediment samples were analyzed for the parameters presented in Table 1-1; the analytical results are presented in Appendix A. Locations were selected to geographically represent bordering wetlands and lands subject to flooding along the River.

2.1.3 **Biota Sampling and Analysis**

2.1.3.1 Phase I Biota Sampling and Analysis

The Phase I biota sampling and analysis program and sampling procedures are described in Section 4.3.1.6 of the Final Work Plan (WP), August 1989) and Section 4.1.7 of the Field Sampling and Analysis Plan (SAP, August 1989).

Fish Sampling and Analysis

Phase I sampling of biota included collection of three different fish species for tissue analysis: Yellow perch (Perca flavescens), brown bullhead (Ictalurus nebulosus), and largemouth bass (Micropterus salmoides) at four selected sampling locations, FH3-101 through FH3-104 (see Figure 1-A). Sampling was conducted from September through December 1989. Severe weather conditions during sampling at the Sudbury Reservoir forced the discontinuation of the fish sampling in early December. The three species were selected to represent a range of trophic levels, including game fish. The four locations were selected to provide samples from a control reservoir upstream from the Site (Sudbury Reservoir, location FH3-104) and from three increasingly distant downstream locations.

The sample locations included FH3-102, which encompasses the Reservoir No. 2 impoundment (Reach 3); FH3-103, which includes the Reservoir No. 1 impoundment (Reach 4); and FH3-101, which includes the Saxonville Dam impoundment (Reach 6). Upstream migration of the sampled species within this portion of the River is prevented by the four spillway dams, however, these spillways do not prevent downstream migration of fish resulting in some mixing of populations.

Fish were collected at the locations using standard collection techniques. Techniques included electroshocking, gill netting, and hook and line. Electroshocking, using boat-mounted equipment, involved stunning the fish with an electric current and collecting the species of interest with dip nets. Gill netting involved setting monofilament gill nets at several locations within the sampling area so the fish became entangled in the nets. Nets were recovered and the fish of interest were retained as samples. Two types of hook and line apparatus were used during the sampling event: conventional rod and reel and weighted trout lines.

Samples of both muscle tissue (fillet) and offal were analyzed. All samples were analyzed for TAL metals, semi-volatile organics, and pesticides. Approximately twenty-five percent of the samples were also analyzed for methyl mercury. However, because of the low number of fish collected at some locations, the TAL metals, semivolatile organics, and pesticides fractions were prioritized over the methyl mercury analysis. Therefore, when the required sample weight for the metals, semi-volatile organics, and pesticides was achieved, the remaining samples (if available) were submitted for methyl mercury analysis.

The Final Work Plan specified that ten individuals per species of similar size be collected at each location for edible tissue (fillet) analysis, resulting in a total of 120 samples. To the extent that conditions permitted, fish size was to be consistent at each location. However, the sampling team often did not have an abundant catch and was not able to collect the full requirement of samples per species from each location. In an effort to maintain the required number of samples per location, most of the fish caught were needed to meet minimum weight requirements for analysis. This resulted in a wider variation in the size and weight of fish than was originally anticipated.

The less than anticipated catch, possibly resulted from cooler seasonal temperatures where fish become less mobile, or to effects on population density from contamination. Severe weather conditions during sampling at the Sudbury Reservoir (FH3-104), with eventual icing of the reservoir, forced the discontinuation of the biota sampling in early December.

Table 2-3 presents a summary of all Phase I fish collected, including the number of samples per species from each location, the types of analyses, and the fish weight and length. A range of weights or lengths is presented for those samples which were composited. The analytical results for fish sampling are discussed in Section 4.3.4 and are presented in Appendix C, the Data Summary Analytical Database.

Benthic Macroinvertebrate Survey

In Phase I, an assessment of the benthic macroinvertebrate community was conducted on samples from 45 of the sediment sampling locations, as presented in Table 1-1. Sample collection and preparation methods are presented in the SAP (April 1990). At each location approximately five gallons of sediment was collected and sieved for benthic organisms. Samples were sorted and specimens from the sample were collected. Sorting continued until 100 specimens were collected or the sample was exhausted. Any remaining sample was preserved in ethanol and sent to the laboratory for sorting. Results of this survey are presented in Section 4.5 of this report.

TABLE 2-3

FISH SAMPLING SUMMARY – PHASE I

NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

FINAL

LOCATION AND SAMPLE IDENT. NO.	SPECIES	NO. OF FISH	BNA/PEST METALS FILLET	METHYL Hg FILLET	BNA/PEST METALS OFFAL	METHYL Hg OFFAL	WEIGHT OF FISH (grams)	LENGTH OF FISH (ft)	TOTAL FISH IN SPECIES
FH3-101-BF302	BULLHEAD	2	Y	N	Y	N	200-247	.79-.82	
FH3-101-BF303	BULLHEAD	1	Y	N	Y	N	317	0.94	5
FH3-101-BF304	BULLHEAD	1	Y	N	N	Y	320	0.98	BULLHEAD
FH3-101-BF305	BULLHEAD	1	Y	N	N	Y	513	1.06	
FH3-101-BO306	BULLHEAD	4	N	N	Y	Y	COMPOSITE	COMPOSITE	
FH3-101-MF287	BASS	1	Y	Y	Y	N	916	1.33	
FH3-101-MF288	BASS	1	Y	Y	N	Y	642	1.21	4
FH3-101-MF289	BASS	1	Y	Y	N	.	556	1.12	BASS
FH3-101-MO307	BASS	3	N	N	Y	Y	COMPOSITE	COMPOSITE	
FH3-101-YF290	Y. PERCH	1	Y	N	Y	N	368	1.01	
FH3-101-YF291	Y. PERCH	2	Y	N	Y	N	116-159	.70-.76	
FH3-101-YF293	Y. PERCH	1	Y	N	N	Y	292	0.91	
FH3-101-YF294	Y. PERCH	1	Y	Y	Y	Y	296	0.92	
FH3-101-YF295	Y. PERCH	2	Y	N	Y	N	172-192	.79-.81	11
FH3-101-YF297	Y. PERCH	3	Y	Y	Y	Y	217-234	.86-.91	Y. PERCH
FH3-101-YF298	Y. PERCH	3	Y	Y	Y	Y	188-209	.82-.83	
FH3-101-YF299	Y. PERCH	4	Y	Y	Y	Y	76-180	.62-.79	
FH3-101-YF300	Y. PERCH	4	Y	N	Y	Y	83-155	.70-.86	
FH3-101-YF301	Y. PERCH	4	Y	N	Y	Y	133-155	.73-.77	
FH3-101-YO308	Y. PERCH	10	N	N	Y	Y	COMPOSITE	COMPOSITE	
'3-102-BF279	BULLHEAD	2	Y	N	Y	N	237-274	.88-89	
.3-102-BF280	BULLHEAD	1	Y	N	Y	N	452	1.03	
FH3-102-BF281	BULLHEAD	1	Y	N	Y	N	374	0.98	
FH3-102-BF282	BULLHEAD	1	Y	N	Y	N	370	1.01	7
FH3-102-BF283	BULLHEAD	2	Y	N	Y	N	301-369	.92-1.0	BULLHEAD
FH3-102-BF284	BULLHEAD	1	Y	N	Y	N	585	1.19	
FH3-102-BF286	BULLHEAD	1	Y	N	Y	N	390	1.04	
FH3-102-BO285	BULLHEAD	6	N	N	Y	N	COMPOSITE	COMPOSITE	
FH3-102-MF243	BASS	1	Y	Y	Y	N	2723	2.85	
FH3-102-MF244	BASS	1	Y	Y	N	Y	1724	1.62	
FH3-102-MF245	BASS	1	Y	Y	Y	N	1461	1.51	
FH3-102-MF246	BASS	1	Y	N	N	Y	922	1.30	
FH3-102-MF247	BASS	1	Y	N	Y	N	624	1.24	12
FH3-102-MF248	BASS	1	Y	N	N	Y	535	1.11	BASS
FH3-102-MF249	BASS	1	Y	N	Y	N	534	1 16	
FH3-102-MF251	BASS	1	Y	N	N	Y	1918	1 66	
FH3-102-MF252	BASS	1	Y	N	Y	N	840	1.30	
FH3-102-MF253	BASS	1	Y	N	N	Y	563	1.47	
FH3-102-MF258	BASS	1	Y	Y	N	N	394	1.04	
FH3-102-MO267	BASS	10	N	N	Y	Y	COMPOSITE	COMPOSITE	
FH3-102-YF254	Y PERCH	7	Y	Y	Y	Y	72-114	.62-.74	
FH3-102-YF255	Y PERCH	16	Y	Y	Y	Y	68-110	.60-.70	
FH3-102-YF256DU	Y PERCH	16	Y	Y	Y	Y	68-110	.60-.70	
FH3-102-YF257	Y PERCH	6	Y	Y	Y	Y	65-180	.58-.81	9
FH3-102-YF259	Y PERCH	8	Y	Y	Y	Y	56-70	.58-.63	Y. PERCH
FH3-102-YF276	Y. PERCH	3	Y	N	N	N	73-163	.64-.83	
FH3-102-YF277	Y. PERCH	1	Y	N	N	N	247	0.94	
FH3-102-YF278	Y. PERCH	1	Y	N	N	N	342	1.03	
3-102-YO275	Y. PERCH	16	N	N	Y	Y	COMPOSITE	COMPOSITE	

Notes:

FH3-101 = SAXONVILLE IMPOUNDMENT
FH3-102 = RESERVOIR No. 2
FH3-103 = RESERVOIR No. 1
FH3-104 = SUDBURY RESERVOIR

TABLE 2-3
FISH SAMPLING SUMMARY – PHASE I
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

LOCATION AND SAMPLE IDENT. NO.	SPECIES	NO. OF FISH	BNA/PEST METALS FILLET	METHYL Hg FILLET	BNA/PEST METALS OFFAL	METHYL Hg OFFAL	WEIGHT OF FISH (grams)	LENGTH OF FISH (ft)	TOTAL FISH IN SPECIES
FH3-103-BF210	BULLHEAD	1	Y	Y	Y	N	510	1.30	
FH3-103-BF219	BULLHEAD	1	Y	N	N	Y	656	1.13	
FH3-103-BF221	BULLHEAD	1	Y	N	Y	N	566	1.20	
FH3-103-BF222	BULLHEAD	1	Y	N	Y	N	683	1.12	
FH3-103-BF223	BULLHEAD	1	Y	Y	N	Y	703	1.16	12
FH3-103-BF226	BULLHEAD	1	Y	N	Y	N	568	1.11	BULLHEAD
FH3-103-BF227	BULLHEAD	1	Y	N	N	Y	392	1.05	
FH3-103-BF228	BULLHEAD	1	Y	N	N	Y	593	1.15	
FH3-103-BF236	BULLHEAD	1	Y	N	N	N	678-546	1.19-1.11	
FH3-103-BF237DU	BULLHEAD	1	Y	N	N	N	678-546	1.19-1.11	
FH3-103-BF238	BULLHEAD	1	Y	N	N	N	665	1.13	
FH3-103-BO234	BULLHEAD	8	N	N	Y	Y			
FH3-103-MF201	BASS	1	Y	Y	Y	N	1116	1.33	
FH3-103-MF202	BASS	1	Y	Y	N	Y	949	1.30	
FH3-103-MF203	BASS	1	Y	N	Y	N	2185	1.70	
FH3-103-MF204	BASS	1	Y	Y	Y	N	2652	1.78	
FH3-103-MF204DU	BASS	1	Y	Y	Y	N	2652	1.78	
FH3-103-MF206	BASS	1	Y	N	N	Y	2692	1.76	12
FH3-103-MF207	BASS	1	Y	N	Y	Y	618	1.16	BASS
FH3-103-MF215	BASS	1	Y	N	N	Y	646	1.20	
FH3-103-MF216	BASS	1	Y	N	Y	N	528	1.17	
FH3-103-MF217	BASS	1	Y	N	N	Y	439	1.08	
FH3-103-MF220	BASS	1	Y	N	N	Y	722	1.25	
FH3-103-MO211	BASS	10	N	N	Y	Y	COMPOSITE	COMPOSITE	
FH3-103-YF212	Y. PERCH	4	Y	Y	Y	N	151-232	.78-.86	
FH3-103-YF213	Y. PERCH	5	Y	Y	N	Y	117-240	.70-.90	
FH3-103-YF214	Y. PERCH	7	Y	Y	Y	N	75-118	.60-.72	
FH3-103-YF224	Y. PERCH	2	Y	Y	N	Y	161-235	.78-.89	
FH3-103-YF224	Y. PERCH	2	Y	Y	N	Y	122-266	.74-.93	
FH3-103-YF229	Y. PERCH	3	Y	N	Y	N	100-177	.66-.8	13
FH3-103-YF230	Y. PERCH	3	Y	N	Y	N	99-155	.68-.79	Y. PERCH
FH3-103-YF231	Y. PERCH	3	Y	N	N	Y	140-166	.76-.77	
FH3-103-YF232	Y. PERCH	3	Y	N	N	Y	114-120	.68-.73	
FH3-103-YF233	Y. PERCH	3	Y	N	Y	N	89-200	.67-.82	
FH3-103-YF239	Y. PERCH	3	Y	N	N	N	266-292	.88-.94	
FH3-103-YF240DU	Y. PERCH	3	Y	N	N	N	266-292	.88-.94	
FH3-103-YO235	Y. PERCH	10	N	N	Y	Y			
FH3-104-MF260	BASS	1	Y	Y	Y	Y	659	1.15	
FH3-104-MF261	BASS	1	Y	Y	Y	Y	622	1.16	
FH3-104-MF262	BASS	1	Y	Y	Y	N	874	1.33	
FH3-104-MF263	BASS	1	Y	Y	Y	N	1253	1.42	
FH3-104-MF264	BASS	1	Y	Y	Y	N	1336	1.45	
FH3-104-MF265	BASS	1	Y	Y	Y	N	683	1.23	13
FH3-104-MF266	BASS	1	Y	Y	N	Y	557	1.10	BASS
FH3-104-MF268	BASS	1	Y	N	N	Y	872	1.28	
FH3-104-MF270	BASS	1	Y	N	N	Y	985	1.35	
FH3-104-MF271	BASS	1	Y	Y	N	Y	1442	1.49	
FH3-104-MF272DU	BASS	1	Y	Y	N	N	1442	1.49	
FH3-104-MO273	BASS	5	N	N	Y	N	COMPOSITE	COMPOSITE	
FH3-104-MO274	BASS	5	N	N	N	Y	COMPOSITE	COMPOSITE	

Notes:
FH3-101 = SAXONVILLE IMPOUNDMENT
FH3-102 = RESERVOIR No. 2
FH3-103 = RESERVOIR No. 1
FH3-104 = SUDBURY RESERVOIR

2.1.3.2 Biota Phase II Sampling and Analyses

Phase II biota sampling and analyses included additional fish sampling and benthic organism collection. These surveys were completed by EPA and the U.S. FWS. NUS was responsible for data validation and interpretation of the fish data and interpretation of the benthic organism data.

Fish Sampling and Analysis

Sampling of biota during Phase II (July 1990) included collection of two fish species for tissue analysis. This activity was performed by the U.S. FWS in cooperation with EPA. The species collected included Yellow perch (Perca flavescens) and largemouth bass (Micropterus Salmoides) at seven selected locations throughout the Sudbury River. These included two upstream reference sites, FH3-204 (Cedar Swamp Pond) and FH3-205 (Southville Pond); and five downstream sites including FH3-206 (Mill Pond), FH3-202 (Reservoir No. 2), FH3-203 (Reservoir No. 1), FH3-201 (Saxonville Reservoir), and FH3-207 (Fairhaven Bay). No yellow perch were observed or captured for analysis in Southville Pond.

Fish were captured using an electroshocking boat at all locations. Additionally, experimental gill nets were used at Cedar Swamp Pond. Fish were weighed, measured, and scales were removed for age determination; whole fish were packaged for selected contaminant analyses. Fish analyses included TAL metals and TCL organics (including methyl mercury). The analytical results are presented in Appendix C (See FWS report in Appendix E).

Caddis Fly Larvae Sampling and Analyses

The Phase II benthic organism sampling included the collection of caddis fly larvae (aquatic insects) at six locations in the Sudbury River. The caddis fly larvae sampling locations correspond to surface water and sediment sample locations numbered SD3-128, 129, 130, 131, 132, and 133. These organisms were collected for mercury and methyl mercury analysis since a portion of their life cycle involves the filtering of River water to acquire food. Therefore, the contaminant content in the body burden of these organisms may be indicative of the contaminants which are available to all benthic organisms in the River system and may also serve as bioconcentrators and bioaccumulators of contaminants.

The caddis fly larvae sampling program was performed by the Region I Environmental Services Division (ESD) Biology Section. The ESD report is presented in Appendix F and the analytical results of the survey are described in Section 4.6.

2.1.4 Biological Survey

This section provides a summary of the wildlife and wetlands assessment conducted along the Sudbury River.

2.1.4.1 Sudbury River Wetlands Assessment

In October 1989, a field assessment was performed of bordering wetlands in the vicinity of the Site and in the Sudbury River immediately downstream from the Site. Wetland vegetation and hydrology were observed at 27 key locations along approximately ten miles of the River between Ashland and the Massachusetts Turnpike north of Framingham. The wetlands assessment report is provided in Appendix G.

A brief qualitative assessment was made of the wildlife potential in the Sudbury River Study Area. The findings of this study are presented in Section 3.6.4.3.

2.2 Eastern Wetlands Sampling and Analysis

The Phase I and II Eastern Wetlands sampling and analysis program and sampling procedures are described in Section 4.3.1.5 of the Final Work Plan (WP), (August 1989) and Sections 4.1.6 and 4.2.4, respectively, of the Field Sampling and Analysis Plan (SAP, August 1989) and the Final Sampling and Analysis Plan Amendment No. 2 (October 1990). The analytical results for the Eastern Wetlands sampling are discussed in Section 4.7 and are presented in Appendix D, the Data Summary Analytical Database.

2.2.1 Physiography

The Eastern Wetlands is an area of approximately ten acres east of the abandoned Trolley bed at the Nyanza Site. The wetland area studied in this survey includes two open water ponds (approximately two to three acres) which are separated by an earthen dike. Surficial drainage from the Nyanza Site enters the wetland from the western side of the old Trolley embankment through a granite slab culvert as illustrated in Figure 1-D. Surface water flow between the two ponds is constricted through a narrow opening in the dike. Standing water was present over approximately 30 percent of the wetland areas to a depth of from one to three feet.

The wetland area presently drains north through Trolley Brook to its confluence with Chemical Brook. Trolley Brook and Chemical Brook drain in a northeasterly direction through the Chemical Brook Culvert and discharge through the Outfall Creek into the Raceway near Concord Street in Ashland (Figure 1-A, Detail).

2.2.2 Eastern Wetlands Surface Water Sampling and Analysis

Phase I surface water sampling included the collection of two surface water samples, numbered SW3-104 and SW3-105, as illustrated in Figure 1-A. The samples were submitted to CLP for analysis for the parameters presented in Table 1-2. Station SW3-105 was also included in the monthly surface water sampling. No additional surface water sampling and analysis was performed in the Eastern Wetlands during Phase II.

2.2.3 Eastern Wetlands Sediment Sampling and Analysis

The Phase I sediment sampling in the Eastern Wetlands included the collection of five samples to obtain initial information on potential contamination; the Phase II study provided detailed information on the horizontal and vertical distribution of contaminants in the sediments, as described below.

2.2.3.1 Phase I Eastern Wetlands Sediment Sampling and Analysis

The Phase I sediment sampling in the Eastern Wetlands included five sediment sample stations numbered SD3-106 through SD3-110, as presented in Figure 1-A. In addition, subsurface sediment samples were collected at a depth of from six to 12 inches at all five stations to provide information on vertical distribution of contaminants at these locations. The 10 sediment samples were submitted to a CLP laboratory and analyzed for TAL metals and methyl mercury.

2.2.3.2 Phase II Eastern Wetlands Sampling and Analysis

Unconsolidated sediments in the Eastern Wetlands area were sampled in Phase II to provide information on the horizontal and vertical distribution of contaminants in the wetland. The sampling program included advancing a total of 32 sediment soil borings. Twenty-three samples were collected from areas of free-standing water, with four discrete sample intervals. Sample intervals included: zero to two, two to four, four to five and five to six feet below sediment surface at most locations. Nine additional samples were collected from two discrete one-foot sample intervals in areas adjacent to the open water or from those areas which appeared to be affected only by seasonal flooding. Each discrete sample interval collected within the Eastern Wetlands was a grab sample.

A total of 108 sediment samples were submitted for CLP analyses, which included TCL volatile organics, BNA, Pesticides, PCBs, site-specific organic compounds, and TAL metals.

2.3 Chemical/Cold Spring Brook Culverts/Raceway Sampling and Analysis

2.3.1 Visual Inspection/Mapping

A reconnaissance was made of the Chemical Brook and Cold Spring Brook Culverts to determine the applicability of viewing the interior of the culverts (Figure 1-A). The focus of this task was to determine the integrity of the structures and establish whether sediment deposition was occurring. Such deposits could be a continuing source of contamination. Based on the reconnaissance, a televiewing inspection was performed in the Chemical Brook Culvert in January 1991. It was determined that televiewing the Cold Spring Brook Culvert was not feasible. A memoranda discussing the reconnaissance results are presented in Appendix H.

2.3.1.1 Chemical Brook Culvert Inspection/Sampling & Analysis

The visual inspection of the Chemical Brook Culvert included measuring water and sediment depths in the stormwater lines and manholes. General information concerning the stormwater lines such as construction materials, line diameter, and the presence of feeder lines was recorded.

The televiewing inspection of the Chemical Brook Culvert indicated it was constructed over a long period of time based on the various construction techniques and materials encountered. Sections of the system had also been repaired or replaced in a piecemeal fashion. Materials included section(s) of cast iron pipe, corrugated steel pipe, cement pipe, and a granite slab/block construction. The bottom of the slab/block construction was open to the environment. The Culvert is a stormline system and several storm drain feeder lines were present throughout the length of the pipe. The televiewing inspection was ended at Front Street in Ashland, Massachusetts, where debris blocked further advancement of the video camera. It appears that catch basins and areas of large debris deposition, such as tree branches, may act as minor sediment depositional areas. A review of the video inspection is presented in Appendix H.

Surface water sampling included the collection of one surface water sample at the Culvert outfall, numbered SW3-106, as shown in Figure 1-A. The sample was submitted for CLP analysis for parameters presented in Table 1-2. Station SW3-105, which is associated with the Eastern Wetland, is located at the culvert's intake. Samples collected from SW3-105 can be used for comparison with contaminant concentrations within the culvert. Results are presented in Section 4.8.

The Chemical Brook Culvert sediment sampling included the collection of five surface sediment samples, numbered SD3-112 (Phase I) and SD3-200, 201, 205, and 206 (Phase II). Station SD3-112 was at the Culvert outfall; Stations SD3-200 and 201 were collected along the Culvert in catch basins where sediment had accumulated; and Stations SD3-205 and 206 were collected in the Outfall Creek. Results are presented in Section 4.8.

2.3.1.2 Cold Spring Brook Culvert

No surface water samples were collected in the Cold Spring Brook Culvert (formerly designated the Trolley Brook Wetlands Culvert). Inspections of aerial photography, supported by field confirmation, indicated that the Culvert was not a surficial drainage route from the Eastern Wetlands as originally presumed. During both Phases I and II sampling rounds, there was no water available for sampling at the Culvert outfall. However, during Phase I, surface water (Station SW3-103) was sampled at the apparent conjunction of the Culvert with Cold Spring Brook.

No sediment samples were collected within the Cold Spring Brook Wetlands Culvert. During both Phases I and II sampling rounds, surface water was not being discharged from the Culvert outfall; this may be due to a blockage in the Culvert or to a leak prior to the discharge point. However, during Phase I operations, one sediment sample (Station SD3-105) was collected at the confluence of the Culvert with Cold Spring Brook. It was analyzed for the parameters presented in Table 1-1.

2.3.1.3 Raceway Surface Water Sampling

One surface water sample (SW3-136) was collected in the Raceway for the parameters listed in Table 1-2.

Two profile sediment sample locations, Stations SD3-244 and SD3-245, were established within the Raceway during a supplemental Phase II sample round. Two-depth profile samples (zero to six and six to 12 inches) were collected at each location. The sediment samples were collected for the parameters presented in Table 1-1.

3

3.0 GENERAL CHARACTERISTICS OF THE SITE STUDY AREA

3.1 Introduction

The Sudbury River Study Area is situated within the Metrowest area of eastern Massachusetts, (the western portion of the Boston metropolitan area). The Sudbury River and its tributaries in the Study Area flow through several communities that range in size from approximately 4,000 to 65,000 residents (Table 3-1). The area is classified as semi-rural to urban-suburban.

The population in the area has grown rapidly since World War II because of its proximity and access to the Boston metropolitan area, the City of Worcester, and the economic expansion of technology-related industries along major transportation routes, including Interstate Routes 495 and 90 (Figure 3-1). Individual communities have felt the effect of population and employment growth as a result of major highway construction within the last 30 years. These once rural communities, with an agricultural and small-scale manufacturing economic base, have become suburban.

Because of the dramatic population growth since 1950, land use patterns in the Study Area have changed substantially. The portion of the Study Area that falls within the Town of Framingham is the most developed due to the growing number of business and manufacturing concerns along I-495 and Route 9. Residential land use in the Study Area has approximately tripled in acreage, with a corresponding decrease in the amount of land used for agricultural purposes.

Within the Sudbury River drainage basin, vegetation on undeveloped marshy land and land formerly used for farming is generally in the brushy thicket stage. Many areas support fair to good quality stands of white pine, pitch pine, and mixed hardwoods.

3.2 Surface Features

The Study Area includes approximately 33 miles of the Sudbury River and the surficial drainage routes from the Nyanza Site in Ashland, Massachusetts. The surficial drainage routes include the Eastern Wetlands and Trolley Brook which drain the eastern/southeastern portion of the Site, and Chemical Brook which drains the northwestern onsite wetland. Both brooks combine and form the Chemical Brook Culvert which eventually drains to the Sudbury River (Figures 2-C and 2-D).

TABLE 3-1
POPULATION OF TOWNS ALONG THE SUDBURY RIVER
NYANZA III - SUDBURY RIVER STUDY

Town	Population Count
Westborough	14,133
Southborough	6,628
Ashland	12,066
Framingham	64,969
Wayland	11,874
Sudbury	14,358
Lincoln	7,666
Concord	17,076

Source: U.S. Bureau of the Census as of April 1, 1990

FINAL

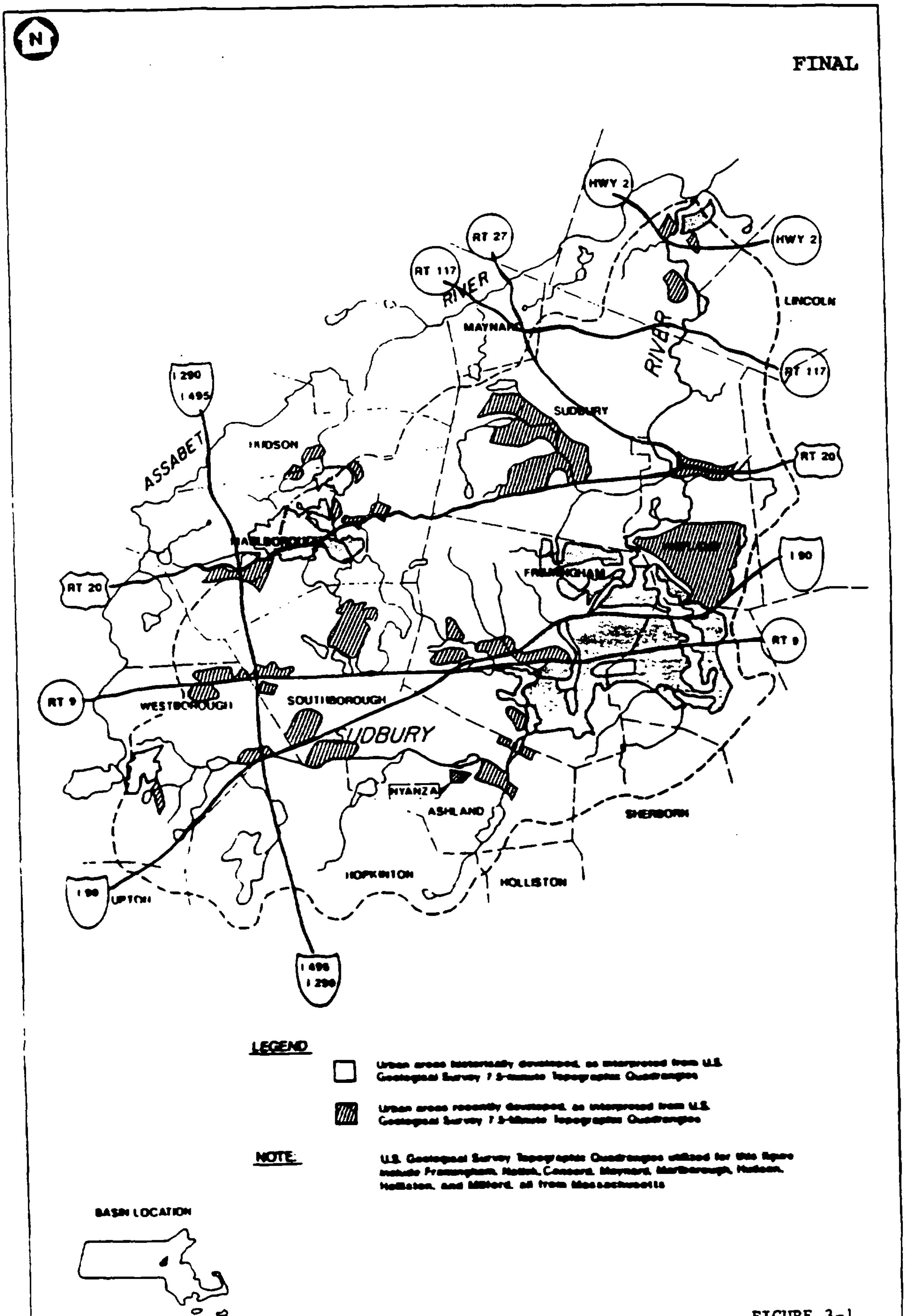


FIGURE 3-1

LOCATION OF WELL-DEVELOPED URBAN ZONES AND MAJOR HIGHWAYS
NYANZA III - SUDBURY RIVER STUDY
MIDDLESEX CO., MASSACHUSETTS

Site Vicinity

The Nyanza Site is drained by two small Brooks, Chemical Brook and Trolley Brook. The Chemical Brook source area is the wetland located in the northwestern portion of the Site (Western Wetland); the Brook flows eastward along the railroad tracks which delineate the Site's northern border. The Brook has a watershed of about 83 acres (NUS, 1985). Chemical Brook was remediated as part of construction activities associated with Operable Unit I.

Trolley Brook flows northeast through a wetland along the eastern border of the Site, following the berm of an abandoned trolley line. The Eastern Wetland is approximately ten acres, of which approximately three acres is open water. Trolley Brook joins Chemical Brook near the railroad tracks. The combined flow discharges to the Sudbury River through an underground culvert (Chemical Brook Culvert) that has an outfall downstream of Concord Street, about 2,000 feet northeast of the northern limit of the Site. A visual and remote video inspection was performed on the Chemical Brook Culvert and is described in Section 2.3 of this report.

A second culvert, referred to as Cold Spring Brook Culvert, appears to be comprised of a groundwater seepage area, parking lot runoff, and storm-event runoff from a small wetland area east of the Site; it is not a surficial drainage route of the Eastern Wetlands. In a previous report (Technical Directive Memorandum, March, 1990), this second culvert was designated the Trolley Brook Wetlands Culvert, since it appeared that the Culvert was a surficial drainage from the wetlands. However, inspection of aerial photographs, with field confirmation, indicated that the culvert is separated from the Eastern Wetlands by uplands. Therefore, the name was determined to be inappropriate and changed to the Cold Spring Brook Culvert. Historical information provided by private citizens and visual observations were used to plot the approximate location of this Culvert as it drains easterly to Cold Spring Brook.

Sudbury River Description

The headwaters of the Sudbury River is Cedar Swamp Pond, in Westborough, Massachusetts. The River flows approximately eight miles eastward through Hopkinton and Ashland, and then approximately 25 miles northward through Framingham, Sudbury, and Wayland, to the confluence with the Assabet River in Concord, Massachusetts. The Concord River begins at this point and flows northward 16 miles to the Merrimack River in Lowell, Massachusetts.

The Merrimack River flows east, discharging to the Atlantic Ocean (Figure 3-2). The average hydraulic gradient of the upper Sudbury River is approximately five feet per mile. However, the average gradient of the River between the Saxonville Dam and the Assabet River is less than one foot per mile.

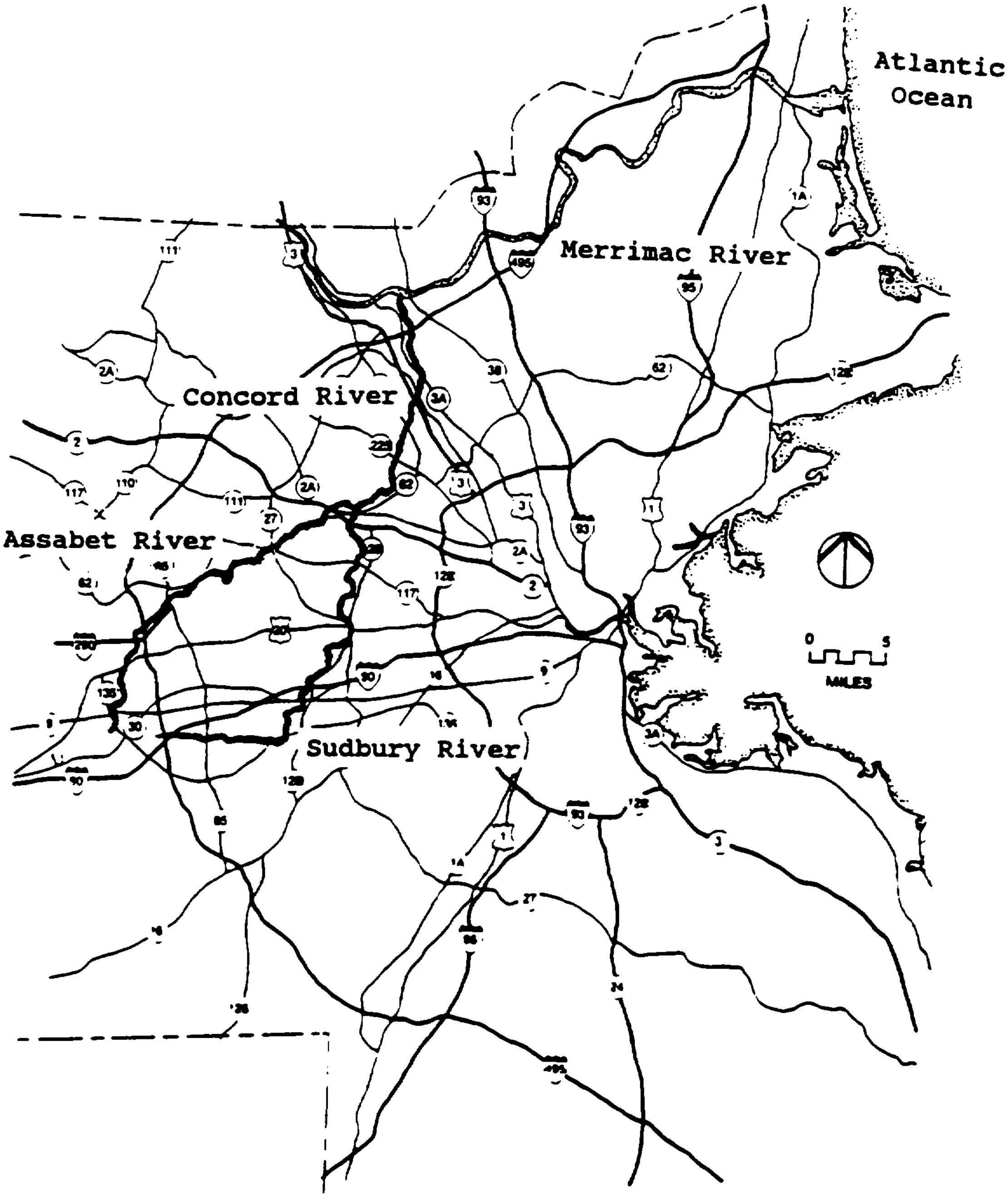
The watershed area of the Sudbury River is approximately 165 square miles. The Sudbury River watershed from Cedar Swamp to Dam No. 1 in Framingham consists primarily of uplands. Gentle to steep hills and ridges of bedrock and glacial till are found in the watershed. The largest surface water bodies associated with the River are located in this area and include Reservoirs Nos. 1, 2, and 3, and the Sudbury Reservoir. The overflow from the Sudbury Reservoir drains into Reservoir No. 3 and subsequently into Reservoir No. 1 in Framingham. The River also receives water from three other reservoirs: Whitehall, Hopkinton, and Ashland.

The topography of the watershed from Dam No. 1 to the Assabet River in Concord is gently rolling and consists of stratified glacial drift interspersed with many drumlins. In this area of the basin, the Sudbury River flows through extensive wetlands which overlie stratified glacial drift. The River floodplain is nearly three miles wide in the Wayland vicinity (Reach 7). The largest surface water bodies of interest in this portion of the watershed are the Saxonville Pond impoundment, Heard Pond, and Fairhaven Bay.

The stretch of the River from Westborough to Saxonville is characterized by a series of dams. The Sudbury River had more than a dozen small and medium-sized mills above Saxonville. Many of the impoundments associated with these mills exist today behind intact or partially collapsed dams. These include the Cordaville Dam, Mill Pond Dam (a.k.a. Myrtle Street Dam), Fenwick Street Dam, and the Saxonville Dam (a.k.a. Colonna Dam) (Figure 1-A). Several other dams were built in the late 1800s to form Reservoir Nos. 1 and 2. A USGS gauging station is located at the Saxonville Dam. A second gauging station is maintained by the MDC at the outlet of Reservoir No. 1 (Dam No. 1) in Framingham Center (Figure 1-1).

3.2.1 Surface Water Use

Sections of the Sudbury River are part of the MDC's backup water supply system. Reservoir Nos. 1 and 2, on the south branch of the Sudbury River, have not been used for drinking water since 1930 and are maintained only as an emergency water supply. Sudbury Reservoir and Framingham Reservoir No. 3, which comprise the North Sudbury System, are used to supplement water supplies during summertime high demand periods (DWPC 1988). The Sudbury Reservoir and Framingham Reservoir No. 3 are on a separate tributary of the Sudbury River and do not receive surface water flow from the Site.



NYANZA III - SUDBURY RIVER STUDY
REMEDIAL INVESTIGATION
STUDY AREA LOCATION MAP

FIGURE 3-2

NUS
CORPORATIO
A Halliburton Compan

dapted from The Concord, Sudbury and Assabet Rivers, A Guide to anoeing, Wildlife and History, The Sudbury River Trustees, 1990

The Sudbury River in Ashland is classified as Class B water, according to Massachusetts Surface Water Quality Standards. Class B water is designated for uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation. Surface waters/wetlands in the vicinity of the Nyanza Site are accessible to the public.

Major discharges to the Sudbury River originate at the Raytheon Company and the Wayland and Marlborough Easterly Wastewater Treatment Plant (WWTP) which discharges to Hop Brook, a tributary of the Sudbury River in Wayland. The WWTP has been at its present location since 1896. In 1973, it was upgraded to an advanced treatment facility incorporating nitrification and phosphorus removal. The Raytheon Company wastewater treatment discharge to the Sudbury River consists of electroplating process wastewater and sanitary wastewater (DWPC 1988).

Portions of the Sudbury River are used for numerous recreational purposes. These include boating, fishing, hiking, and other passive recreational activities. Limited access to many parts of the River (MDC restrictions, fishing advisories, and private lands) prevent full utilization of its recreational potential. Water use in the Reservoirs is restricted by MDC policy which prohibits boating, fishing, swimming, and skating. However, it should be noted that this restriction is being reviewed by MDC.

3.2.2 Land Use

Land uses along the Sudbury River shoreline are varied. The land is largely undeveloped in the vicinity of Cedar Swamp in Westborough. The upper portion of the River flows through the residential sections of Southborough and then through Ashland Center, where it is bordered by mixed zoning areas including residential, commercial, and industrial properties. The River flows into Reservoir No. 2, Reservoir No. 1 and then into Framingham, where river-front property is characterized by urban land uses, downriver to the Saxonville area of Framingham. The river shoreline regains a rural character downstream from the Saxonville Dam. From the Framingham/Wayland town line northward approximately nine miles to Route 117, the River is bordered by the Great Meadows National Wildlife Refuge (Reach 8, Figure 1-A). Heard Pond, which is in this area, is reported to be occasionally inundated by River flooding. Downstream of the refuge, bordering land uses include agriculture and forests, to the Route 27 overpass in Wayland where residential development and a country club dominate river-front usage.

The River is bordered by meadows and wetlands downstream from Wayland, with occasional residential usage. The River flows into Fairhaven Bay which is bordered by forested hills and the historic

Baker Farm on the Concord/Lincoln town line. Downstream from the Bay, the River is bordered by wetlands, residences, and a canoe rental establishment near the confluence with the Assabet River in Concord, Massachusetts.

Land use patterns in the Sudbury River watershed have changed significantly, as would be expected from the dramatic growth of the area since 1950 (Table 3-2). During this period, the total acreage in forest and wetlands has not changed appreciably. Residential land uses have tripled in acreage with an associated decrease in the amount of land used for agricultural purposes.

The residential character of the communities within the watershed is largely low density, single family housing units. However, in recent years, significant multi-family construction has occurred. Typically, business, commercial, and industrial uses are concentrated in town centers and along major transportation routes that pass through the watershed (Massachusetts Turnpike (Interstate 90), Interstate 495, and Routes 2, 9, 30).

3.3 Climate

The Study Area is situated in a temperate-humid weather zone. Climatic characteristics include changeable weather, large daily and annual ranges in temperature, seasonal variability between years, and uniform distribution of precipitation throughout the year.

The regional National Oceanic and Atmospheric Administration (NOAA) Climatological Station is located in Worcester, approximately 15 miles west of the Study Area. Data from this station, from the 1951-1980 record period, were used to describe the general climate of the Study Area.

The Study Area lies within the central climatological division of Massachusetts where the Atlantic Ocean has a limited effect. July is the warmest month with a normal mean temperature of 70 degrees Fahrenheit. The three coldest months (December, January, and February) have an average temperature of approximately 25 degrees Fahrenheit. Prevailing wind direction from November through June is from the northwest, whereas southwesterly winds prevail from July through October.

Precipitation occurs an average of 80 days per year, with mean monthly normal precipitation ranging from a low of 3.3 inches in February to a high of 4.4 inches in both August and November. The mean annual precipitation is 47 inches. The mean annual snowfall is approximately 48 inches, which is equivalent to about five

TABLE 3-2
SUDBURY RIVER WATERSHED LAND USES, 1951 - 1981
NYANZA III - SUDBURY RIVER STUDY

	1951(1)	1971(1)	1981(2)
Forest (acres)	101,907	97,058	95,116
(% of Total)	55.6%	52.9%	51.9%
Wetland	14,796	14,066	14,066
	8.1%	7.7%	7.7%
Agriculture	51,020	23,327	16,960
	27.8%	12.7%	9.2%
Residential	12,244	33,428	41,067
	6.7%	18.2%	22.4%
C/I/M/T*	1,387	8,045	8,715
	4.0%	4.4%	4.8%
Open/Recreational	2,043	7,473	7,473
	1.0%	4.1%	4.1%

* Includes commercial, industrial, mining, and transportation land use.

(1) MacConnell, William P. Remote Sensing of Twenty Years of Change in Middlesex (Worcester) Counties, 1951 - 1971, 1974.

(2) Parsons, Brinkerhaff, Quado and Douglas, Inc., Sudbury Reservoir Water Treatment Plant, Draft Environmental Impact Report.

inches of water. The average annual evapotranspiration rate is estimated at about 21 inches and the average annual runoff is 22 inches (NUS, 1985a).

3.4 General Geology

The topography of the watershed of the Sudbury River is characterized by a flat meandering river valley within a kame and kettle landscape created during the Pleistocene glaciation. This valley is rimmed by bedrock and glacial till uplands which form the surface watershed divide.

3.4.1 Soils

Soils in the Sudbury River watershed originated primarily from glacial materials. Upland areas, (elevations greater than 200 feet above Mean Sea Level), are covered with two to three feet of loam underlain by glacial till. Cobbles and boulders are common, as are bedrock outcrops on steeper slopes.

Valley soils (elevations below 200 feet Mean Sea Level) were deposited predominantly by glacial meltwater streams. More recent alluvial and organic sediments are results of modern river deposition.

The soils derived from glacial meltwater streams are coarse and well drained. These occur along the main River valley and along major tributaries in Framingham. Soils in Wayland, Sudbury, Lincoln, and Concord were deposited in the many glacial lakes which occupied large portions of the River valley. These poorly drained soils are characterized by finer grained, silt-sized particles and are often overlain by an organic muck or peat layer which may be up to 20 feet thick (SCS, 1973).

Within the watershed there are two broad groups, or associations, of soils. The soils in the Paxton-Hollis-Canton Association typify the upland areas of the watershed. These soils, derived from glacial till, are stony, fine sandy loam at ground surface and are well drained. Exceptions occur in the Paxton soils which have a permeable layer at depths of from two to four feet and Hollis soils where bedrock may occur at or just below ground surface. Paxton soils comprise about 50 percent of this association, Hollis soils about 15 percent, and Canton soils about 10 percent. The remainder of the association consists of a variety of less extensive fine grained soils.

The Hinckley-Windsor-Muck Association is the second major category of soils found in the watershed of the Sudbury River. The Association constitutes the majority of soils present within the watershed, particularly in the River floodplain and along major tributaries. These soils were formed from materials pre-sorted by glacial meltwaters. The Hinckley soils, comprising 50 percent of the association, and Windsor soils, 30 percent, are coarse and very permeable. Muck soils, approximately 10 percent of the association, are derived from organic matter deposited on top of the glacial lake sediments and are found throughout the watershed. A number of other soils, minor in extent, comprise the remaining 20 percent.

3.4.2 Bedrock

The relief and configuration of the pre-glacial bedrock surface determines the resulting thickness of overlying glacial deposits and the amount of water potentially available in those deposits. Over the last 60 million years, streams and rivers have incised a valley along faulted and fractured zones of weakness in the bedrock (SCS, 1973). Pleistocene glaciation further eroded the watershed by scouring and eroding the bedrock surface and deepening the valleys.

The bedrock which underlies the Nyanza Site has been described by the USGS (Nelson, 1974) as a quartz monzonite, locally referred to as the Milford Granite. This pink to light gray granite sequence is believed to be of Lower Paleozoic to Precambrian in age and generally is unfoliated. Bedrock throughout the central portions of the Study Area, from Route 9 north to Sudbury, is characterized by more mafic granitic rocks and minor felsic metavolacanic sequences. These units are grouped within the Milford granite sequence.

North of Sudbury, the area is underlain by the Nashoba sequence. This sequence is locally represented by coarse grained biotite granite, a muscovite-biotite granite, Andover granite, which is the Straw Hollow Diorite, and other undifferentiated intrusives. A minor amphibolite/gneiss sequence is present south of Concord.

Nelson (1974) has identified four faults which are within a two mile radius of the Nyanza Site. Ebasco (1974) has observed some fractures in the granite at several locations. These locations include the bottom of dry lagoons on the Site, outcrops about one mile from the Site and samples of bedrock recovered from borings. Slight weathering was observed along several of the fractures and is interpreted as an indication of groundwater migration along the fractures. Other regional faults may affect regional hydrogeology.

3.5 Surface Water Hydrology

This section describes the surface water runoff and the infiltration characteristics from the Nyanza Site to the Sudbury River. This information is required to assess the potential pathways and receptors of contaminated surface water and sediment.

3.5.1 Hydrological Setting

The Nyanza Site is located in the drainage basin of the Sudbury River, a tributary to Concord River, which is, in turn, a tributary to the Merrimack River, as shown on Figures 1-1 and 3-1.

The Nyanza Site is drained by two small Brooks, Chemical Brook and Trolley Brook, as shown on Figure 1-A and 1-D. The western wetland in the northwestern corner of the Nyanza Site forms the headwaters of the intermittent stream, Chemical Brook. Chemical Brook flows easterly along the northern boundary of the Site, parallel to the Conrail Railroad tracks. Chemical Brook has a watershed of about 83 acres. The western wetland and Chemical Brook were remediated in 1990 as part of construction activities associated with Operable Unit I.

Trolley Brook watershed comprises approximately 185 acres, originates on Megunko Hill in the southern portion of the Site and flows along the western embankment of the abandoned trolley bed and into the wetland (Eastern Wetland) along the eastern border of the Site. Trolley Brook flows under the trolley bed through a culvert, then along the western side of the trolley bed, under Megunko Road and merges with Chemical Brook at a culvert near the Conrail railroad tracks. The combined flow discharges through Chemical Brook Culvert, approximately 2,000 feet northeast of the Sudbury River Raceway. The culvert discharges to the Outfall Creek, which flows in a northeasterly direction to discharge into the Raceway (Figures 1-A and 1-D).

The Raceway converges with the Sudbury River approximately 700 feet downstream from the Culvert Outfall Creek. The Raceway is an old mill spillway diverted at Mill Pond and roughly parallels the River for approximately 2,600 feet. From Mill Pond, the Raceway enters a culvert and passes beneath reconditioned mill buildings on Main Street. The Raceway emerges again near the intersection of Main and Pleasant Streets and flows easterly, converging with the River near the Front Street crossing.

The recharge to Chemical and Trolley Brooks is from surface runoff/precipitation and from shallow groundwater, depending on the season (Ebasco, 1991). The wetlands act as water storage areas during the dry summer months.

Chemical Brook is fed by groundwater after heavy rain and during periods of high groundwater in the spring melt. During these episodes, the wetlands act as groundwater discharge areas. Chemical Brook and its source area are often dry in summer months; this area then becomes a groundwater recharge area. Eastern Wetland, however, is an area of groundwater discharge and almost always contains flowing water (Ebasco, 1990).

Approximately 0.5 mile east (downstream) from the Chemical Brook Culvert is the Cold Spring Brook confluence and the upstream end of Reservoir No. 2. From this point, the River flows north into the southwestern arm of Reservoir No. 1. Additionally, the outlet of the Sudbury Reservoir flows east into Reservoir No. 3 which flows into the northwestern arm of Reservoir No. 1. Reservoir No. 3 and the Sudbury Reservoir are on a separate tributary of the Sudbury River and do not receive surface water flow from the Nyanza Site. The Sudbury River flows out of the northeastern end of Reservoir No. 1. The average annual discharge below Reservoir No. 1 is 118 cubic feet/second (U.S. Geological Survey, 1989).

3.6 Sudbury River

3.6.1 Hydrology

A detailed description of the Sudbury River is provided in Section 3.2. The headwaters of the Sudbury River is in Cedar Swamp, east of Westborough, Massachusetts. The river flows eastward through Hopkinton and Ashland, and then northward through Framingham, Sudbury, Wayland, Lincoln and Concord. The Sudbury joins the Assabet River in Concord, Massachusetts, forming the Concord River.

The watershed area of the Sudbury River is approximately 165 square miles. The largest surface water bodies of the River include Reservoir Nos. 1, 2, and 3; Sudbury Reservoir; Saxonville Impoundment; and Fairhaven Bay. The overflow from the Sudbury Reservoir drains into Reservoir Nos. 3 and 1 in Framingham. The River also receives flows from three other reservoirs which are all upstream of the Site: Whitehall, Hopkinton, and Ashland.

The stretch of the River from Westborough to Saxonville is characterized by a series of dams. The Sudbury River had more than a dozen small- and medium-sized mills above Saxonville. These include the Cordaville Dam, Mill Pond Dam (Myrtle Street), Fenwick Street Dam, and the Saxonville Dam (a.k.a. Colonna Dam). Several other dams were built in the late 1800s to form Reservoir Nos. 1 and 2.

3.6.2 Sediments/Bathymetry

A survey of Reservoir Nos. 1 and 2 was performed in August/September 1989 by the USGS to provide bathymetric and sediment thickness maps for refining sediment sampling locations (Appendix I). More than seven miles of ground-penetrating radar profiles were obtained along selected segments. Depth of water ranged from zero to more than 20 feet. Soft sediment thickness ranged from less than one foot to more than three feet. Depth of water and sediment thickness were verified by physical measurements along selected transects.

Sudbury River sediments were characterized consistent with the American Society for Testing and Materials (ASTM) standard sieve analysis (ASTM D-421 and D-422). There are four primary divisions of soils: clay, silt, sand, and gravel. Coarse-grained particles include sands and gravels, while fine-grained particles include silts and clays. Sediment particles may be classified as cohesive or noncohesive. Cohesive sediments include clays, some silts, and associated organic materials. These fine-grained sediments can adsorb contaminants and form bonds between particles that result in flocculation during overland or stream flow (Novotny and Chester, 1981). Noncohesive sediments, mostly particles of sand and gravel size, are transported as individual particles. Their sorption potential is small compared to cohesive sediments.

The chart below presents characteristics of the different substrate materials.

Material	Particle Size (mm)	Sorption Potential
Clay	0.001-0.002	high
Silt	0.006 - 0.074	moderate
Sand	0.074 - 2	low
Gravel	2 - 75	low

The three major sources of suspended sediments in bodies of water are shore erosion, river inflow (plant and animal material), and human activity such as erosion from mining, logging, and agriculture. These sediments are dispersed and settled by an ongoing process involving wave action and currents until the sediments are either transported out of the system or are buried by further sedimentation and compaction, thus becoming a permanent part of the bottom sediments. Sediments can be resuspended by increased water velocities during storm/runoff events. However, smaller sized particles may be resuspended by lower water velocities. In some instances, a hard-packed clay may require a higher suspending velocity than gravel. Approximate velocities required to initiate movement of particles along a stream bed (traction) are presented in Table 3-3 (Hynes, 1970).

TABLE 3-3
CRITICAL MEAN CURRENT VELOCITY (cm/sec) TO INITIATE TRACTION IN SEDIMENT
NYANZA III - SUDBURY RIVER STUDY

Type of Bed	Clear Water	Muddy Water
Fine-grained clay	30	50
Sandy clay	30	50
Hard clay	60	100
Fine Sand	20	30
Coarse sand	30 - 50	45 - 70
Fine gravel	60	80
Medium gravel	160 - 80	80 -100
Coarse gravel	100 - 140	180

Areas with fine-grained sediments typically exhibit higher Total Organic Carbon (TOC) values than those with coarse-grained sediments. This is primarily due to the adsorptive nature of these small particles. Fine sediments that are high in TOC bind with a wide range of organic and inorganic compounds. Results from grain size and TOC analyses of sediments collected in the Study Area are presented in Appendix A.

The grain size analysis indicated that nearly 50 percent of the sediment samples from the River were predominantly silts and clays. Nearly 25 percent of the sediments were predominantly gravel or sands while the remaining 25 percent were predominantly gravel or organic material. Generally, silts and clays were found in the wider stretches of the River and the Reservoirs where flow velocities were lower, allowing fine sediments to settle out.

Sands and gravels were found in the narrower stretches of the River where flow velocities were generally higher. Selection of sampling locations was biased toward areas where finer grained sediments were deposited and could be recovered during sampling. The finer grained sediments would absorb more mercury and other contaminants than the coarser grained sediments, and thus indicate the extent of contaminant migration within the River system.

The average depth of the Sudbury River is approximately two to three feet with the exception of Fairhaven Bay, which is about six feet deep. Typical stream depths vary from reach to reach depending on the regional gradient and channel cross-sectional geometry. In addition to water depths varying as a result of the geometry and slope of the River channel, stream flow and water level elevation vary on a seasonal basis and, in part, as a function of the amount of water released at individual dams. Generally, however, Reservoirs 1 and 2 range from 10 to 25 feet deep. The USGS bathymetry report presented in Appendix I includes more detail on depths of water in Reservoirs 1 and 2.

3.6.3 Wetlands

The wetlands associated with the Sudbury River system were assessed in 1989 and reported under separate cover (Appendix F). The wetlands assessment contains a description of the wetlands and associated plant cataloging.

The Nyanza Site related contaminants appear to have had little or no visible effect on the vegetation or hydrology of the wetlands. However, wetlands adjacent to and on the Nyanza Site have been heavily disturbed by machinery and equipment during Site remediation. The absence of visible damage to vegetation is not an indication of the presence of the systemic effect of contamination in the wetlands. Most plant species are not killed or inhibited by levels of contamination which may be harmful to wildlife or human health.

3.6.4 Ecology

The Sudbury River provides a diversity of habitat types. The headwaters at Cedar Swamp is an extensive wetland with a variety of wetland types, e.g., heath bog, shrub/scrub, forested, and open water. Several abandoned mill ponds are typically followed by riffle/run rapids. Channelization has been established through some urbanized areas (Ashland and Framingham) and the impoundments of Mill Pond, Reservoir Nos. 2 and 1, and the Saxonville Impoundment have altered the natural flow and ecology of the valley. The floodplains of the Great Meadows National Wildlife Refuge provide a diverse habitat, including open water, marshes, and uplands.

The physiology, typical of much of the Sudbury River, has developed a stream community in the large water bodies that is similar to a community in standing water. The bottoms of the sluggish areas of the River include fine silts and muck with a vegetative surface layer. Occasional riffle/runs, which are highly oxygenated, are generally found, in the areas directly downstream of the impoundments and in some of the channelized urban areas. Riffle/runs were not observed beyond the quickwater after the Saxonville Dam. The stream bottom of these riffles is typically comprised of fine sand, gravel, and cobbles.

3.6.4.1 Vegetation

The wetlands located upriver of Reservoir Nos. 2 and 1 can generally be described as streamside wooded swamps dominated by red maple (Acer rubrum), speckeled alder (Alnus rugosa), silky dogwood (Cornus amomum), and buckthorn (Rhamnus frangula). The Reservoirs consist of a series of open water impoundments with limited wetland types. The shorelines of the Reservoirs are often bordered by mixed hardwood forests and planted stands of Northern white cedar (Thuja occidentalis) or red pine (Pinus resinosa) and usually do not have marsh wetlands along the edges. Where residences border the reservoirs, limited areas of lawn and shrubbery have been planted to the waters' edge. Downstream, as the River flows through the Great Meadows National Wildlife Refuge, extensive shrub swamp floodplains of buttonbush (Cephalanthus occidentalis), purple loosetrife (Lythrum salicaria), and shallow and deep marshes of cattail (Typha latifolia) appear. Marshes of broad- and narrow-leaved aquatic vegetation such as pickerelweed (Pontederia cordata) and sedge (Carex sp.) and large, vigorous stands of wild rice (Zizania aquatica), and wild millet (Echinochola sp.) are also present.

Most of the shallow water zone of the large water bodies of the River and the low gradient sections of the River (Reaches 1 and 7 through 10) have dense growth of submerged and floating-leafed plants including coontail (Ceratophyllum demersum), fanwort (Cabomba carolinianal), watermilfoil (Myriophyllum sp.), bladderwort (Utricularia sp.), slender pondweed (Potemogeton pusillus), ribbonleaf pondweed (P. epihydrus), and bushy pondweed (Najas flexilus). Waterlillies, (Nuphar variegatum and Nymphaea oderata) were found in coves and other low-flow areas.

The low gradient and slower flow sections of the Sudbury River through Wayland and Sudbury are bordered by stands of emergent vegetation such as cattails (Typha latifolia). Downstream of the Route 20 bridge, sections of the River channel support moderate to dense growth of ribbonleaf pondweed and tapegrass (Vallisneria americana). Floating duckweed (Lemna sp.) and water chestnut (Trapa natans) become abundant towards the River's confluence with the Assabet River.

3.6.4.2 Fisheries

The Sudbury River provides sport fishing for a variety of common warm-water game and pan species. Table 3-4 presents several species of fish that were found in the Sudbury River which are common in Massachusetts and some are typically consumed by anglers.

The Massachusetts Division of Fisheries and Wildlife annually stocks trout in Hopkinton, Southborough, and Ashland. Much of the Sudbury River is unsuitable for trout and most other sport fish (with the exception of those listed above), due to low dissolved oxygen levels in some areas of the River (DWPC, 1988)

3.6.4.3 Wildlife

Although the area surrounding the wetlands along the Sudbury River typically is highly developed, human activity within the wetlands themselves appears to be minimal. The variety of food sources observed in the wetlands could support many species of mammals, birds, and reptiles.

TABLE 3-4
SUDBURY RIVER FISH
NYANZA III - SUDBURY RIVER STUDY

Largemouth Bass	*Micropterus salmoides*
Yellow Perch	*Perca flavescens*
Brown Bullhead	*Ictalurus nebulosus*
Yellow Bullhead	*Ictalurus natalis*
Black Crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
White Perch	*Morone americana*
Pumpkinseed	*Lepomis gibbosus*
Chain Pickerel	*Esox niger*
Redfin Pickeral	*Esox americanus*
Rainbow Trout	*Oncorhynchus mykiss*
American Eel	*Anguilla rostrata*
Brook Trout	*Salvelinus fontinailis*
Common Carp	*Cyprinus carpio*
Creek Anubsucker	*Semotilus atromaculatus*
Golden Shiner	*Notenigonus crysolencas*

The wetlands associated with the Great Meadows National Wildlife Refuge in Reach 8 have high wildlife value. Excellent vegetative conditions exist for seed crops and wildlife plant food; the cattail marshes provide excellent migrating, nesting, and breeding habitat.

Thirteen species of fish presented in Table 3-4 were observed throughout the Sudbury River System. Several others were reported to be present. The index of fish species present is qualitative. Sampling operations targeted specific species of fish and other species may not have been noticed.

Wildlife observations provide an additional indicator of habitat type and current use. No formal wildlife inventory was conducted, although species observed during the course of the vegetation assessment were recorded. Mammal observations include woodchuck (Marmota monax) burrows, raccoon (Procyon lotor) tracks, and beaver (Castor canadensis). Squirrels (Sciurus carolinensis) and chipmunks (Tsmias striatus) were also sighted in trees in the wetlands. Birds present include Blue Jays (Cyanocitta cristata), Crows (Corvus brachyrhynchos), Hawks (Buteo sp.), Black-capped Chickadees (Parus atricapillus), Blue Heron (Ardea herodias), Osprey (Pandion haliaetus), and Woodpeckers. Waterfowl, including Mallards (Anas platyrhynchos) and Canadian Geese (Branta canadensis) were frequently observed on the impoundments. Reptiles observed included Painted Turtles (Chrysemys picta) and Green Frogs (Rana clamitans).

The number of animal species observed are fewer than expected and was limited by the brief time spent at each site. During the wetlands assessment, most time was spent noting vegetation and hydrology and most visits were made during daylight hours. A comprehensive faunal study would require extended site visits during different times of the year both at night and during daylight. Lists of wildlife observed or expected to exist along the Sudbury River (including mammals, birds, fish, reptiles, and amphibians) are presented in Appendix J.

Currently endangered, threatened, and species of special concern exist in the Study Area according to the Natural Heritage and Endangered Species Program as presented in Table 3-5. Three verified vernal pools exist in Reach 6. This review was performed by the Natural Heritage and Endangered Species Program and concerns only rare and endangered species of animals and plants for which the program maintains Site-specific records.

TABLE 3-5
ENDANGERED, THREATENED AND SPECIES OF SPECIAL CONCERN ALONG THE SUDBURY RIVER
NYANZA III - SUDBURY RIVER STUDY

Common Name	Scientific Name	State Status
Reach 1		
Golden-winged Warbler	Vermivora chrysotera	endangered
Reach 4		
Certified Vernal Pool		
Englemann's Umbrella-sedge	Cyperus engelmannii	SC
Reach 6		
Three Certified Vernal Pools		
Reach 7		
Least Bittern	Ixobychus exilis	threatened
American Bittern	Botaurus lentiginosus	SC
King Rail	Rallus elegans	threatened
Common Moorhen		
River Bulrush	Scirpus fluviatilis	SC
Reach 8		
Blue-spotted salamander	Ambystoma laterale	SC
Common Moorhen	Gallinula chloropus	SC
Reach 9		
Eastern Box Turtle	Terrapene carolina	SC
Linear-leaved Milkweed	Asclepias verticillata	threatened
Climbing Fumitory	Adlumia fungosa	threatened
Swamp Oats	Sphenopholis pensylvanica	threatened

SC = Species of special concern
Source: Natural Heritage and Endangered Species Program (Appendix J)

3.7 Eastern Wetlands

A description of the Eastern Wetlands is presented in Sections 2.2 and 3.5. The Wetlands are bordered by the old trolley line on the west, by Megunko Road and an oil storage depot on the north, and by uplands on the east and south. The Wetlands receive surficial drainage from the Site and waste effluent discharge from various manufacturing operations in the area (Ebasco, 1991).

Historical aerial photography (1938 through 1981) indicates changes in the extent of the Eastern Wetlands. The original wetland area (1938) was bisected by the old trolley line in the northeast corner of the Site and extended across Megunko Road into the present industrial area. Subsequent photos show filling of the area across Megunko Road (1952) and industrial construction in 1963, 1970, and 1979. As a result of filling and construction activities, it appears that the remaining wetlands east of the old trolley bed (Eastern Wetlands) have expanded, with more open water visible from 1963 to 1981. The Trolley Brook wetland (wetland area west of the old trolley line bed) was remediated under Operable Unit I in 1990 (Ebasco 1991).

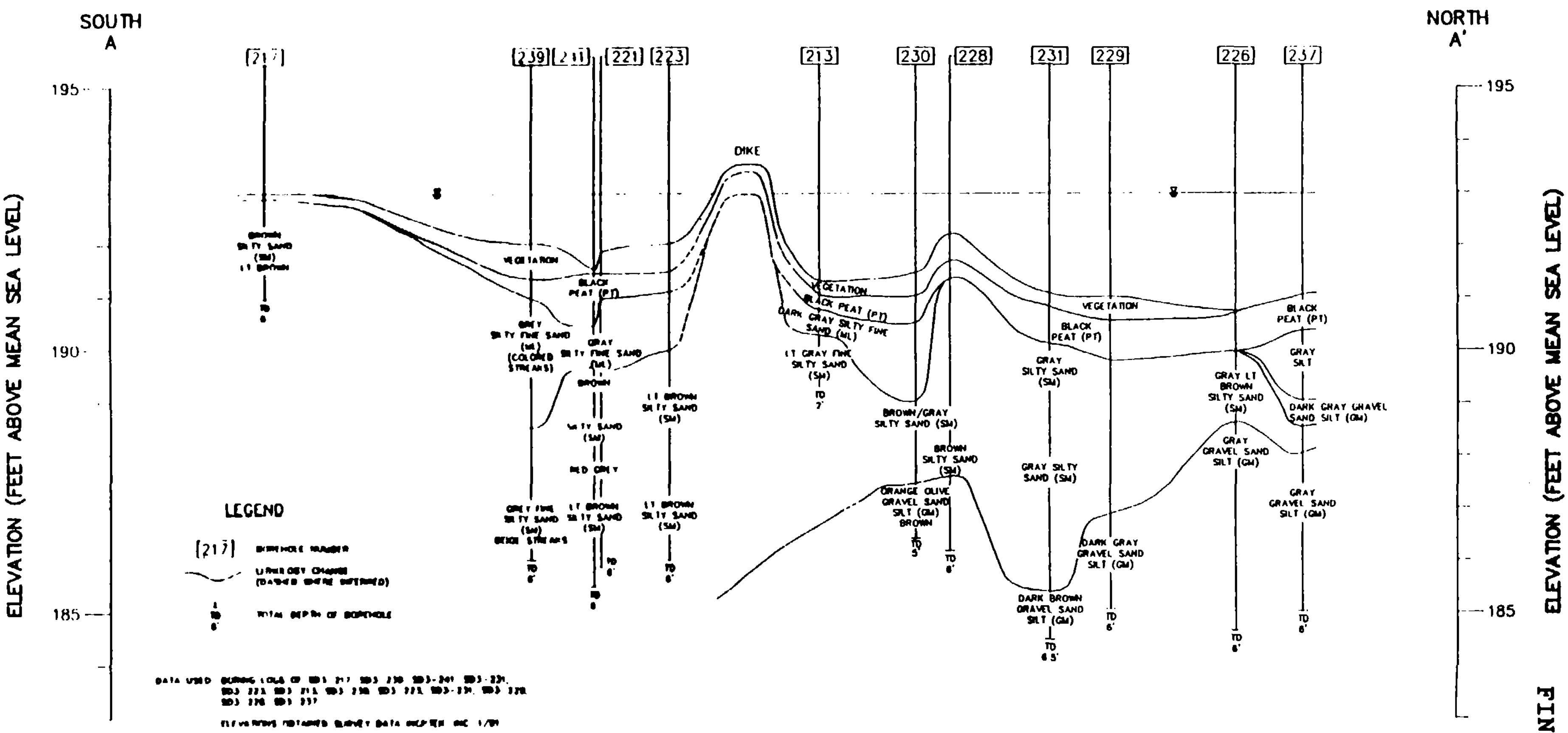
3.7.1 Hydrology

Eastern Wetlands is a palustrine wetland system located east of the old trolley line railbed on the eastern border of the Nyanza Site. The wetland receives with surface water drainage from the eastern portion of the Nyanza Site and surrounding uplands. Surface water from the Site enters the wetland from a feeder stream in the south/southwest portion of the wetland. The stream passes under through a stone culvert and the old trolley line. Another stream feeds the wetland from uplands south and offsite. Surface water discharge from the northwestern corner of the wetland into Trolley Brook which flows northward to the confluence with Chemical Brook. It appears that the Wetlands has been bisected by an earthen dike (approximately two feet above the surface water level). A limited hydrological connection through the dike is provided by a small open culvert.

3.7.2 Sediments

Sediments within the Eastern Wetlands were typically comprised of six to 12 inches of vegetation or a peat layer followed by several feet of silty sands or fine to coarse sands. See Section 3.6.2 for a discussion of the classification system and sediment types. Grain size results are presented in Appendix A. A cross-section profile of selected soil borings within the Wetlands is illustrated in Figure 3-3 (See Figure 1-D for cross - section profile location).

W92194F



DATA USED: BORING LOGS OF SD3 217, SD3 230, SD3-241, SD3-231, SD3 223, SD3 213, SD3 [illegible] SD3 221, SD3-239, SD3 228, SD3 226, SD3 237

ELEVATIONS OBTAINED [illegible] SURVEY DATA [illegible] INC. 1/91

WATER LEVELS FROM [illegible]

DATA WAS NOT COLLECTED ON THE DIKE BETWEEN THE IMPOUNDMENTS, THEREFORE THE LITHOLOGY WAS INTERPOLATED TO REPRESENT THE DIKE

DRAFT

0 100 200
HORIZONTAL SCALE IN FEET

0 2 4
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION 50x

FIGURE 3-3

CROSS SECTION A-A'
EASTERN WETLANDS
NYANZA - OPERABLE UNIT III, ASHLAND, MA

NUS CORPORATION

FINAL

ACAD: 0214\\...DWG 5/30/91

3.7.3 Ecology

The Eastern Wetlands has been divided into two areas by the earthen dike. The northern portion of the Wetlands consists of a fairly large (approximately two to three acres), shallow (approximately one to three feet deep) pond. The dominant wetland class consists of open water with emergent marsh habitats on the eastern and southeastern fringe of the pond. The shallow emergent habitat consists of robust, persistent emergent vegetation dominated by cattails.

The southern portion of the Wetlands has a smaller (less than one acre), shallow pond. However, in this area the emergent marsh habitats comprise a relatively larger portion of this wetland complex with common reed (Phragmites sp.) and purple loosestrife as the dominant components. The phragmites and purple loosestrife represent invasive species which typically out-compete native vegetation and form nearly monotypic plant communities. In addition, both species have limited wildlife food value and can reduce structural diversity within the Wetlands. The eastern and southern areas also have scrub-shrub and forested habitats as significant components of this Wetlands system. Common woody species within the scrub-shrub habitat include Alder-buckthorn (Rhamnus frangula) and silky dogwood. Red maple is the dominant overstory species within the forested habitats with northern red oak (Quercus rubra) and cottonwood (Populus deltoides) as associated species.

Few wildlife species were observed in the area during sampling operations in November 1989 and December 1990, possibly due to the sampling activities. Observations included Mallard ducks and unidentified small fish, crayfish and tadpoles.

3.8 Chemical Brook Culvert

3.8.1 Hydrology

A detailed description of The Chemical Brook Culvert is presented in Section 3.2 and shown in Figures 1-A and 1-D. Trolley Brook, which drains the Eastern Wetlands; and Chemical Brook, which drains the western wetland area, converge and discharge into the Chemical Brook Culvert. The culvert flows northeast approximately 2,000 feet where it discharges to the Raceway and eventually to the Sudbury River.

In 1985, the DEQE undertook an Interim Response Measure to construct a culvert from the Chemical Brook/Trolley Brook Conrail tracks culvert crossing, parallel to the tracks, to Cherry Street and Tilton Avenue. One foot of clean fill was also placed in the area of the construction.

A remote video inspection was performed within the culvert; the results of this inspection are presented in Section 2.3.1.

3.8.2 Sediments

A visual and video inspection were performed at the Chemical Brook Culvert. These inspections indicated little deposition of sediments in the Culvert from the railroad tracks to the intersection of Main and Front Street near the end point of the video inspection. Typically, less than two inches of sediment was present in the junction box or catch basins, with less sediment present in the corrugated steel or cement Culvert sections. Portions of the Culvert have been replaced in a piecemeal fashion with newer construction. It appears that the Culvert is flushed relatively clean during high energy storm events. Exceptions to this may be in the older portions of the culvert (the rectangular slab stone sections). These sections were not accessible for visual inspection and water depth interfered with any determination of sediment presence or depth during the video inspection. Also, due to the stone construction of the culvert, the section from Front Street to the discharge point at the Raceway could not be inspected with the video system. Therefore, it is possible sediments were present in greater quantity in the sections of the Culvert with the older stone construction than in the currogated steel or cement sections. The base of the stone lined Culvert is an open stream bed, which allows water to infiltrate to the water table. Sediment may accumulate between cobbles or in potholes which may be present.

3.8.3 Ecology

The ecology of the Chemical Brook Culvert is not considered a important component of this system. The Culvert's primary function is to carry storm water and spring runoff from the Eastern Wetlands to the Sudbury River.

4

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Introduction

This section discusses the nature and extent of contamination in water, sediment and fish collected in the Sudbury River and associated wetland systems. Data is organized by Reach; other areas, such as Cold Spring Brook and the Eastern Wetlands are discussed separately. Contaminant levels found within each Reach are discussed and compared to background levels. Results of Phase I and II sampling events, including the Eastern Wetlands drilling program are included. This section also presents a discussion of other potential sources of contamination. Contaminants associated with Nyanza Site sources which were identified by previous investigations are termed Site-related contaminants. Contaminants associated with "point" and "non-point" off-site sources are termed Study Area contaminants.

Discussions focus on Site-related contaminants. These include (but are not limited to) mercury, chromium, 1,2-dichlorobenzene (1,2-DCB), chlorobenzene, and TCE. Of these, only mercury (and associated methylmercury) is considered unique to the Nyanza Site discharges. Later sampling and analysis events were limited to inorganic contaminants due to low concentrations of organics detected and the relative importance of mercury.

Other organic compounds and metals have been reported to be associated with Site; however due to the widespread presence of other potential contributors of similar contaminants, no clear conclusion can be drawn pertaining to the origin of these other contaminants. Lead is of particular interest. Although it is a documented Site-related contaminant, lead is ubiquitous in the Study Area. Widespread use of lead in transportation, agriculture and the chemical industry has resulted in elevated levels of lead in the Sudbury River in no distinct pattern of occurrence. This type of widespread occurrence is discussed in Section 4.2.

The analytical database is presented in Appendices A through D. The data were assimilated into summary tables (Tables 4-1 through 4-3) presented in this section. Other analytical data is summarized elsewhere as appropriate.

4.1.1 Monthly Water Quality Sampling Results

A discussion of the monthly sampling results is included as Appendix L, which describes potential environmental effects caused by fluctuations of each parameter analyzed.

TABLE 4-1

SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY

INORGANICS	SEDIMENT – INORGANICS UNITS: mg/kg														
	BACKGROUND REACH 1, SUDBURY RESERVOIR, RESERVOIR 3					REACH 2					REACH 3				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	11 OF 11	8200 81	8200 81	16800	2870	12 OF 12	7606 00	7608.33	16800.00	3010.00	23 OF 23	12210.00	12210.00	21500.0	5660.0
ANTIMONY	1 OF 9	6 46	6 06	6 9	6 9	0 OF 8					1 OF 22	18.00	4.11	18.0	18.0
ARSENIC	8 OF 11	10 64	8 74	21.1	2 5	10 OF 12	8 11	6 95	14.90	2 55	17 OF 23	9.14	7.61	21.5	2.1
BARIUM	11 OF 11	66 66	66 66	178	13 3	12 OF 12	71.48	71 48	209.00	13.90	23 OF 23	69.65	69.65	116.0	18.2
BERYLLIUM	8 OF 10	0 93	0 85	1 8	0 37	7 OF 10	1.03	0 87	1 90	0.10	18 OF 23	1.84	1.52	4.3	0.5
CADMIUM	0 OF 9					0 OF 8					8 OF 23	11.13	4.96	19.9	1.3
CALCIUM	11 OF 11	2161 61	2161 61	4020	588	12 OF 12	3097 42	3097.42	10500 00	620 00	22 OF 23	2699.67	2608.54	4910 0	607.0
CHROMIUM	9 OF 11	24 70	22 40	65 2	6 6	11 OF 12	38 32	34.00	216 00	5.70	22 OF 23	305.62	292.62	2620.0	13.9
COBALT	10 OF 11	11 00	10 05	18 8	3 7	10 OF 11	13 15	13 66	27 70	2.90	7 OF 23	18.76	11.27	28.9	9.0
COPPER	8 OF 11	86 70	73 02	340 4	6 8	9 OF 12	50 03	40 19	184 00	10.80	21 OF 23	200.73	184.47	454.0	13.3
IRON	11 OF 11	22124 06	22124 06	110000	4110	12 OF 12	16252 50	16252 50	34600 00	6500 00	23 OF 23	20973.33	20973 33	47400 0	7960.0
LEAD	11 OF 11	65 00	65 00	248	6	12 OF 12	58 07	58.07	295.00	19.90	23 OF 23	137.97	137.97	285.0	8.6
MAGNESIUM	11 OF 11	1677 82	1677 82	3260	762	12 OF 12	1774 75	1774.75	3720.00	825.00	23 OF 23	3054.79	3054.79	5030.0	1480.0
MANGANESE	11 OF 11	434 61	434 51	1640	65 9	12 OF 12	867 87	867.87	4100.00	76.40	23 OF 23	391.42	391.42	847.0	68.0
MERCURY	2 OF 9	1 06	0 27	1 59	0 5	5 OF 9	6 81	3.81	30.60	0.22	21 OF 22	17.43	15.96	54.6	0.2
NICKEL	5 OF 11	20 58	11 35	61	3 2	4 OF 12	9.67	7.47	19.10	5.45	11 OF 23	48.65	26.43	88.8	14.0
POTASSIUM	11 OF 11	872 84	872 84	1386	224	12 OF 12	585.02	585.02	1260.00	175.00	17 OF 23	1407.69	1076.28	2260.0	412.0
SELENIUM	2 OF 7	3 00	1 04	3 1	2 9	0 OF 8					8 OF 23	1.82	0.81	4.0	0.3
SILVER	0 OF 9					0 OF 8					0 OF 23				
SODIUM	9 OF 11	214 02	188 17	388	72	12 OF 12	407.87	407.87	1480.00	48.60	5 OF 23	317.25	164.40	425.0	201.0
VANADIUM	10 OF 11	21 71	20 19	48.46	10 2	11 OF 12	20.48	19.80	45.60	6.80	22 OF 23	38.11	35.02	87.9	11.7
ZINC	11 OF 11	133 66	133 60	629	13 6	11 OF 12	138.62	126.44	330.00	26.85	21 OF 23	192.20	177.08	435.0	27.0
THALLIUM	0 OF 8					0 OF 8					0 OF 22				

Frequency:	Number of detections in the number of samples validated
Average Detected:	The arithmetic average of only detected concentrations
Average Reported:	The arithmetic average of the detected concentrations and one half the detection limit for undetected values reported

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA II REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
PAGE 2

SEDIMENT – INORGANICS

UNITS. mg/kg

INORGANICS	REACH 4					REACH 5					REACH 6				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	13 OF 13	12621.54	12621.54	22600.00	6660	6 OF 6	7023.33	7023.33	20700.00	3140.00	21 OF 21	11636.90	11636.40	19300.00	4260.00
ANTIMONY	0 OF 12					0 OF 6					0 OF 17				
ARSENIC	9 OF 13	13.66	10.66	32.30	4.6	3 OF 6	6.06	3.83	9.20	3.65	20 OF 21	12.03	11.10	24.00	0.75
BARIUM	13 OF 13	69.91	69.91	136.00	21.2	6 OF 6	73.16	73.16	225.00	27.20	21 OF 21	65.84	65.80	143.00	21.70
BERYLLIUM	7 OF 12	1.11	0.80	3.60	0.84	1 OF 6	0.25	0.48	0.25	0.25	2 OF 17	1.85	0.49	2.00	1.70
CADMIUM	8 OF 13	6.66	4.01	14.60	4.4	0 OF 6					6 OF 17	7.50	3.63	13.60	3.40
CALCIUM	13 OF 13	2323.40	2323.40	4410.00	815	6 OF 6	2273.33	2273.33	4070.00	1170.00	21 OF 21	3676.86	3677.60	7165.00	834.00
CHROMIUM	12 OF 13	76.26	71.01	224.00	11	3 OF 6	30.62	17.95	60.60	13.65	20 OF 21	69.84	66.60	281.00	11.90
COBALT	8 OF 13	16.66	14.66	34.60	10.6	1 OF 6	6.90	4.45	6.90	6.90	11 OF 17	20.19	16.16	35.60	8.90
COPPER	10 OF 13	140.01	115.65	332.00	20.6	3 OF 6	67.40	41.67	158.00	10.90	19 OF 21	127.32	113.50	303.00	27.00
IRON	13 OF 13	20176.46	20176.40	37100.00	6870	6 OF 6	10486.67	10486.67	18000.00	6960.00	21 OF 21	20672.38	20588.10	44200.00	7920.00
LEAD	13 OF 13	93.96	93.96	219.00	5.1	6 OF 6	237.99	237.99	809.00	24.95	21 OF 21	285.65	285.70	876.00	2.40
MAGNESIUM	13 OF 13	2342.31	2342.31	3500.00	1270	6 OF 6	1838.33	1838.33	3300.00	1320.00	21 OF 21	3402.14	3401.90	4660.00	1610.00
MANGANESE	13 OF 13	540.23	540.23	1030.00	115	6 OF 6	699.83	699.83	1935.00	194.00	21 OF 21	569.26	569.30	1416.00	126.00
MERCURY	11 OF 12	3.66	3.38	7.30	0.01	5 OF 6	1.17	0.98	4.10	0.30	14 OF 20	5.00	3.30	17.60	0.33
NICKEL	11 OF 13	32.21	20.66	63.00	6.2	1 OF 6	16.10	6.79	16.10	16.10	13 OF 21	28.05	20.30	78.40	11.00
POTASSIUM	7 OF 13	881.71	804.34	1340.00	558	3 OF 6	924.17	812.50	1296.50	555.00	14 OF 21	1063.57	706.30	1650.00	283.00
SELENIUM	8 OF 12	1.66	1.74	4.00	0.45	2 OF 6	0.43	0.46	0.44	0.41	7 OF 19	3.13	1.37	6.10	1.70
SILVER	0 OF 5					1 OF 6	6.40	1.90	6.40	6.40	0 OF 9				
SODIUM	1 OF 13	1230.00	211.92	1230.00	1230	2 OF 6	589.73	280.83	1110.00	69.45	9 OF 21	464.00	266.60	1720.00	113.00
VANADIUM	13 OF 13	34.80	34.83	87.10	12.6	6 OF 6	17.05	17.05	30.70	9.40	17 OF 21	39.33	55.90	83.00	10.60
ZINC	12 OF 13	173.66	181.05	327.00	26.3	5 OF 6	233.46	199.66	765.00	72.30	20 OF 21	306.00	292.30	564.00	30.10
THALLIUM	0 OF 10					0 OF 6					0 OF 9				

Frequency:	Number of detections in the number of samples validated
Average Detected:	The arithmetic average of only detected concentrations
Average Reported:	The arithmetic average of the detected concentrations and one half the detection limit for undetected values reported

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
PAGE 3

SEDIMENT - INORGANICS
UNITS: mg/kg

INORGANICS	REACH 7					REACH 8					REACH 9				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	13 OF 13	7738.92	7738.90	16800.00	1840.00	6 OF 6	6636.67	6636.00	8310.00	4310.00	3 OF 3	9806.67	9806.00	11700.00	7020.00
ANTIMONY	0 OF 12					0 OF 1					0 OF 0				
ARSENIC	10 OF 13	11.04	10.13	40.60	2.30	6 OF 6	12.13	12.13	30.00	4.20	3 OF 3	32.03	32.00	64.60	15.30
BARIUM	13 OF 13	92.42	92.42	272.00	15.80	6 OF 6	113.42	113.41	222.00	26.60	3 OF 3	116.70	116.00	151.00	66.10
BERYLLIUM	2 OF 10	0.57	0.67	0.61	0.52	0 OF 1					0 OF 0				
CADMIUM	2 OF 12	11.50	2.21	17.90	5.10	1 OF 3	4.30	2.08	4.30	4.30	2 OF 2	7.05	7.05	8.60	5.50
CALCIUM	13 OF 13	2636.15	2636.15	6330.00	566.00	6 OF 6	4121.67	4121.00	5210.00	2770.00	3 OF 3	5150.00	5150.00	5620.00	4160.00
CHROMIUM	10 OF 13	61.58	47.96	209.00	10.30	5 OF 6	26.30	22.00	38.40	14.20	3 OF 3	50.27	50.26	78.00	17.80
COBALT	4 OF 12	8.40	7.05	10.40	7.60	3 OF 4	8.33	7.20	8.90	7.30	3 OF 3	14.20	14.20	18.60	9.30
COPPER	9 OF 13	88.89	66.94	278.00	18.80	6 OF 6	67.62	67.61	96.60	14.40	3 OF 3	63.33	63.33	135.00	17.10
IRON	13 OF 13	14826.92	13826.92	58000.00	2870.00	6 OF 6	15561.67	15561.00	32000.00	6710.00	3 OF 3	17533.33	17533.30	18000.00	16700.00
LEAD	13 OF 13	117.44	117.84	520.00	2.80	6 OF 6	66.77	66.70	100.00	6.80	3 OF 3	115.27	115.26	164.00	4.80
MAGNESIUM	13 OF 13	2566.31	2566.31	4670.00	411.00	6 OF 6	1566.33	1566.30	1980.00	1130.00	3 OF 3	1883.33	1883.30	2090.00	1700.00
MANGANESE	13 OF 13	388.29	388.29	1430.00	57.80	6 OF 6	1660.17	1660.10	5660.00	123.00	3 OF 3	429.33	429.33	516.00	348.00
MERCURY	8 OF 11	2.08	1.52	8.50	0.21	5 OF 5	1.62	1.62	2.10	0.88	2 OF 2	3.15	3.15	3.90	2.40
NICKEL	5 OF 13	22.48	11.29	44.10	8.70	2 OF 5	11.80	7.08	13.10	10.50	2 OF 2	24.95	24.95	28.10	21.80
POTASSIUM	9 OF 13	988.67	821.38	1210.00	119.00	6 OF 6	360.00	360.00	437.00	303.00	3 OF 3	577.67	577.66	759.00	383.00
SELENIUM	5 OF 13	2.48	1.18	7.20	0.85	3 OF 6	1.43	0.75	1.60	1.00	0 OF 0				
SILVER	0 OF 8					0 OF 1					0 OF 0				
SODIUM	8 OF 13	211.20	174.48	374.00	75.20	6 OF 6	404.00	404.00	614.00	142.00	3 OF 3	237.33	237.33	379.00	136.00
VANADIUM	12 OF 13	21.04	19.55	47.00	8.30	5 OF 5	9.72	9.72	12.80	6.60	3 OF 3	18.40	18.40	23.10	11.40
ZINC	11 OF 13	199.30	170.08	646.00	25.60	6 OF 6	187.37	187.36	329.00	38.20	3 OF 3	197.13	197.13	319.00	20.40
THALLIUM	0 OF 7					0 OF 1					0 OF 0				

Frequency:	Number of detections in the number of samples validated
Average Detected:	The arithmetic average of only detected concentrations
Average Reported:	The arithmetic average of the detected concentrations and one half the detection limit for undetected values reported

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
PAGE 4

AVERAGE AVERAGE AVERAGE

SEDIMENT - INORGANICS

UNITS: mg/kg

INORGANICS	REACH 10					EASTERN WETLANDS					CHEMICAL BROOK CULVERT				
	FREQUENCY	AVERAGE DETECTED	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	5 OF 5	6780.00	6780	17600.00	1880.00	10 OF 10	7216.00	7216	11050.00	4350.00	2 OF 2	3520.00	3520.00	3690.00	3350.00
ANTIMONY	0 OF 5					1 OF 10	6.70	6.07	6.70	6.70	0 OF 2				
ARSENIC	5 OF 5	5.88	5.88	12.20	2.80	10 OF 10	6.59	6.59	12.70	2.30	2 OF 2	4.30	4.30	6.60	2.00
BARIUM	5 OF 5	33.61	33.61	64.30	16.00	8 OF 10	38.13	33.615	57.70	25.50	2 OF 2	18.65	18.65	25.90	11.40
BERYLLIUM	0 OF 5					10 OF 10	2.21	2.21	4.00	0.52	2 OF 2	0.45	0.45	0.56	0.34
CADMIUM	0 OF 5					0 OF 10					0 OF 2				
CALCIUM	5 OF 5	1620.00	1620	2480.00	870.00	10 OF 10	6941.50	6941.5	16400.00	714.00	2 OF 2	1048.00	1048.00	1130.00	966.00
CHROMIUM	4 OF 5	12.13	11.24	17.10	7.30	9 OF 10	136.79	123.68	462.00	16.80	2 OF 2	82.30	82.30	135.00	29.60
COBALT	5 OF 5	4.24	4.24	6.40	2.80	3 OF 10	15.83	7.41	31.20	6.80	2 OF 2	4.40	4.40	4.60	4.20
COPPER	2 OF 5	28.15	14.115	31.00	25.30	8 OF 10	75.54	63.73	120.00	19.60	2 OF 2	63.35	63.35	92.50	34.20
IRON	5 OF 5	7102.00	7102	10800.00	3090.00	10 OF 10	11671.00	11671	38200.00	1980.00	2 OF 2	20505.00	20505.00	33200.00	7810.00
LEAD	5 OF 5	22.48	22.48	33.80	7.80	10 OF 10	72.58	72.58	142.00	6.50	2 OF 2	38.25	38.25	57.50	19.00
MAGNESIUM	5 OF 5	1277.20	1277.2	2510.00	365.00	10 OF 10	958.55	958.55	2010.00	195.00	2 OF 2	1172.00	1172.00	1890.00	454.00
MANGANESE	5 OF 5	178.04	178.04	336.00	84.80	9 OF 10	317.17	289.11	1320.00	26.40	2 OF 2	90.60	90.60	119.00	62.20
MERCURY	2 OF 5	0.37	0.101	0.53	0.20	8 OF 10	44.84	35.878	152.00	0.23	2 OF 2	6.80	6.80	7.10	6.50
NICKEL	5 OF 5	7.37	7.37	11.10	4.80	5 OF 10	16.98	10.1425	40.40	5.40	0 OF 2				
POTASSIUM	5 OF 5	527.40	527.4	1360.00	100.00	9 OF 10	293.47	314.12	656.00	92.20	2 OF 2	314.50	314.50	326.00	303.00
SELENIUM	0 OF 5					8 OF 10	2.55	1.43	6.50	0.54	0 OF 2				
SILVER	0 OF 5					0 OF 10					0 OF 2				
SODIUM	5 OF 5	127.81	127.81	287.00	42.70	8 OF 10	1098.03	911.495	4630.00	20.20	2 OF 2	161.50	161.50	165.00	158.00
VANADIUM	5 OF 5	9.16	9.16	15.80	4.80	10 OF 10	17.67	17.57	37.40	5.70	2 OF 2	12.00	12.00	18.00	6.00
ZINC	5 OF 5	38.36	38.36	63.40	20.80	8 OF 10	76.25	65.3925	164.00	10.50	2 OF 2	92.95	92.95	103.00	82.90
THALLIUM	0 OF 5					0 OF 10					0 OF 2				

Frequency: Number of detections in the number of samples validated
Average Detected: The arithmetic average of only detected concentrations
Average Reported: The arithmetic average of the detected concentrations and one half the detection limit for undetected values reported

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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INORGANICS	SEDIMENT – INORGANICS UNITS: mg/kg OUTFALL CREEK					RACEWAY					COLD SPRING BROOK				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	3 OF 3	5676 67	5676 67	11500 00	2460 00	4 OF 4	22850 00	22850.00	29200	15400	2 OF 2	9225.00	9225.00	10700.00	7750.00
ANTIMONY	0 OF 3					0 OF 4					0 OF 2				
ARSENIC	3 OF 3	2 83	2 83	4 10	2 20	4 OF 4	24 98	24 98	37.2	18 65	1 OF 2	4.30	3.50	4.30	4.30
BARIUM	3 OF 3	31 86	31 86	66 60	12 66	4 OF 4	44 10	44 10	72.1	32.7	2 OF 2	59.35	59.00	65.50	53.20
BERYLLIUM	1 OF 3	2 20	1 07	2 20	2 20	4 OF 4	7 06	7 06	10.15	4	1 OF 2	1.90	1.00	1.90	1.90
CADMIUM	0 OF 3					2 OF 4	4 30	2 28	5.6	3	0 OF 2				
CALCIUM	3 OF 3	1989 83	1989 83	4340 00	708 50	4 OF 4	2768 25	2768 25	4090	1360	2 OF 2	3255.00	3255 00	4240.00	2270.00
CHROMIUM	3 OF 3	341 60	341 60	988 00	18 00	4 OF 4	155 50	155.50	208	129	1 OF 2	16.70	15.15	16.70	16.70
COBALT	2 OF 3	3 95	4 56	4 30	3 60	4 OF 4	114 69	114 69	235	65.5	2 OF 2	12.65	12.60	14.30	11.00
COPPER	3 OF 3	137 83	137 83	356 00	19 60	4 OF 4	217.75	217.75	308	142	2 OF 2	31.30	31.50	32 90	29.70
IRON	3 OF 3	11325 00	11325 00	20200 00	5725 00	4 OF 4	27375 00	27375 00	35500	13000	2 OF 2	13600.00	13600.00	15200.00	12000.00
LEAD	3 OF 3	105 95	105 95	233 00	27 80	4 OF 4	435 75	435 75	758	287	2 OF 2	234.50	234 00	328.00	141.00
MAGNESIUM	3 OF 3	1856 33	1856 33	3090 00	829 00	4 OF 4	2653 75	2653.75	3660	1810	2 OF 2	3000.00	3000.00	3330.00	2670.00
MANGANESE	3 OF 3	164 67	164 57	308 00	81 40	4 OF 4	456 25	456 25	864	110	2 OF 2	658.00	658 00	854 00	462.00
MERCURY	3 OF 3	35 33	36 33	99 20	1 60	4 OF 4	0 71	0 71	0.97	0.475	0 OF 2				
NICKEL	0 OF 3					4 OF 4	89 69	89 69	166	45.7	0 OF 2				
POTASSIUM	3 OF 3	715 00	715 00	933 00	406 00	4 OF 4	1166 00	1166.00	1570	666	2 OF 2	1545.00	1545.00	2020.00	1070.00
SELENIUM	0 OF 3					0 OF 4					0 OF 2				
SILVER	0 OF 3					0 OF 4					0 OF 2				
SODIUM	2 OF 3	80 15	100 66	94 70	65 60	4 OF 4	813 75	813.75	1120	417	1 OF 2	428.00	244 50	428 00	428.00
VANADIUM	3 OF 3	17 29	17 29	38 10	6 25	4 OF 4	44 50	44 50	51.2	35.6	2 OF 2	31.10	30.90	41.40	20.80
ZINC	3 OF 3	169 30	169 30	380 00	63 80	4 OF 4	365 66	365 86	542	259.5	2 OF 2	148.00	148.00	166.00	130.00
THALLIUM	0 OF 3					0 OF 4					0 OF 2				

Frequency:	Number of detections in the number of samples validated
Average Detected:	The arithmetic average of only detected concentrations
Average Reported:	The arithmetic average of the detected concentrations and one half the detection limit for undetected values reported

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT - INORGANICS
UNITS mg/kg

INORGANICS	BORDERING WETLANDS					HEARD POND					EASTERN WETLANDS DRILLING 0 TO 2 FOOT DEPTH INTERVAL				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	10 OF 10	12474.00	12474.000	18300.00	8880.00	1 OF 1	10580.00	10580.00	10580.00	10580.00	23 OF 32	9356.26	8024.22	15400.00	4570.00
ANTIMONY	0 OF 9					0 OF 1					0 OF 31				
ARSENIC	8 OF 10	9.62	8.220	11.80	3.90	1 OF 1	10.85	10.85	10.85	10.85	14 OF 32	2.63	1.71	7.00	0.61
BARIUM	10 OF 10	38.13	38.125	87.60	18.10	1 OF 1	89.60	89.60	89.60	89.60	32 OF 32	32.54	32.54	64.70	12.90
BERYLLIUM	9 OF 9	0.91	0.916	1.60	0.28	0 OF 1					26 OF 32	2.10	1.60	8.20	1.20
CADMIUM	0 OF 9					0 OF 1					2 OF 31	2.60	0.65	3.40	1.60
CALCIUM	10 OF 10	1363.00	1363.000	3860.00	328.00	1 OF 1	4200.00	4200.00	4200.00	4200.00	32 OF 32	2797.81	2797.81	13400.00	1290.00
CHROMIUM	9 OF 10	25.09	24.010	101.00	11.60	1 OF 1	40.20	40.20	40.20	40.20	25 OF 32	51.71	41.62	424.00	4.80
COBALT	9 OF 9	7.38	7.384	13.40	4.20	0 OF 1					17 OF 31	12.85	7.66	74.00	3.30
COPPER	4 OF 10	34.30	18.013	83.40	14.20	1 OF 1	136.00	136.00	136.00	136.00	17 OF 32	57.16	31.60	319.00	6.10
IRON	10 OF 10	14281.50	14281.500	30700.00	8850.00	1 OF 1	16400.00	16400.00	16400.00	16400.00	25 OF 32	7641.60	6311.62	21900.00	3720.00
LEAD	10 OF 10	71.18	71.180	754.00	8.40	1 OF 1	149.00	149.00	149.00	149.00	21 OF 32	302.42	201.90	5760.00	6.30
MAGNESIUM	10 OF 10	2082.00	2082.000	3080.00	1400.00	1 OF 1	2370.00	2370.00	2370.00	2370.00	31 OF 32	1566.71	1554.16	2620.00	360.00
MANGANESE	10 OF 10	297.92	297.915	1070.00	78.45	1 OF 1	335.50	335.50	335.50	335.50	30 OF 32	90.92	86.31	476.00	30.40
MERCURY	5 OF 9	1.80	1.071	7.80	0.13	1 OF 1	3.50	3.50	3.50	3.50	26 OF 32	7.29	6.12	91.50	0.17
NICKEL	2 OF 10	17.65	7.180	21.60	13.60	1 OF 1	11.30	11.30	11.30	11.30	14 OF 31	11.77	7.50	23.4	2.3
POTASSIUM	10 OF 10	474.80	474.800	923.00	206.00	1 OF 1	703.50	703.50	703.50	703.50	32 OF 32	512.27	512.27	934.00	150.00
SELENIUM	1 OF 9	1.20	0.070	1.20	1.20	0 OF 1					0 OF 31				
SILVER	0 OF 9					0 OF 1					0 OF 24				
SODIUM	6 OF 10	181.10	113.468	222.00	77.80	1 OF 1	729.00	729.00	729.00	729.00	15 OF 32	667.73	369.11	3750.00	137.00
VANADIUM	10 OF 10	28.07	28.066	67.60	17.70	1 OF 1	21.70	21.70	21.70	21.70	30 OF 31	13.92	13.61	22.60	6.10
ZINC	4 OF 10	75.75	41.078	127.00	34.80	1 OF 1	302.00	302.00	302.00	302.00	23 OF 32	54.34	42.55	290.00	18.20
THALLIUM	0 OF 9					0 OF 1					2 OF 31	1.30	0.46	1.40	1.20

Frequency:	Number of detections in the number of samples validated
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TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMIEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT - ORGANICS

UNITS. ug/kg

ORGANIC COMPOUNDS	BACKGROUND REACH 1, SUDBURY RESERVOIR, RESERVOIR 3					REACH 2					REACH 3				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	0 OF 4					2 OF 12	6 000	8 000	8 000	4.000	0 OF 8				
ACETONE	1 OF 4	10 00	255 25	10 0	10 0	6 OF 13	201 833	120 538	310 000	46 000	4 OF 8	182 50	131 21	310.0	37.0
1,2-DICHLOROETHENE (TOTAL)	0 OF 3					1 OF 9	31 000	6 722	31.000	31.000	0 OF 6				
METHYL ETHYL KETONE	0 OF 3					4 OF 8	47.000	27 781	80.000	26.000	3 OF 6	26 33	14 08	32.0	17.0
TRICHLOROETHENE	0 OF 3					0 OF 9					0 OF 9				
BENZENE	0 OF 3					0 OF 9					0 OF 9				
TETRACHLOROETHENE	0 OF 3					0 OF 9					0 OF 9				
TOLUENE	0 OF 3					0 OF 9					0 OF 9				
CHLOROBENZENE	0 OF 3					2 OF 9	23.500	9 444	27.000	20.000	0 OF 9				
1,3-DICHLOROBENZENE	0 OF 3					0 OF 9					0 OF 9				
1,4-DICHLOROBENZENE	0 OF 3					2 OF 10	770.000	641.000	1100.000	440.000	1 OF 9	125 50	1101.72	125.5	125.5
1,2-DICHLOROBENZENE	0 OF 3					3 OF 10	1460.000	678.000	1800 000	580.000	0 OF 9				
(3-AND/OR 4-)METHYLPHENOL	0 OF 3					0 OF 9					0 OF 9				
NITROBENZENE	0 OF 3					0 OF 9					0 OF 9				
BENZOIC ACID	0 OF 3					0 OF 5					1 OF 9	340 00	5404 44	340.0	340.0
1,2,4-TRICHLOROBENZENE	0 OF 3					2 OF 9	670 000	638 889	760.000	580.000	3 OF 9	125 33	1062 56	180.0	66 0
NAPHTHALENE	0 OF 3					1 OF 9	1180 000	599.444	1180 000	1180.000	1 OF 9	120 00	1111.39	120.0	120.0
2-METHYLNAPHTHALENE	0 OF 3					2 OF 9	275 000	546.667	410.000	140.000	0 OF 9				
ACENAPHTHYLENE	0 OF 3					4 OF 9	283 750	486 111	500 000	93.000	3 OF 9	540 00	818 61	880 0	120 0
ACENAPHTHENE	0 OF 3					3 OF 9	479 667	544 333	1235 000	84 000	1 OF 9	100 00	1109 17	100 0	100.0
DIBENZOFURAN	0 OF 3					2 OF 9	605 000	556 111	1060 000	150.000	0 OF 9				
DIETHYL PHTHALATE	0 OF 3					0 OF 9					0 OF 9				
FLUORENE	0 OF 3					4 OF 9	466 000	607.111	1500.000	97.000	2 OF 9	180 00	1090 63	200 0	120.0
N-NITROSODIPHENLYAMINE	0 OF 3					0 OF 9					3 OF 9	180 00	1019.17	240.0	140.0
PHENANTHRENE	2 OF 4	150 00	378 75	160 0	140 0	10 OF 11	1775 500	1634 545	10850 0	480.000	9 OF 9	1367 78	1367 78	7300 0	65 0
ANTHRACENE	0 OF 3					8 OF 10	755 750	753 850	2900 000	94.500	4 OF 8	164 75	1052 17	240 0	49 0
DI-N-BUTYLPHTHALATE	0 OF 3					0 OF 9					2 OF 8	2655 00	1645 28	5200 0	110.0
FLUORANTHENE	3 OF 4	210 00	414 25	320 0	87 0	11 OF 11	2014 091	2014 091	9250.000	450.000	9 OF 9	2331 67	2331.67	12000 0	170.0
PYRENE	3 OF 4	180 67	385 50	270 0	52 0	10 OF 11	1819 000	1669 091	8900 000	510.000	9 OF 9	2461 11	2461 11	11000 0	130 0
BENZYL BUTYL PHTHALATE	0 OF 3					0 OF 9					0 OF 9				
BENZO(A)ANTHRACENE	0 OF 3					9 OF 11	1061 111	1105 456	4400 000	420 000	7 OF 9	1195 00	1346 11	4500 0	55.0
CHRYSENE	2 OF 4	160 00	383 75	180 0	140 0	10 OF 11	988 500	1092 273	4200 000	210 000	8 OF 9	1741 88	1737 22	7700 0	100.0
BIS(2-ETHYLHEXYL) PHTHALATE	0 OF 3					8 OF 9	694 667	650 889	2000 000	138 000	5 OF 9	524 00	790 83	910 0	320.0
DI-N-OCTYLPHTHALATE	0 OF 3					0 OF 9					0 OF 9				
BENZO (B) FLUORANTHENE	2 OF 3	185 00	308 25	200 0	170 0	9 OF 11	973 889	1034 091	3550 000	350 000	8 OF 9	1470 00	1495 56	4400 0	110.0
BENZO (K) FLUORANTHENE	0 OF 3					9 OF 10	921 667	989 500	3800 000	240 000	8 OF 9	1468 50	1494 22	3900 0	73.0
BENZO-A-PYRENE	1 OF 3	81 00	435 33	81 0	81 0	7 OF 10	1070 714	1027 500	3750 000	240 000	8 OF 9	1147 75	1209 11	4400 0	72 0
INDENO (1,2,3-CD) PYRENE	0 OF 3					2 OF 9	532 500	826 111	900 000	165 000	7 OF 9	474 36	785 61	1800 0	51.0
DIBENZO(A,H)ANTHRACENE	0 OF 3					2 OF 9	86 500	514 222	93 000	80 000	2 OF 9	220 00	1109 67	310 0	130.0
BENZO(GHI)PERYLENE	0 OF 3					3 OF 9	368 833	593 500	650 000	128 500	7 OF 9	457 78	772 72	1600 0	55.0
4,4'-DDE (P,P'-DDE)	0 OF 3					1 OF 9	58 000	16 583	58 000	58 000	1 OF 9	60 00	32 08	60 0	60.0
4,4'-DDD (P,P -DDD)	0 OF 3					1 OF 9	30 570	30 889	30 570	30 570	3 OF 9	169 33	84 78	370 0	53 0
4,4'-DDT (P,P'-DDT)	0 OF 3					4 OF 10	413 875	172 425	1400 000	71 000	0 OF 9				
GAMMA-CHLORDANE /2	0 OF 3					0 OF 9					0 OF 9				
PCB-1254 (AROCLOR 1254)	0 OF 3					0 OF 9					0 OF 9				
MONOMETHYLMERCURY	0 OF 3					1 OF 3	312	109 000	312	312	1 OF 18	26 3	108 55	26 3	26 3
DIMETHYLMERCURY	0 OF 3					0 OF 3					1 OF 18	19 1	7 44	19 1	19.1

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA II REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT - ORGANICS

UNITS ug/kg

ORGANIC COMPOUNDS	REACH 4					REACH 5					REACH 6				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	0 OF 2					0 OF 1					0 OF 4				
ACETONE	1 OF 2	2600.00	1382.0	2600.0	2600.0	0 OF 1					2 OF 4	465.00	401.25	570.0	360.0
1,2-DICHLOROETHENE (TOTAL)	0 OF 2					0 OF 1					0 OF 4				
METHYL ETHYL KETONE	1 OF 2	64.00	59.5	54.0	64.0	0 OF 1					3 OF 4	82.17	59.13	110.0	30.5
TRICHLOROETHENE	0 OF 2					0 OF 1					0 OF 4				
BENZENE	0 OF 2					0 OF 1					0 OF 4				
TETRACHLOROETHENE	0 OF 2					0 OF 1					0 OF 4				
TOLUENE	0 OF 2					0 OF 1					0 OF 4				
CHLOROBENZENE	0 OF 2					0 OF 1					0 OF 4				
1,3-DICHLOROBENZENE	0 OF 2					0 OF 1					0 OF 4				
1,4-DICHLOROBENZENE	0 OF 2					0 OF 1					0 OF 4				
1,2-DICHLOROBENZENE	0 OF 2					0 OF 1					0 OF 4				
(3-AND/OR 4-)METHYLPHENOL	0 OF 2					1 OF 1	130.00	130.0	130.0	130.0	0 OF 4				
NITROBENZENE	0 OF 2					0 OF 1					0 OF 4				
BENZOIC ACID	2 OF 2	130.00	130.0	140.0	120.0	0 OF 1					3 OF 4	395.00	8671.25	630.0	205.0
1,2,4-TRICHLOROBENZENE	0 OF 2					0 OF 1					0 OF 4				
NAPHTHALENE	0 OF 2					0 OF 1					0 OF 4				
2-METHYLNAPHTHALENE	0 OF 2					0 OF 1					0 OF 4				
ACENAPHTHYLENE	0 OF 2					1 OF 1	160.00	160.0	160.0	160.0	0 OF 4				
ACENAPHTHENE	0 OF 2					0 OF 1					1 OF 4	74.00	2168.00	74.0	74.0
DIBENZOFURAN	0 OF 2					0 OF 1					0 OF 4				
DIETHYL PHTHALATE	0 OF 2					0 OF 1					0 OF 4				
FLUORENE	0 OF 2					0 OF 1					1 OF 4	160.00	2178.75	160.0	160.0
N-NITROSODIPHENLYAMINE	0 OF 2					0 OF 1					0 OF 4				
PHENANTHRENE	1 OF 2	170.00	1085.0	170.0	170.0	1 OF 1	540.00	540.0	540.0	540.0	4 OF 4	1171.25	1171.25	1600.0	660.0
ANTHRACENE	1 OF 2	140.00	237.0	140.0	140.0	1 OF 1	150.00	150.0	150.0	150.0	2 OF 4	205.00	2077.50	240.0	170.0
DI-N-BUTYLPHTHALATE	0 OF 2					0 OF 1					0 OF 4				
FLUORANTHENE	2 OF 2	260.00	260.0	270.0	250.0	1 OF 1	1100.00	1100.0	1100.0	1100.0	4 OF 4	1975.00	1975.00	2600.0	1100.0
PYRENE	2 OF 2	255.00	255.0	260.0	250.0	1 OF 1	1100.00	1100.0	1100.0	1100.0	4 OF 4	2075.00	2075.00	2900.0	1500.0
BENZYL BUTYL PHTHALATE	0 OF 2					1 OF 1	630.00	630.0	630.0	630.0	2 OF 4	175.00	2062.50	220.0	130.0
BENZO(A)ANTHRACENE	1 OF 2	110.00	272.0	110.0	110.0	1 OF 1	470.00	470.0	470.0	470.0	4 OF 4	1017.50	1017.50	1500.0	510.0
CHRYSENE	2 OF 2	205.00	205.0	220.0	190.0	1 OF 1	700.00	700.0	700.0	700.0	3 OF 4	1306.67	2730.00	1500.0	920.0
BIS(2-ETHYLHEXYL) PHTHALATE	0 OF 2					1 OF 1	330.00	330.0	330.0	330.0	3 OF 4	1416.67	2812.50	1900.0	750.0
DI-N-OCTYLPHTHALATE	0 OF 2					0 OF 1					1 OF 4	220.00	2133.75	220.0	220.0
BENZO (B) FLUORANTHENE	2 OF 2	275.00	275.0	400.0	150.0	1 OF 1	1400.00	1400.0	1400.0	1400.0	4 OF 4	1617.50	1626.25	3400.0	760.0
BENZO (K) FLUORANTHENE	1 OF 2	150.00	242.0	150.0	150.0	0 OF 1					3 OF 4	863.33	2412.50	980.0	770.0
BENZO-A-PYRENE	2 OF 2	140.00	140.0	150.0	130.0	1 OF 1	320.00	320.0	320.0	320.0	3 OF 4	788.33	2341.25	1100.0	210.0
INDENO (1,2,3-CD) PYRENE	1 OF 2	84.00	252.0	84.0	84.0	1 OF 1	240.00	240.0	240.0	240.0	3 OF 4	531.67	2148.75	740.0	260.0
DIBENZO(A,H)ANTHRACENE	0 OF 2					0 OF 1					0 OF 4				
BENZO(GHI)PERYLENE	1 OF 2	82.00	251.0	82.0	82.0	1 OF 1	270.00	270.0	270.0	270.0	3 OF 4	578.33	2183.75	820.0	240.0
4,4'-DDE (P,P'-DDE)	0 OF 2					0 OF 1					0 OF 4				
4,4'-DDD (P,P'-DDD)	0 OF 2					0 OF 1					1 OF 4	700.00	399.38	700.0	700.0
4,4'-DDT (P,P'-DDT)	0 OF 2					0 OF 1					0 OF 4				
GAMMA-CHLORDANE /2	0 OF 2					0 OF 1					0 OF 4				
PCB-1254 (AROCLOR 1254)	0 OF 2					0 OF 1					0 OF 4				
MONOMETHYLMERCURY	1 OF 7	76.30	20.7	76.3	76.3	0 OF 2					0 OF 13				
DIMETHYLMERCURY	0 OF 7					0 OF 2					0 OF 13				

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT - ORGANICS
UNITS ug/kg

ORGANIC COMPOUNDS	REACH 7					REACH 8					REACH 9				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	0 OF 3					** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
ACETONE	2 OF 3	1260.00	871.0	1860.0	660.0										
1,2-DICHLOROETHENE (TOTAL)	0 OF 3														
METHYL ETHYL KETONE	2 OF 3	177.00	123.0	330.0	24.0										
TRICHLOROETHENE	0 OF 3														
BENZENE	0 OF 3														
TETRACHLOROETHENE	0 OF 3														
TOLUENE	0 OF 3														
CHLOROBENZENE	0 OF 3														
1,3-DICHLOROBENZENE	0 OF 3														
1,4-DICHLOROBENZENE	0 OF 3														
1,2-DICHLOROBENZENE	0 OF 3														
(3-AND/OR 4-)METHYLPHENOL	0 OF 3														
NITROBENZENE	0 OF 3														
BENZOIC ACID	3 OF 3	573.33	573.0	1300.0	130.0										
1,2,4-TRICHLOROBENZENE	0 OF 3														
NAPHTHALENE	0 OF 3														
2-METHYLNAPHTHALENE	1 OF 3	78.00	478.0	78.0	78.0										
ACENAPHTHYLENE	0 OF 3														
ACENAPHTHENE	1 OF 3	110.00	480.0	110.0	110.0										
DIBENZOFURAN	0 OF 3														
DIETHYL PHTHALATE	0 OF 3														
FLUORENE	1 OF 3	140.00	488.0	140.0	140.0										
N-NITROSODIPHENLYAMINE	0 OF 3														
PHENANTHRENE	3 OF 3	583.33	583.0	1200.0	220.0										
ANTHRACENE	1 OF 3	210.00	521.0	210.0	210.0										
DI-N-BUTYLPHTHALATE	0 OF 3														
FLUORANTHENE	3 OF 3	853.33	853.0	1800.0	350.0										
PYRENE	3 OF 3	876.67	876.0	1700.0	350.0										
BENZYL BUTYL PHTHALATE	1 OF 3	810.00	855.0	810.0	810.0										
BENZO(A)ANTHRACENE	3 OF 3	430.00	430.0	880.0	160.0										
CHRYSENE	3 OF 3	640.00	640.0	1200.0	280.0										
BIS(2-ETHYLHEXYL) PHTHALATE	2 OF 3	720.00	646.0	1100.0	340.0										
DI-N-OCTYLPHTHALATE	0 OF 3														
BENZO (B) FLUORANTHENE	3 OF 3	518.67	518.0	810.0	230.0										
BENZO (K) FLUORANTHENE	3 OF 3	446.67	446.0	850.0	190.0										
BENZO-A-PYRENE	2 OF 3	530.00	720.0	880.0	180.0										
INDENO (1,2,3-CD) PYRENE	1 OF 3	540.00	631.0	540.0	540.0										
DIBENZO(A,H)ANTHRACENE	0 OF 3														
BENZO(GHI)PERYLENE	1 OF 3	610.00	655.0	610.0	610.0										
4,4'-DDE (P,P'-DDE)	0 OF 3														
4,4'-DDD (P,P'-DDD)	0 OF 3														
4,4'-DDT (P,P'-DDT)	0 OF 3														
GAMMA-CHLORDANE /2	1 OF 3	18.00	1358.0	18.0	18.0										
PCB-1254 (AROCLOR 1254)	1 OF 3	510.00	3338.0	510.0	510.0										
MONOMETHYLMERCURY	0 OF 3					** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
DIMETHYLMERCURY	0 OF 3														

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
PAGE 10

SEDIMENT – ORGANICS

UNITS. ug/kg

ORGANIC COMPOUNDS	REACH 10					EASTERN WETLANDS – PHASE I					CHEMICAL BROOK CULVERT				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	** NO SAMPLES COLLECTED IN THIS REACH **					0 OF 2					0 OF 2				
ACETONE						1 OF 2	1600 00	900	1600 0	1600 0	0 OF 2				
1,2-DICHLOROETHENE (TOTAL)						2 OF 2	72 25	72 25	130 0	14 5	2 OF 2	25.00	25 0	43 0	7.0
METHYL ETHYL KETONE						1 OF 2	450 00	237.75	450 0	450 0	0 OF 2				
TRICHLOROETHENE						1 OF 2	170 00	91 375	170 0	170 0	1 OF 2	72 00	37 7	72.0	72.0
BENZENE						0 OF 2					1 OF 2	2 00	2 7	2 0	2.0
TETRACHLOROETHENE						0 OF 2					1 OF 2	2 00	2 7	2.0	2.0
TOLUENE						0 OF 2					0 OF 2				
CHLOROBENZENE						1 OF 2	1600 00	808.375	1600 0	1600 0	2 OF 2	52 00	52 0	77 0	27.0
1,3-DICHLOROBENZENE						0 OF 2					1 OF 2	100 00	535 0	100 0	100.0
1,4-DICHLOROBENZENE						1 OF 2	1600 00	1212 5	1600 0	1600 0	2 OF 2	465 00	465 0	590 0	340.0
1,2-DICHLOROBENZENE						1 OF 2	7200 00	4012 5	7200 0	7200 0	2 OF 2	1650 00	1650 0	1900 0	1400.0
(3-AND/OR 4-)METHYLPHENOL						1 OF 2	260 00	1827 5	260 0	260 0	0 OF 2				
NITROBENZENE						1 OF 2	650 00	737 5	650 0	650.0	1 OF 2	310 00	372 0	310.0	310.0
BENZOIC ACID						0 OF 2					0 OF 2				
1,2,4-TRICHLOROBENZENE						1 OF 2	3100 00	1982 5	3100 0	3100 0	2 OF 2	835 00	835 0	870 0	800.0
NAPHTHALENE						1 OF 2	2300 00	1582 5	2300 0	2300 0	2 OF 2	565 00	565 0	600 0	530.0
2-METHYLNAPHTHALENE						0 OF 2					1 OF 2	180 00	307 0	180 0	180.0
ACENAPHTHYLENE						0 OF 2					1 OF 2	140 00	287 0	140 0	140.0
ACENAPHTHENE						0 OF 2					0 OF 2				
DIBENZOFURAN						0 OF 2					1 OF 2	92 00	263 0	92 0	92.0
DIETHYL PHTHALATE						0 OF 2					0 OF 2				
FLUORENE						0 OF 2					1 OF 2	84.00	259 0	84 0	84.0
N-NITROSODIPHENLYAMINE						0 OF 2					2 OF 2	230 00	230 0	250 0	210.0
PHENANTHRENE						1 OF 2	620 00	722 5	620 0	620 0	2 OF 2	760 00	760 0	790 0	730 0
ANTHRACENE						0 OF 2					2 OF 2	215 00	215 0	250 0	180.0
DI-N-BUTYLPHTHALATE						0 OF 2					0 OF 2				
FLUORANTHENE						1 OF 2	1600 00	1212 5	1600 0	1600 0	2 OF 2	1300 00	1300 0	1400 0	1200.0
PYRENE						1 OF 2	1700 00	1262 5	1700 0	1700 0	2 OF 2	1200 00	1200 0	1200 0	1200.0
BENZYL BUTYL PHTHALATE						0 OF 2					0 OF 2				
BENZO(A)ANTHRACENE						0 OF 2					2 OF 2	710 00	710 0	810 0	810.0
CHRYSENE						1 OF 2	1200 00	1012 5	1200 0	1200 0	2 OF 2	745 00	745 0	780 0	730.0
BIS(2-ETHYLHEXYL) PHTHALATE						0 OF 2					2 OF 2	150 00	150 0	200 0	100.0
DI-N-OCTYLPHTHALATE						0 OF 2					0 OF 2				
BENZO (B) FLUORANTHENE						2 OF 2	1475 00	1475	2500 0	200 0	2 OF 2	820 00	820 0	840 0	800.0
BENZO (K) FLUORANTHENE						0 OF 2					2 OF 2	680 00	680 0	760 0	580.0
BENZO-A-PYRENE						1 OF 2	860 00	842 5	860 0	860 0	2 OF 2	720 00	720 0	770 0	670.0
INDENO (1,2,3-CD) PYRENE						0 OF 2					1 OF 2	330 00	382 0	330 0	330.0
DIBENZO(A,H)ANTHRACENE						0 OF 2					0 OF 2				
BENZO(GHI)PERYLENE						0 OF 2					1 OF 2	270 00	352 0	270 0	270.0
4,4'-DDE (P,P'-DDE)						0 OF 2					0 OF 2				
4,4'-DDD (P,P'-DDD)						1 OF 2	117 00	75 5	117 0	117 0	0 OF 2				
4,4'-DDT (P,P'-DDT)						0 OF 2					0 OF 2				
GAMMA-CHLORDANE /2						0 OF 2					0 OF 2				
PCB-1254 (AROCLOR 1254)						0 OF 2					0 OF 2				
MONOMETHYLMERCURY	** NO SAMPLES COLLECTED IN THIS REACH **					2 OF 11	179 00	67 59	229 0	129 0	** NO SAMPLES COLLECTED IN THIS REACH **				
DIMETHYLMERCURY						0 OF 11									

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT – ORGANICS
UNITS ug/kg

ORGANIC COMPOUNDS	OUTFALL CREEK					RACEWAY					COLD SPRING BROOK				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	2 OF 3	31 75	22 17	55 0	8 5	1 OF 4	62 00	542 38	62	62	** NO SAMPLES COLLECTED IN THIS REACH **				
ACETONE	1 OF 3	34 00	18 87	34 0	34 0	2 OF 4	485 00	767.50	760	210					
1,2-DICHLOROETHENE (TOTAL)	1 OF 3	1 00	2 75	1 0	1 0	3 OF 4	738 67	568 88	1300	110					
METHYL ETHYL KETONE	0 OF 2					1 OF 4	44 00	542.25	44	44					
TRICHLOROETHENE	3 OF 3	2 83	2 83	4 0	0 8	4 OF 4	17071 25	17071 25	44000	5					
BENZENE	0 OF 3					0 OF 4									
TETRACHLOROETHENE	1 OF 3	0 80	2 72	0 8	0 8	0 OF 4									
TOLUENE	1 OF 3	0 40	2 05	0 4	0 4	0 OF 4									
CHLOROBENZENE	0 OF 3					4 OF 4	5917 50	5917 50	19500	30					
1,3-DICHLOROBENZENE	0 OF 3					0 OF 4									
1,4-DICHLOROBENZENE	0 OF 3					0 OF 4									
1,2-DICHLOROBENZENE	2 OF 3	247 50	885 00	280 0	205 0	2 OF 4	5200 00	4300 00	7100	3300					
(3-AND/OR 4-)METHYLPHENOL	0 OF 3					0 OF 4									
NITROBENZENE	2 OF 3	350 00	733 33	500 0	200 0	0 OF 4									
BENZOIC ACID	0 OF 3					0 OF 0									
1,2,4-TRICHLOROBENZENE	3 OF 3	880 00	800 83	1300 0	650 0	0 OF 4									
NAPHTHALENE	3 OF 3	218 33	218 33	340 0	150 0	2 OF 4	5250 00	4081 25	6700	3800					
2-METHYLNAPHTHALENE	0 OF 3					0 OF 4									
ACENAPHTHYLENE	2 OF 3	292 50	283 33	310 0	275 0	0 OF 4									
ACENAPHTHENE	0 OF 3					0 OF 4									
DIBENZOFURAN	0 OF 3					0 OF 4									
DIETHYL PHTHALATE	1 OF 3	880 00	714 17	880 0	880 0	0 OF 4									
FLUORENE	0 OF 3					2 OF 4	2500 00	2906 25	2800	2200					
N-NITROSODIPHENLYAMINE	2 OF 3	260 00	673 33	280 0	230 0	0 OF 4									
PHENANTHRENE	3 OF 3	830 00	830 00	830 0	380 0	4 OF 4	12112 50	12112 50	16000	8300					
ANTHRACENE	2 OF 3	138 00	580 67	185 0	87 0	3 OF 4	2833 33	3231 25	3100	2700					
DI-N-BUTYLPHTHALATE	0 OF 3					0 OF 4									
FLUORANTHENE	3 OF 3	1308 67	1308 67	1800 0	820 0	4 OF 4	14262 50	14262 50	20000	10050					
PYRENE	3 OF 3	1800 00	1800 00	2500 0	1100 0	4 OF 4	8400 00	8400 00	13000	6800					
BENZYL BUTYL PHTHALATE	1 OF 3	130 00	815 00	130 0	130 0	0 OF 4									
BENZO(A)ANTHRACENE	3 OF 3	800 00	800 00	1050 0	840 0	3 OF 4	6933 33	5712 50	11000	4300					
CHRYSENE	3 OF 3	1078 67	1078 67	1400 0	880 0	3 OF 4	6350 00	5975 00	8600	3850					
BIS(2-ETHYLHEXYL) PHTHALATE	3 OF 3	880 00	880 00	2000 0	320 0	1 OF 4	2500 00	2793 75	2500	2500					
DI-N-OCTYLPHTHALATE	0 OF 3					0 OF 4									
BENZO (B) FLUORANTHENE	3 OF 3	1233 33	1233 33	1750 0	870 0	3 OF 4	4066 67	4262 50	5200	2500					
BENZO (K) FLUORANTHENE	1 OF 3	1000 00	473 33	1000 0	1000 0	3 OF 4	4116 67	4300 00	6300	2550					
BENZO-A-PYRENE	3 OF 3	800 00	800 00	1200 0	800 0	3 OF 4	3566 67	3687 50	4700	2600					
INDENO (1,2,3-CD) PYRENE	2 OF 3	577 50	453 33	635 0	520 0	0 OF 4									
DIBENZO(A,H)ANTHRACENE	0 OF 3					0 OF 4									
BENZO(GHI)PERYLENE	2 OF 3	635 00	401 67	730 0	540 0	0 OF 4									
4,4'-DDE (P,P'-DDE)	0 OF 3					2 OF 4	18 00	10 50	21 2	14 8					
4,4'-DDD (P,P'-DDD)	0 OF 3					2 OF 4	83 20	32 04	108	58 4					
4,4'-DDT (P,P'-DDT)	0 OF 3					0 OF 4									
GAMMA-CHLORDANE /2	0 OF 3					0 OF 4									
PCB-1254 (AROCLOR 1254)	0 OF 3					2 OF 4	350 49	198 06	589	111 88					
MONOMETHYLMERCURY	0 OF 1					** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
DIMETHYLMERCURY	0 OF 1														

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SEDIMENT - ORGANICS
UNITS ug/kg

ORGANIC COMPOUNDS	BORDERING WETLANDS					HEARD POND					Eastern Wetlands Drilling 0 - 2 foot interval				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
METHYLENE CHLORIDE	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **					2 OF 32	825 50	139 52	1600 00	51 00
ACETONE											6 OF 32	34 17	229 22	110 00	7 00
1,2-DICHLOROETHENE (TOTAL)											10 OF 32	572 03	282 13	5500 00	0 30
METHYL ETHYL KETONE											0 OF 32				
TRICHLOROETHENE											16 OF 32	313 38	218 38	3400 00	0 30
BENZENE											1 OF 32	4 00	110 86	4 00	4 00
TETRACHLOROETHENE											0 OF 32				
TOLUENE											3 OF 32	8 33	110 81	16 00	2 00
CHLOROBENZENE											15 OF 32	5553 73	2604 60	34000 00	3 00
1,3-DICHLOROBENZENE											10 OF 32	90 40	273 75	290 00	18 00
1,4-DICHLOROBENZENE											13 OF 32	908 69	579 81	3100 00	48 00
1,2-DICHLOROBENZENE											15 OF 32	3618 73	1677 69	13000 00	33 00
(3-AND/OR 4-)METHYLPHENOL											1 OF 32	74 00	347 18	74 00	74 00
NITROBENZENE											8 OF 32	101 25	1311 25	140 00	66 00
BENZOIC ACID											13 OF 32	292 27	324 83	1600 00	21 00
1,2,4-TRICHLOROBENZENE											9 OF 32	159 33	303 56	320 00	42 00
NAPHTHALENE											1 OF 32	62 00	352 25	62 00	62 00
2-METHYLNAPHTHALENE											1 OF 32	60 00	351 56	60 00	60 00
ACENAPHTHYLENE											3 OF 32	31 33	329 66	45 00	21 00
ACENAPHTHENE											1 OF 32	43 00	351 03	43 00	43 00
DIBENZOFURAN											0 OF 32				
DIETHYL PHTHALATE											1 OF 32	60 00	351 56	60 00	60 00
FLUORENE											5 OF 32	53 60	308 38	75 00	25.00
N-NITROSODIPHENLYAMINE											13 OF 32	42 77	223 94	170 00	10.00
PHENANTHRENE											7 OF 32	78 14	310 22	170 00	23 00
ANTHRACENE											3 OF 32	45 00	329 53	91 00	21.00
DI-N-BUTYLPHTHALATE											14 OF 32	70 57	235 33	270 00	15 00
FLUORANTHENE											19 OF 32	58 69	169 50	260 00	10 00
PYRENE											1 OF 32	25 00	360 31	25 00	25 00
BENZYL BUTYL PHTHALATE											2 OF 32	83 00	348 69	140 00	26 00
BENZO(A)ANTHRACENE											2 OF 32	125 50	348 63	190 00	61 00
CHRYSENE											3 OF 32	78 33	339 22	100 00	62 00
BIS(2-ETHYLHEXYL) PHTHALATE											2 OF 32	22 50	337 97	36 00	9.00
DI-N-OCTYLPHTHALATE											4 OF 32	80 50	320 84	160 00	41.00
BENZO (B) FLUORANTHENE											0 OF 32	0 00	0 00	0 00	0 00
BENZO (K) FLUORANTHENE											10 OF 32	280 00	334 22	860 00	41 00
BENZO-A-PYRENE											1 OF 32	120 00	353 44	120 00	120 00
INDENO (1,2,3-CD) PYRENE											0 OF 32	0 00	0 00	0 00	0 00
DIBENZO(A,H)ANTHRACENE											1 OF 32	120 00	353 44	120 00	120 00
BENZO(GHI)PERYLENE											0 OF 32				
4,4'-DDE (P,P'-DDE)											0 OF 32				
4,4'-DDD (P,P'-DDD)											0 OF 32				
4,4'-DDT (P,P'-DDT)											0 OF 32				
GAMMA-CHLORDANE /2											0 OF 32				
PCB-1254 (AROCLOR 1254)											0 OF 32				
MONOMETHYLMERCURY	5 OF 5					** NO SAMPLES COLLECTED IN THIS REACH **					0 OF 0				
DIMETHYLMERCURY	0 OF 2										0 OF 0				
ETHYLBENZENE											1 OF 32	0 70	110 78	0 70	0 70
XYLENES (TOTAL)											3 OF 32	2 67	110 27	5 00	1 00
PHENOL											2 OF 32	62 00	340 75	68 00	56 00
2-CHLOROPHENOL											1 OF 32	20 00	345 18	20 00	20 00
VINYLCHLORIDE											2 OF 32	68 00	222 03	130 00	6 00

FINAL

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SURFACE WATER – TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 1 SUDBURY RESERVOIR RESERVOIR NO 3 - BACKGROUND -					REACH 2					REACH 3				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	2 OF 7	220 00	64 00	231 00	209 00	3 OF 7	1178 50	525 30	3220 00	100 00	5 OF 5	128 70	128 70	168 00	92 50
ANTIMONY	0 OF 7					0 OF 7					0 OF 5				
ARSENIC	0 OF 7					1 OF 7	3 00	4 71	3 00	3 00	0 OF 5				
BARIUM	6 OF 7	16 15	15 70	23 10	8 80	7 OF 7	33 81	33 81	132 00	12 60	2 OF 5	12 55	5 62	12 60	12 50
BERYLLIUM	0 OF 7					1 OF 7	7 50	2 61	7 50	7 50	0 OF 5				
CADMIUM	0 OF 7					1 OF 7	7 20	2 64	7 20	7 20	0 OF 5				
CALCIUM	7 OF 7	10817 14	10817 14	12400 00	8200 00	7 OF 7	9317 86	9317 86	13000 00	6140 00	5 OF 5	7052 00	7052 00	7260 00	6790 00
CHROMIUM	0 OF 7					1 OF 7	7 00	5 31	7 00	7 00	0 OF 5				
COBALT	0 OF 7					1 OF 7	27 70	25 39	27 70	27 70	0 OF 5				
COPPER	1 OF 7	3 10	3 90	3 10	3 10	1 OF 7	27 70	13 52	27 70	27 70	0 OF 5				
IRON	5 OF 7	887 20	705 50	1040 00	750 00	5 OF 7	3943 60	2943 82	16100 00	458 00	5 OF 5	551 60	551 00	673 00	425 00
LEAD	1 OF 7	21 10	3 90	21 10	21 10	2 OF 7	33 90	11 36	66 50	1 30	2 OF 5	1 00	1 00	1 00	1 00
MAGNESIUM	7 OF 7	2490 00	2490 00	2900 00	1810 00	7 OF 7	2233 57	2233 57	3030 00	1570 00	5 OF 5	1730 00	1730 00	1780 00	1650 00
MANGANESE	6 OF 7	91 83	80 70	111 00	75 80	7 OF 7	1533 70	1533 70	9840 00	66 20	5 OF 5	63 38	63 38	83 60	54 60
MERCURY	0 OF 6					0 OF 7					0 OF 5				
NICKEL	1 OF 7	17 70	5 10	17 70	17 70	1 OF 7	77 40	22 01	77 40	77 40	0 OF 5				
POTASSIUM	7 OF 7	2401 43	2401 43	3100 00	1810 00	7 OF 7	1971 43	1971 43	2560 00	1540 00	5 OF 5	1952 00	1952 00	2260 00	1730 00
SELENIUM	0 OF 7					0 OF 7					1 OF 5	19300 00	3861 53	19300 00	19300 00
SILVER	1 OF 7	10 80	4 74	10 80	10 80	1 OF 7	68 90	9 56	68 90	68 90	3 OF 5	9 90	6 94	11 90	8 40
SODIUM	7 OF 7	28871 43	28871 43	38200 00	18000 00	7 OF 7	28757 14	28757 14	33800 00	19600 00	4 OF 5	19950 00	19820 00	20600 00	19700 00
THALLIUM	0 OF 7					0 OF 7					0 OF 5				
VANADIUM	0 OF 7					2 OF 7	14 35	22 59	16 10	12 60	0 OF 5				
ZINC	1 OF 7	6 20	6 02	6 20	6 20	1 OF 7	125 00	24 81	125 00	125 00	1 OF 5	8 00	8.74	8 00	8 00

SURFACE WATER – FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 1 SUDBURY RESERVOIR - BACKGROUND -					REACH 2					REACH 3				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	0 OF 5					2 OF 7	54 13	20 28	67 30	40 95	1 OF 1	80 60	80 60	80 60	80 60
ANTIMONY	0 OF 5					0 OF 7					0 OF 1				
ARSENIC	0 OF 5					1 OF 7	1 20	4 73	1 20	1 20	0 OF 1				
BARIUM	5 OF 5	17 52	17 52	19 70	14 80	7 OF 7	21 17	21 17	33 60	12 20	1 OF 1	12 60	12 60	12 60	12 60
BERYLLIUM	0 OF 5					0 OF 7					0 OF 1				
CADMIUM	0 OF 5					0 OF 7					0 OF 1				
CALCIUM	5 OF 5	11070 00	11070 00	12400 00	9880 00	7 OF 7	9081 43	9081 43	10700 00	8240 00	1 OF 1	7120 00	7120 00	7120 00	7120 00
CHROMIUM	0 OF 5					0 OF 7					0 OF 1				
COBALT	0 OF 5					0 OF 7					0 OF 1				
COPPER	0 OF 5					0 OF 7					0 OF 1				
IRON	4 OF 5	450 50	410 00	502 00	352 00	4 OF 7	500 38	387 71	623 00	281 00	1 OF 1	310 00	310 00	310 00	310 00
LEAD	0 OF 5					0 OF 7					0 OF 1				
MAGNESIUM	5 OF 5	2770 00	2770 00	2980 00	2290 00	7 OF 7	2135 71	2135 71	2480 00	1530 00	1 OF 1	1700 00	1700 00	1700 00	1700 00
MANGANESE	4 OF 5	56 05	55 00	87 00	24 80	6 OF 7	109 60	98 99	157 00	54 60	1 OF 1	48 60	48 60	48 60	48 60
MERCURY	0 OF 5					0 OF 7					0 OF 1				
NICKEL	1 OF 5	7 00	3 90	7 00	7 00	0 OF 7					0 OF 1				
POTASSIUM	5 OF 5	2646 00	2646 00	3010 00	2470 00	7 OF 7	1820 71	1820 71	2340 00	1530 00	1 OF 1	1720 00	1720 00	1720 00	1720 00
SELENIUM	0 OF 5					0 OF 7					0 OF 1				
SILVER	0 OF 5					0 OF 7					0 OF 1				
SODIUM	5 OF 5	34140 00	34140 00	38000 00	29800 00	7 OF 7	29092 86	29092 86	34300 00	19100 00	1 OF 1	19700 00	19700 00	19700 00	19700 00
THALLIUM	0 OF 7					0 OF 7					0 OF 1				
VANADIUM	0 OF 5					0 OF 7					0 OF 1				
ZINC	3 OF 5	15 43	12 11	21 60	10 00	0 OF 7					1 OF 1	18 50	18 50	18 50	18 50

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SURFACE WATER - TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 4					REACH 5					REACH 6				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	2 OF 2	714 00	714 00	1340 00	88 00	0 OF 2					3 OF 4	216 53	171 06	461 00	82 00
ANTIMONY	0 OF 2					0 OF 2					0 OF 4				
ARSENIC	0 OF 2					1 OF 2	1 10	1 05	1 10	1 10	0 OF 4				
BARIUM	1 OF 2	24 70	12 85	24 70	24 70	1 OF 2	12 75	16 30	12 75	12 75	1 OF 4	16 20	4 80	16 20	16 20
BERYLLIUM	0 OF 2					0 OF 2					0 OF 4				
CADMIUM	0 OF 2					0 OF 2					0 OF 4				
CALCIUM	2 OF 2	7300 00	7300 00	7800 00	6800 00	2 OF 2	9722 50	9722 50	11600 00	7845 00	4 OF 4	9028 75	9028 75	9660 00	8785 00
CHROMIUM	1 OF 2	8 00	4 50	8 00	8 00	0 OF 2					0 OF 4				
COBALT	0 OF 2					0 OF 2					0 OF 4				
COPPER	0 OF 2					0 OF 2					0 OF 4				
IRON	2 OF 2	1515 00	1515 00	2580 00	450 00	0 OF 2					3 OF 4	469.33	463 75	507 00	446 00
LEAD	2 OF 2	6 85	6 85	12 60	1 10	0 OF 2					1 OF 4	2 40	1 35	2 40	2 40
MAGNESIUM	2 OF 2	1800 00	1800 00	1900 00	1700 00	2 OF 2	2212 50	2212 50	2640 00	1785 00	4 OF 4	2052 50	2052 50	2110 00	2000 00
MANGANESE	2 OF 2	120 35	120 35	200 00	40 70	1 OF 2	106 00	69 45	106 00	106 00	4 OF 4	96 35	96 35	167 00	70 10
MERCURY	0 OF 1					0 OF 1					0 OF 3				
NICKEL	0 OF 2					0 OF 2					0 OF 4				
POTASSIUM	2 OF 2	1285 00	1285 00	1500 00	1070 00	2 OF 2	1870 00	1870 00	2190 00	1550 00	4 OF 4	2156 25	2156 25	2425 00	1640 00
SELENIUM	0 OF 2					0 OF 2					0 OF 4				
SILVER	0 OF 2					0 OF 2					0 OF 4				
SODIUM	2 OF 2	19800 00	19800 00	21000 00	18600 00	2 OF 2	26275 00	26275 00	31100 00	21450 00	4 OF 4	22500 00	22500 00	25300 00	21000 00
THALLIUM	0 OF 2					0 OF 2					0 OF 4				
VANADIUM	0 OF 2					0 OF 2					0 OF 4				
ZINC	0 OF 2					0 OF 2					0 OF 4				

SURFACE WATER - FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 4					REACH 5					REACH 6				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	1 OF 1	107 00	107 00	107 00	107 00	0 OF 1					3 OF 3	110 57	110 57	174 00	78 30
ANTIMONY	0 OF 1					0 OF 1					0 OF 3				
ARSENIC	1 OF 1	80 00	80 00	80 00	80 00	0 OF 1					0 OF 3				
BARIUM	0 OF 1					0 OF 1					0 OF 3				
BERYLLIUM	0 OF 1					0 OF 1					0 OF 3				
CADMIUM	0 OF 1					0 OF 1					0 OF 3				
CALCIUM	1 OF 1	7700 00	7700 00	7700 00	7700 00	1 OF 1	11900 00	11900 00	11900 00	11900 00	3 OF 3	9003 33	9003 33	9380 00	8770 00
CHROMIUM	0 OF 1					0 OF 1					0 OF 3				
COBALT	0 OF 1					0 OF 1					0 OF 3				
COPPER	0 OF 1					0 OF 1					0 OF 3				
IRON	1 OF 1	350 00	350 00	350 00	350 00	0 OF 1					3 OF 3	429 00	429 00	525 00	330 00
LEAD	1 OF 1	1 80	1 80	1 80	1 80	0 OF 1					0 OF 3				
MAGNESIUM	1 OF 1	1740 00	1740 00	1740 00	1740 00	1 OF 1	2680 00	2680 00	2680 00	2680 00	3 OF 3	2056 67	2056 67	2120 00	2020 00
MANGANESE	1 OF 1	41 30	41 30	41 30	41 30	0 OF 1					3 OF 3	68 17	68 17	75 80	58 60
MERCURY	0 OF 1					0 OF 1					0 OF 3				
NICKEL	0 OF 1					0 OF 1					0 OF 3				
POTASSIUM	1 OF 1	1310 00	1310 00	1310 00	1310 00	1 OF 1	2190 00	2190 00	2190 00	2190 00	3 OF 3	2313 33	2313 33	2550 00	2120 00
SELENIUM	0 OF 1					0 OF 1					0 OF 3				
SILVER	0 OF 1					0 OF 1					0 OF 3				
SODIUM	1 OF 1	20000 00	20000 00	20000 00	20000 00	1 OF 1	31300 00	31300 00	31300 00	31300 00	3 OF 3	15500 00	15500 00	23000 00	2100 00
THALLIUM	0 OF 1					0 OF 1					0 OF 3				
VANADIUM	0 OF 1					0 OF 1					0 OF 3				
ZINC	1 OF 1	22 80	22 80	22 80	22 80	0 OF 1					0 OF 3				

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
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SURFACE WATER - TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 7					REACH 8					REACH 9				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	1 OF 4	103.00	37.50	103.00	103.00	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY	0 OF 4														
ARSENIC	0 OF 4														
BARIUM	1 OF 4	21.30	7.30	21.30	21.30										
BERYLLIUM	0 OF 4														
CADMIUM	0 OF 4														
CALCIUM	4 OF 4	11305.00	11305.00	13100.00	9880.00										
CHROMIUM	0 OF 4														
COBALT	0 OF 4														
COPPER	0 OF 4														
IRON	3 OF 4	526.67	456.75	870.00	311.00										
LEAD	0 OF 4														
MAGNESIUM	4 OF 4	2560.00	2560.00	2950.00	2150.00										
MANGANESE	3 OF 4	85.00	74.50	119.00	48.00										
MERCURY	0 OF 4														
NICKEL	0 OF 4														
POTASSIUM	4 OF 4	2187.50	2187.50	2380.00	1870.00										
SELENIUM	0 OF 4														
SILVER	1 OF 4	6.50	3.50	6.50	6.50										
SODIUM	4 OF 4	24050.00	24050.00	27800.00	20800.00										
THALLIUM	0 OF 4														
VANADIUM	0 OF 4														
ZINC	0 OF 4														

SURFACE WATER - FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 7					REACH 8					REACH 9				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	2 OF 4	131.50	72.24	155.00	108.00	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY	0 OF 4														
ARSENIC	0 OF 4														
BARIUM	1 OF 4	20.00	7.10	20.00	20.00										
BERYLLIUM	0 OF 4														
CADMIUM	0 OF 4														
CALCIUM	4 OF 4	11412.50	11412.50	13400.00	9850.00										
CHROMIUM	0 OF 4														
COBALT	0 OF 4														
COPPER	0 OF 4														
IRON	1 OF 4	376.00	164.50	376.00	376.00										
LEAD	0 OF 4														
MAGNESIUM	4 OF 4	2517.50	2517.50	2900.00	2130.00										
MANGANESE	3 OF 4	61.40	54.25	80.00	47.20										
MERCURY	0 OF 4														
NICKEL	0 OF 4														
POTASSIUM	4 OF 4	2202.50	2202.50	2540.00	1920.00										
SELENIUM	0 OF 4														
SILVER	1 OF 4	6.00	3.00	6.00	6.00										
SODIUM	4 OF 4	24025.00	24025.00	27800.00	20300.00										
THALLIUM	0 OF 4														
VANADIUM	0 OF 4														
ZINC	0 OF 4														

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
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SURFACE WATER – TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 10					EASTERN WETLANDS					CHEMICAL BROOK CULVERT				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	** NO SAMPLES COLLECTED IN THIS REACH **					1 OF 2	756 00	421 20	756 00	756 00	** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY						0 OF 2									
ARSENIC						0 OF 2									
BARIUM						2 OF 2	8 53	8 50	9 40	7 65					
BERYLLIUM						0 OF 2									
CADMIUM						0 OF 2									
CALCIUM						2 OF 2	14250 00	14250 00	14500 00	14000 00					
CHROMIUM						1 OF 2	79 00	79 00	79 00	79 00					
COBALT						0 OF 2									
COPPER						1 OF 2	14 60	14 60	14 60	14 60					
IRON						1 OF 2	1420 00	1078 20	1420 00	1420 00					
LEAD						2 OF 2	4 03	4 00	5 30	2 75					
MAGNESIUM						2 OF 2	1187 50	1187 50	1245 00	1130 00					
MANGANESE						2 OF 2	100 73	100 70	108 00	93 45					
MERCURY						2 OF 2	2 09	2 10	3 80	0 37					
NICKEL						0 OF 2									
POTASSIUM						2 OF 2	974 50	974 50	1085 00	864 00					
SELENIUM						0 OF 2									
SILVER						0 OF 2									
SODIUM						2 OF 2	11090 00	11090 00	18100 00	6080 00					
THALLIUM						0 OF 2									
VANADIUM						0 OF 2									
ZINC						0 OF 2									

SURFACE WATER – FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	REACH 10					EASTERN WETLANDS					CHEMICAL BROOK CULVERT				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	** NO SAMPLES COLLECTED IN THIS REACH **					0 OF 2					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY						0 OF 2									
ARSENIC						0 OF 2									
BARIUM						2 OF 2	6 80	6 80	8 10	5 50					
BERYLLIUM						0 OF 2									
CADMIUM						0 OF 2									
CALCIUM						2 OF 2	12950 00	12950 00	14900 00	11000 00					
CHROMIUM						0 OF 2									
COBALT						0 OF 2									
COPPER						0 OF 2									
IRON						0 OF 2									
LEAD						1 OF 2	8 70	8 80	8 70	8 70					
MAGNESIUM						2 OF 2	1142 50	1140 80	1290 00	995 00					
MANGANESE						1 OF 2	92 80	51 33	92 80	92 80					
MERCURY						2 OF 2	0 43	0 43	0 49	0 37					
NICKEL						0 OF 2									
POTASSIUM						2 OF 2	984 50	984 50	1140 00	829 00					
SELENIUM						0 OF 2									
SILVER						0 OF 2									
SODIUM						2 OF 2	10290 00	10290 00	15900 00	4680 00					
THALLIUM						0 OF 2									
VANADIUM						0 OF 2									
ZINC						0 OF 2									

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SURFACE WATER - TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	OUTFALL CREEK					RACEWAY					COLD SPRING BROOK				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	1 OF 1	201 00	203 00	203 00	203 00	0 OF 1					1 OF 1	165 00	165 00	165 00	165 00
ANTIMONY	0 OF 1					0 OF 1					0 OF 1				
ARSENIC	0 OF 1					0 OF 1					0 OF 1				
BARIUM	1 OF 1	10 90	10 90	10 50	10 90	1 OF 1	16 4	16 4	16 4	16 4	0 OF 1				
BERYLLIUM	0 OF 1					0 OF 1					0 OF 1				
CADMIUM	0 OF 1					0 OF 1					0 OF 1				
CALCIUM	1 OF 1	17700 00	17700 00	17700 00	17700 00	1 OF 1	10025	10025	10025	10025	1 OF 1	9570 00	9570 00	9570 00	9570 00
CHROMIUM	1 OF 1	5 60	5 60	5 60	5 60	0 OF 1					0 OF 1				
COBALT	1 OF 1	2 30	2 30	2 30	2 30	0 OF 1					0 OF 1				
COPPER	0 OF 1					0 OF 1					0 OF 1				
IRON	1 OF 1	1870 00	1870 00	1870 00	1870 00	1 OF 1	1070	1070	1070	1070	1 OF 1	688 00	688 00	688 00	688 00
LEAD	1 OF 1	5 70	5 70	5 70	5 70	0 OF 1					0 OF 1				
MAGNESIUM	1 OF 1	1830 00	1830 00	1830 00	1830 00	1 OF 1	2350	2350	2350	2350	1 OF 1	2490 00	2490 00	2490 00	2490 00
MANGANESE	1 OF 1	140 00	140 00	140 00	140 00	1 OF 1	263 5	263 5	263 5	263 5	1 OF 1	108 00	108 00	108 00	108 00
MERCURY	1 OF 1	0 40	0 40	0 40	0 40	0 OF 1					0 OF 1				
NICKEL	0 OF 1					0 OF 1					0 OF 1				
POTASSIUM	1 OF 1	1790 00	1790 00	1790 00	1790 00	1 OF 1	1675	1675	1675	1675	1 OF 1	2530 00	2530 00	2530 00	2530 00
SELENIUM	0 OF 1					0 OF 1					0 OF 1				
SILVER	0 OF 1					0 OF 1					1 OF 1	13 90	13 90	13 90	13 90
SODIUM	1 OF 1	21400 00	21400 00	21400 00	21400 00	1 OF 1	33000	33000	33000	33000	1 OF 1	16800 00	16800 00	16800 00	16800 00
THALLIUM	0 OF 1					0 OF 1					0 OF 1				
VANADIUM	0 OF 1					0 OF 1					0 OF 1				
ZINC	1 OF 1	47 90	47 90	47 90	47 90	0 OF 1					0 OF 1				

SURFACE WATER - FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	OUTFALL CREEK					RACEWAY					COLD SPRING BROOK				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	1 OF 1	87 00	87 00	87 00	87 00	0 OF 1					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY	0 OF 1					0 OF 1									
ARSENIC	0 OF 1					0 OF 1									
BARIUM	1 OF 1	9 40	9 40	9 40	9 40	1 OF 1	31 4	31 4	31 4	31 4					
BERYLLIUM	0 OF 1					0 OF 1									
CADMIUM	0 OF 1					0 OF 1									
CALCIUM	1 OF 1	17900 00	17400 00	17900 00	17900 00	1 OF 1	9580	9580	9580	9580					
CHROMIUM	0 OF 1					0 OF 1									
COBALT	0 OF 1					0 OF 1									
COPPER	0 OF 1					0 OF 1									
IRON	1 OF 1	880 00	880 00	880 00	880 00	1 OF 1	608	608	608	608					
LEAD	1 OF 1	2 40	2 40	2 40	2 40	0 OF 1									
MAGNESIUM	1 OF 1	1280 00	1280 00	1280 00	1280 00	1 OF 1	2230	2230	2230	2230					
MANGANESE	1 OF 1	123 00	123 00	123 00	123 00	1 OF 1	208 5	208 5	208 5	208 5					
MERCURY	1 OF 1	0 42	0 42	0 42	0 42	0 OF 1									
NICKEL	0 OF 1					0 OF 1									
POTASSIUM	1 OF 1	1780 00	1780 00	1780 00	1780 00	1 OF 1	1625	1625	1625	1625					
SELENIUM	0 OF 1					0 OF 1									
SILVER	0 OF 1					0 OF 1									
SODIUM	1 OF 1	22000 00	22000 00	22000 00	22000 00	1 OF 1	32500	32500	32500	32500					
THALLIUM	0 OF 1					0 OF 1									
VANADIUM	0 OF 1					0 OF 1									
ZINC	1 OF 1	48 10	48 10	48 10	48 10	0 OF 1									

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY

SURFACE WATER - TOTAL INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	BORDERING WETLANDS					HEARD POND				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY										
ARSENIC										
BARIUM										
BERYLLIUM										
CADMIUM										
CALCIUM										
CHROMIUM										
COBALT										
COPPER										
IRON										
LEAD										
MAGNESIUM										
MANGANESE										
MERCURY										
NICKEL										
POTASSIUM										
SELENIUM										
SILVER										
SODIUM										
THALLIUM										
VANADIUM										
ZINC										

SURFACE WATER - FILTERED INORGANICS
UNITS ug/l

INORGANIC COMPOUNDS	BORDERING WETLANDS					HEARD POND				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
ANTIMONY										
ARSENIC										
BARIUM										
BERYLLIUM										
CADMIUM										
CALCIUM										
CHROMIUM										
COBALT										
COPPER										
IRON										
LEAD										
MAGNESIUM										
MANGANESE										
MERCURY										
NICKEL										
POTASSIUM										
SELENIUM										
SILVER										
SODIUM										
THALLIUM										
VANADIUM										
ZINC										

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
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SURFACE WATER - ORGANICS
UNITS ug/l

ORGANIC COMPOUNDS	REACH 10 FREQUENCY	REACH 10 AVERAGE DETECTED	REACH 10 AVERAGE REPORTED	REACH 10 MAXIMUM	REACH 10 MINIMUM	EASTERN WETLANDS FREQUENCY	EASTERN WETLANDS AVERAGE DETECTED	EASTERN WETLANDS AVERAGE REPORTED	EASTERN WETLANDS MAXIMUM	EASTERN WETLANDS MINIMUM	CHEMICAL BROOK CULVERT FREQUENCY	CHEMICAL BROOK CULVERT AVERAGE DETECTED	CHEMICAL BROOK CULVERT AVERAGE REPORTED	CHEMICAL BROOK CULVERT MAXIMUM	CHEMICAL BROOK CULVERT MINIMUM
CHLOROMETHANE	** NO SAMPLES COLLECTED IN THIS REACH **					0 OF 2					** NO SAMPLES COLLECTED IN THIS REACH **				
1,1-DICHLOROETHENE						0 OF 2									
1,2-DICHLOROETHENE (TOTAL)						1 OF 2	6 0	5 3	6 0	6 0					
METHYL ETHYL KETONE						0 OF 2									
TRICHLOROETHENE						1 OF 2	6 5	4 5	6 5	6 5					
1,4-DICHLOROBENZENE						0 OF 2									
1,2-DICHLOROBENZENE						1 OF 2	3 0	4 0	3 0	3 0					
BIS(2-ETHYLHEXYL) PHTHALATE						0 OF 2									
GAMMA-BHC (LINDANE)						0 OF 2									

SURFACE WATER - ORGANICS
UNITS ug/l

ORGANIC COMPOUNDS	OUTFALL CREEK FREQUENCY	OUTFALL CREEK AVERAGE DETECTED	OUTFALL CREEK AVERAGE REPORTED	OUTFALL CREEK MAXIMUM	OUTFALL CREEK MINIMUM	RACEWAY FREQUENCY	RACEWAY AVERAGE DETECTED	RACEWAY AVERAGE REPORTED	RACEWAY MAXIMUM	RACEWAY MINIMUM	COLD SPRING BROOK FREQUENCY	COLD SPRING BROOK AVERAGE DETECTED	COLD SPRING BROOK AVERAGE REPORTED	COLD SPRING BROOK MAXIMUM	COLD SPRING BROOK MINIMUM
CHLOROMETHANE	0 OF 1					0 OF 1					0 OF 1				
1,1-DICHLOROETHENE	0 OF 1					0 OF 1					0 OF 1				
1,2-DICHLOROETHENE (TOTAL)	1 OF 1	12 0	12 0	12 0	12 0	1 OF 1	2	2	2	2	0 OF 1				
METHYL ETHYL KETONE	0 OF 0					0 OF 1					0 OF 1				
TRICHLOROETHENE	1 OF 1	13 0	13 0	13 0	13 0	1 OF 1	2	2	2	2	0 OF 1				
1,4-DICHLOROBENZENE	1 OF 1	1 0	1 0	1 0	1 0	0 OF 1					0 OF 1				
1,2-DICHLOROBENZENE	1 OF 1	4 0	4 0	4 0	4 0	0 OF 1					0 OF 1				
BIS(2-ETHYLHEXYL) PHTHALATE	1 OF 1	1 0	1 0	1 0	1 0	0 OF 1					1 OF 1	58 0	58 0	58 0	58 0
GAMMA-BHC (LINDANE)	0 OF 1					0 OF 1					0 OF 1				

SURFACE WATER - ORGANICS
UNITS ug/l

ORGANIC COMPOUNDS	BORDERING WETLANDS FREQUENCY	BORDERING WETLANDS AVERAGE DETECTED	BORDERING WETLANDS AVERAGE REPORTED	BORDERING WETLANDS MAXIMUM	BORDERING WETLANDS MINIMUM	HEARD POND FREQUENCY	HEARD POND AVERAGE DETECTED	HEARD POND AVERAGE REPORTED	HEARD POND MAXIMUM	HEARD POND MINIMUM
CHLOROMETHANE	** NO SAMPLES COLLECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
1,1-DICHLOROETHENE										
1,2-DICHLOROETHENE (TOTAL)										
METHYL ETHYL KETONE										
TRICHLOROETHENE										
1,4-DICHLOROBENZENE										
1,2-DICHLOROBENZENE										
BIS(2-ETHYLHEXYL) PHTHALATE										
GAMMA-BHC (LINDANE)										

TABLE 4-1
SUMMARY OF SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
PAGE 20

SURFACE WATER - ORGANICS
UNITS ug/l

ORGANIC COMPOUNDS	REACH 1 SUDBURY RESERVOIR - BACKGROUND -					REACH 2					REACH 3				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
CHLOROMETHANE	1 OF 7	11 0	5 0	11 0	11 0	0 OF 7					0 OF 5				
1,1-DICHLOROETHENE	2 OF 7	3 0	2 0	3 0	3 0	0 OF 7					0 OF 5				
1,2-DICHLOROETHENE (TOTAL)	0 OF 7					1 OF 7	1 0	2 3	1 0	1 0	0 OF 5				
METHYL ETHYL KETONE	0 OF 7					0 OF 6					0 OF 3				
TRICHLOROETHENE	0 OF 7					0 OF 7					0 OF 5				
1,4-DICHLOROBENZENE	0 OF 7					0 OF 7					0 OF 5				
1,2-DICHLOROBENZENE	0 OF 7					0 OF 7					0 OF 5				
BIS(2-ETHYLHEXYL) PHTHALATE	0 OF 7					0 OF 7					1 OF 5	1 0	4 2	1 0	1 0
GAMMA-BHC (LINDANE)	0 OF 7					0 OF 7					0 OF 5				

ORGANIC COMPOUNDS	REACH 4					REACH 5					REACH 6				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
CHLOROMETHANE	0 OF 2					0 OF 2					0 OF 4				
1,1-DICHLOROETHENE	0 OF 2					0 OF 2					0 OF 4				
1,2-DICHLOROETHENE (TOTAL)	0 OF 2					0 OF 2					0 OF 4				
METHYL ETHYL KETONE	1 OF 2	10 0	7 5	10 0	10 0	0 OF 2					0 OF 4				
TRICHLOROETHENE	0 OF 2					0 OF 2					0 OF 4				
1,4-DICHLOROBENZENE	0 OF 2					0 OF 2					0 OF 4				
1,2-DICHLOROBENZENE	0 OF 2					0 OF 2					0 OF 4				
BIS(2-ETHYLHEXYL) PHTHALATE	0 OF 2					0 OF 2					0 OF 4				
GAMMA-BHC (LINDANE)	0 OF 2					0 OF 2					1 OF 4	0 015	0 023	0 015	0 015

SURFACE WATER - ORGANICS
UNITS ug/l

ORGANIC COMPOUNDS	REACH 7					REACH 8					REACH 9				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
CHLOROMETHANE	0 OF 4					** NO SAMPLES COLEECTED IN THIS REACH **					** NO SAMPLES COLLECTED IN THIS REACH **				
1,1-DICHLOROETHENE	0 OF 4														
1,2-DICHLOROETHENE (TOTAL)	0 OF 4														
METHYL ETHYL KETONE	0 OF 4														
TRICHLOROETHENE	0 OF 4														
1,4-DICHLOROBENZENE	0 OF 4														
1,2-DICHLOROBENZENE	0 OF 4														
BIS(2-ETHYLHEXYL) PHTHALATE	0 OF 4														
GAMMA-BHC (LINDANE)	0 OF 4														

TABLE 4-2
COMPARISON OF PARAMETERS IN SURFACE WATER TO STANDARDS
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY

PARAMETER	STANDARDS UG/L				DETECTED AVERAGE CONCENTRATIONS UG/L								
					BACKGROUND	WATERSHED AREA				TRIBUTARIES		OTHER AREAS	
	MCL (1)	MCLG (1)	AWQC: ACUTE (2)	AWQC: CHRONIC (2)	REACH 1 SUDBURY RES RES. 3	EASTERN WETLANDS	CULVERT (4)	OUTFALL CREEK	RACEWAY	COLD SPRING BROOK	HEARD POND	BORDERING WETLANDS	EASTERN WETLAND BORINGS
INORGANICS:													
ALUMINUM					220.00	756 00	NS	203.00	0.00	165.00	NS	NS	NS
ANTIMONY	5	3	88 0	30 0	0.00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
ARSENIC (III)	50		360 0	190 0	0 00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
BARIUM	2000	2000			18.15	8 53	NS	10.50	16.40	0.00	NS	NS	NS
BERYLLIUM	1	0	130 0	5 3	0 00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
CADMIUM	5	5	3 9	1.1	0 00	0.00	NS	0.00	0.00	0.00	NS	NS	NS
CALCIUM					10217.14	14250.00	NS	17700.00	10025.00	9570.00	NS	NS	NS
CHROMIUM (III)	100	100	1700 0	210.0	0.00	79.00	NS	5.60	0.00	0.00	NS	NS	NS
COBALT					0 00	0.00	NS	2.30	0.00	0.00	NS	NS	NS
COPPER	1300	1300	18 0	12.0	3.10	14.60	NS	0.00	0.00	0.00	NS	NS	NS
IRON				1000 0	967.20	1420 00	NS	1670.00	1070.00	688.00	NS	NS	NS
LEAD (5)	5	0	83 0	3.2	$\boxed{21.10}$	4.03	NS	$\boxed{5.70}$	0.00	0.00	NS	NS	NS
MAGNESIUM					2450 00	1187.50	NS	1830.00	2350.00	2490.00	NS	NS	NS
MANGANESE					91 93	100.73	NS	140.00	263.50	108.00	NS	NS	NS
MERCURY	2	2	2 4	0 012	0 00	$\boxed{2\ 09}$	NS	0.48	0.00	0.00	NS	NS	NS
NICKEL	100	100	1400 0	160 0	17 70	0 00	NS	0.00	0.00	0.00	NS	NS	NS
POTASSIUM					2481 43	974 50	NS	1790.00	1675.00	2530.00	NS	NS	NS
SELENIUM	50	50	20 0	5 0	0.00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
SILVER			4 1	0 1	16 90	0 00	NS	0.00	0.00	13.90	NS	NS	NS
SODIUM					28871.43	11090.00	NS	21400.00	33000.00	16600.00	NS	NS	NS
THALLIUM	2	0 5	1400 0	40 0	0 00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
VANADIUM					0 00	0.00	NS	0.00	0.00	0.00	NS	NS	NS
ZINC			120 0	110 0	6.20	0 00	NS	47.90	0.00	0.00	NS	NS	NS
ORGANIC COMPOUNDS													
CHLOROMETHANE					11 00	0.00	NS	0.00	0.00	0.00	NS	NS	NS
1,1-DICHLOROETHENE	7	7	11600		3.00	0 00	NS	0.00	0.00	0.00	NS	NS	NS
1,2-DICHLOROETHENE (CIS)	70	70	11600		0 00	8 00	NS	12.00	2.00	0.00	NS	NS	NS
METHYL ETHYL KETONE					0.00	0.00	NS	0.00	0.00	0.00	NS	NS	NS
TRICHLOROETHENE	5	0	45000	21900	0 00	$\boxed{6.50}$	NS	$\boxed{13.00}$	2.00	0.00	NS	NS	NS
1,4-DICHLOROBENZENE	600	600	1120	763	0 00	0 00	NS	1.00	0.00	0.00	NS	NS	NS
1,2-DICHLOROBENZENE	75	75	1120	763	0 00	3 00	NS	4.00	0.00	0.00	NS	NS	NS
BIS(2-ETHYLHEXYL)PHTHALATE					0 00	0 00	NS	1.00	0.00	58.00	NS	NS	NS
GAMMA-BHC (LINDANE)	0 2	0 2	2	0 8	0.00	0 00	NS	0.00	0.00	0.00	NS	NS	NS

(1) MCLS AND MCLGS FROM USEPA, APRIL, 1992
(2) AWQC FROM USEPA, MAY 1, 1991, TOXICITY TO AQUATIC ORGANISMS
(3) AWQC PRESENTED FOR CHROMIUM IS FOR THE TRIVALENT FORM
(4) NS = NO SAMPLES COLLECTED
(5) THE MCL PRESENTED FOR LEAD IS A PROPOSED VALUE (5/1/91) THE PRESENT DRINKING WATER ACTION LEVEL FOR LEAD IS 15 ug/l (4/92)
[ ] BOXED VALUES EXCEED MCL

TABLE 4-
COMPARISON OF PARAMETERS IN SURFACE WATER TO STANDARDS
NYANZA III REMEDIAL INVESTIGATION
PAGE 2

PARAMETER	STANDARDS UG/L				REACHES								
	MCL (1)	MCLG (1)	AWQC: ACUTE (2)	AWQC: CHRONIC (2)	2	3	4	5	6	7	8	9	10
INORGANICS:													
ALUMINUM					1176.50	128.70	714.80	0.00	216.53	103.00	NS	NS	NS
ANTIMONY	5	3	88.0	30.0	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
ARSENIC (III)	50		360.0	190.0	3.00	0.00	0.00	1.10	0.00	0.00	NS	NS	NS
BARIUM	2000	2000			33.81	12.55	24.70	12.75	16.20	21.30	NS	NS	NS
BERYLLIUM	1	0	130 0	5.3	7.50	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
CADMIUM	5	5	3.9	1.1	7.20	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
CALCIUM					9317.86	7052.00	7390.00	9722.50	9028.75	11365.00	NS	NS	NS
CHROMIUM (III)	100	100	1700.0	210.0	7.00	0.00	6.00	0.00	0.00	0.00	NS	NS	NS
COBALT					27.70	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
COPPER	1300	1300	18.0	12.0	27.70	0 00	0.00	0.00	0.00	0.00	NS	NS	NS
IRON				1000.0	3943.60	551.80	1515.00	0.00	469.33	528.67	NS	NS	NS
LEAD (5)	5	0	83 0	3 2	33.90	1.00	6.85	0.00	2.40	0.00	NS	NS	NS
MAGNESIUM					2233.57	1730.00	1800.00	2212.50	2052.50	2560.00	NS	NS	NS
MANGANESE					1533.70	63.38	128.85	106.00	96.35	85.90	NS	NS	NS
MERCURY	2	2	2 4	0.012	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
NICKEL	100	100	1400.0	160.0	77.40	0 00	0.00	0.00	0.00	0.00	NS	NS	NS
POTASSIUM					1971.43	1952.00	1285.00	1870.00	2156.25	2167.50	NS	NS	NS
SELENIUM	50	50	20 0	5.0	0.00	19300.00	0.00	0.00	0.00	0.00	NS	NS	NS
SILVER			4.1	0.1	68.90	9.90	0.00	0.00	0.00	6.50	NS	NS	NS
SODIUM					28757.14	19950.00	19900.00	26275.00	22500.00	24850.00	NS	NS	NS
THALLIUM	2	0.5	1400.0	40.0	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
VANADIUM					14.35	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
ZINC			120.0	110.0	125.00	8.00	0.00	0.00	0.00	0.00	NS	NS	NS
ORGANIC COMPOUNDS													
CHLOROMETHANE					0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
1,1-DICHLOROETHENE	7	7	11600		0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
1,2-DICHLOROETHENE (CIS)	70	70	11600		1.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
METHYL ETHYL KETONE					0.00	0.00	10.00	0.00	0.00	0.00	NS	NS	NS
TRICHLOROETHENE	5	0	45000	21900	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
1,4-DICHLOROBENZENE	600	600	1120	763	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
1,2-DICHLOROBENZENE	75	75	1120	763	0.00	0.00	0.00	0.00	0.00	0.00	NS	NS	NS
BIS(2-ETHYLHEXYL)PHTHALATE					0.00	1.00	0.00	0.00	0.00	0.00	NS	NS	NS
GAMMA-BHC (LINDANE)	0 2	0 2	2	0.8	0.00	0.00	0.00	0.00	0.02	0.00	NS	NS	NS

(1) MCLS AND MCLGS FROM USEPA, APRIL, 1992
(2) AWQC FROM USEPA, MAY 1, 1991, TOXICITY TO AQUATIC ORGANISMS
(3) AWQC PRESENTED FOR CHROMIUM IS FOR THE TRIVALENT FORM
(4) NS - NO SAMPLES COLLECTED
(5) THE MCL PRESENTED FOR LEAD IS A PROPOSED VALUE (5/1/91). THE PRESENT DRINKING WATER ACTION LEVEL FOR LEAD IS 15 ug/l (4/92)
[ ] BOXED VALUES EXCEED MCL

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT

PARAMETER	SUDBURY RESERVOIR, LARGEMOUTH					CEDAR SWAMP POND, LARGEMOUTH BASS				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	3 OF 10	13.65	6.772	14.69	13.06	0 OF 7				
ANTIMONY	0 OF 10					1 OF 7	0.82	0.631	0.82	0.82
ARSENIC	1 OF 10	0.06	0.096	0.06	0.06	0 OF 7				
BARIUM	0 OF 10					0 OF 7				
BERYLLIUM	0 OF 10					0 OF 7				
CADMIUM	0 OF 10					0 OF 7				
CALCIUM	10 OF 10	400.95	400.950	513.22	303.53	7 OF 7	1402.71	1402.714	6460.00	179.00
CHROMIUM	5 OF 10	1.89	1.114	2.84	1.33	2 OF 7	0.43	0.194	0.64	0.22
COBALT	6 OF 10	0.05	0.229	0.08	0.03	0 OF 7				
COPPER	0 OF 10					0 OF 7				
IRON	2 OF 10	82.23	29.001	93.61	70.86	0 OF 7				
LEAD	0 OF 10					1 OF 7	1.17	0.239	1.17	1.17
MAGNESIUM	10 OF 10	379.13	379.128	519.28	264.71	7 OF 7	219.43	219.429	284.00	160.00
MANGANESE	7 OF 10	1.45	1.062	2.43	0.57	0 OF 7				
MERCURY	5 OF 10	0.89	0.489	1.18	0.55	4 OF 7	0.60	0.344	0.96	0.36
NICKEL	0 OF 10					1 OF 7	6.00	1.200	6.00	6.00
POTASSIUM	10 OF 10	5432.44	5432.440	6446.94	3897.49	7 OF 7	2720.00	2720.000	3400.00	1940.00
SELENIUM	1 OF 10	1.80	0.460	1.80	1.80	6 OF 7	0.12	0.109	0.50	0.03
SILVER	0 OF 10					1 OF 7	2.20	0.397	2.20	2.20
SODIUM	10 OF 10	418.12	418.120	524.30	330.84	7 OF 7	529.71	529.714	984.00	376.00
THALLIUM	0 OF 10					0 OF 7				
VANADIUM	6 OF 10	0.49	0.325	0.76	0.31	0 OF 7				
ZINC	10 OF 10	32.36	32.359	61.62	9.72	7 OF 7	13.17	13.171	56.80	3.40

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 2

PARAMETER	CEDAR SWAMP POND, YELLOW PERCH					SOUTHVILLE POND, LARGEMOUTH BASS				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	0 OF 10					0 OF 7				
ANTIMONY	2 OF 10	0.22	0.524	0.25	0.19	0 OF 7				
ARSENIC	0 OF 10					0 OF 7				
BARIUM	0 OF 10					0 OF 7				
BERYLLIUM	0 OF 10					0 OF 7				
CADMIUM	0 OF 10					0 OF 7				
CALCIUM	10 OF 10	2460.90	2460.900	8240.00	133.00	7 OF 7	5245.71	5245.714	12000.00	700.00
CHROMIUM	8 OF 10	0.25	0.222	0.56	0.16	5 OF 7	0.32	0.254	0.70	0.20
COBALT	0 OF 10					1 OF 7	0.48	0.497	0.48	0.48
COPPER	0 OF 10					2 OF 7	2.35	0.877	3.10	1.60
IRON	0 OF 10					1 OF 7	14.30	5.371	14.30	14.30
LEAD	0 OF 7					1 OF 7	0.77	0.239	0.77	0.77
MAGNESIUM	10 OF 10	247.40	247.400	298.00	214.00	7 OF 7	291.71	291.714	376.00	228.00
MANGANESE	0 OF 10					1 OF 7	0.38	0.629	0.38	0.38
MERCURY	3 OF 10	3.33	1.004	9.60	0.20	4 OF 7	0.55	0.315	0.89	0.28
NICKEL	0 OF 10					0 OF 7				
POTASSIUM	10 OF 10	3196.00	3196.000	3380.00	2940.00	7 OF 7	3288.57	3288.571	3660.00	2980.00
SELENIUM	8 OF 10	0.56	0.454	4.00	0.03	7 OF 7	0.10	0.097	0.15	0.06
SILVER	0 OF 10					0 OF 7				
SODIUM	10 OF 10	456.60	456.600	534.00	336.00	7 OF 7	606.86	606.857	704.00	466.00
THALLIUM	1 OF 7	0.08	0.097	0.08	0.08	0 OF 0				
VANADIUM	0 OF 10					0 OF 7				
ZINC	10 OF 10	7.72	7.720	12.40	5.40	6 OF 7	14.00	9.307	21.40	8.60

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 3

PARAMETER	MILL POND, YELLOW PERCH					MILL POND, LARGEMOUTH BASS				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	0 OF 10					0 OF 20				
ANTIMONY	0 OF 10					0 OF 20				
ARSENIC	0 OF 10					0 OF 20				
BARIUM	0 OF 10					0 OF 20				
BERYLLIUM	0 OF 10					0 OF 20				
CADMIUM	0 OF 10					0 OF 20				
CALCIUM	10 OF 10	148.52	148.519	210.13	110.51	20 OF 20	135.82	135.817	391.44	87.16
CHROMIUM	0 OF 10					0 OF 20				
COBALT	0 OF 10					0 OF 20				
COPPER	2 OF 10	0.37	0.274	0.40	0.34	0 OF 20				
IRON	0 OF 10					0 OF 20				
LEAD	0 OF 10					0 OF 20				
MAGNESIUM	10 OF 10	240.49	240.489	257.67	223.87	20 OF 20	243.84	243.841	269.31	213.92
MANGANESE	10 OF 10	0.19	0.188	0.31	0.14	13 OF 20	0.13	0.093	0.20	0.08
MERCURY	2 OF 10	1.43	0.444	1.98	0.88	1 OF 20	1.12	0.250	1.12	1.12
NICKEL	0 OF 10					0 OF 20				
POTASSIUM	10 OF 10	3546.22	3546.217	3861.39	3208.18	20 OF 20	4868.57	4868.566	33251.96	3070.58
SELENIUM	0 OF 10					0 OF 20				
SILVER	1 OF 10	0.02	0.092	0.02	0.02	0 OF 20				
SODIUM	10 OF 10	485.64	485.642	538.51	464.24	20 OF 20	551.66	551.663	614.83	459.40
THALLIUM	0 OF 10					0 OF 20				
VANADIUM	1 OF 10	0.02	0.452	0.02	0.02	14 OF 20	0.04	0.175	0.05	0.02
ZINC	10 OF 10	3.55	3.550	3.91	3.27	20 OF 20	3.16	3.157	3.79	2.59

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 4

PARAMETER	RESERVOIR 2, YELLOW PERCH					RESERVOIR 2, LARGEMOUTH BASS				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	1 OF 16	24.35	2.776	24.35	24.35	6 OF 34	13.88	3.274	16.56	12.42
ANTIMONY	0 OF 16					1 OF 31	15.50	0.962	15.50	15.50
ARSENIC	2 OF 16	0.06	0.080	0.07	0.05	3 OF 34	0.61	0.138	1.75	0.03
BARIUM	0 OF 16					0 OF 34				
BERYLLIUM	0 OF 16					0 OF 34				
CADMIUM	0 OF 16					1 OF 34	0.05	0.050	0.05	0.05
CALCIUM	16 OF 16	404.12	404.119	2393.96	92.30	28 OF 34	157.84	138.812	462.66	68.06
CHROMIUM	0 OF 16					8 OF 34	1.95	0.572	3.41	1.23
COBALT	2 OF 16	0.03	0.442	0.04	0.03	9 OF 33	0.06	0.380	0.13	0.04
COPPER	0 OF 16					4 OF 34	0.62	0.354	1.83	0.21
IRON	0 OF 16					6 OF 34	90.77	18.752	131.68	63.45
LEAD	0 OF 16					4 OF 34	0.41	0.081	0.53	0.29
MAGNESIUM	16 OF 16	252.09	252.087	308.26	209.43	28 OF 34	261.25	223.967	424.63	227.79
MANGANESE	14 OF 16	1.52	1.356	13.75	0.21	23 OF 34	0.55	0.382	1.99	0.07
MERCURY	12 OF 16	1.56	1.244	3.64	0.78	32 OF 34	2.87	2.719	7.60	0.80
NICKEL	0 OF 16					0 OF 34				
POTASSIUM	16 OF 16	3747.80	3747.796	5492.87	3068.97	28 OF 34	3694.25	2946.477	5263.24	3148.47
SELENIUM	0 OF 16					0 OF 34				0.00
SILVER	0 OF 16					1 OF 31	0.44	0.104	0.44	0.44
SODIUM	16 OF 16	437.83	437.828	561.54	249.91	28 OF 34	361.68	401.955	576.16	0.00
THALLIUM	0 OF 16					1 OF 31	1.35	0.135	1.35	1.35
VANADIUM	0 OF 16					13 OF 34	0.39	0.433	1.15	0.02
ZINC	15 OF 16	10.11	9.727	46.33	2.85	33 OF 34	14.44	14.144	85.36	0.31

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 5

PARAMETER	RESERVOIR 2, BULLHEAD FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	RESERVOIR 1, YELLOW PERCH FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	6 OF 7	24.76	21.695	57.13	13.62	4 OF 18	22.67	5.239	28.02	12.64
ANTIMONY	0 OF 7					0 OF 14				
ARSENIC	0 OF 7					1 OF 20	0.45	0.114	0.45	0.45
BARIUM	0 OF 7					1 OF 21	1.06	0.167	1.06	1.06
BERYLLIUM	0 OF 7					0 OF 21				
CADMIUM	0 OF 7					0 OF 21				
CALCIUM	7 OF 7	370 69	442.115	578.34	81.17	21 OF 21	493.04	493.041	4833.78	120.80
CHROMIUM	5 OF 7	2.59	1.990	5.69	1.40	8 OF 21	2.18	1.004	3.28	1.33
COBALT	7 OF 7	0.09	0.085	0.24	0.03	10 OF 20	0.09	0.294	0.20	0.04
COPPER	3 OF 7	6.00	2.841	9.72	4.03	0 OF 21				
IRON	5 OF 7	117.67	89.852	267.45	64.28	9 OF 21	96.85	43.504	140.25	74.48
LEAD	0 OF 7					0 OF 21				
MAGNESIUM	7 OF 7	282.08	282.079	392.74	186.33	21 OF 21	302.20	302.197	451.43	223.53
MANGANESE	7 OF 7	1 77	1.770	5.53	0.93	21 OF 21	2.73	2.725	33.81	0.16
MERCURY	6 OF 7	1 99	1.741	2.85	1.26	2 OF 21	0.76	0.219	0.76	0.76
NICKEL	0 OF 7					0 OF 21				
POTASSIUM	7 OF 7	5171.93	5171.931	7109.96	3456.60	21 OF 21	4279.21	4279.212	5963.71	2960.69
SELENIUM	0 OF 7					0 OF 21				
SILVER	0 OF 7					0 OF 15				
SODIUM	7 OF 7	583.92	583.918	731.70	431.93	21 OF 21	464.32	464.320	637.93	261.49
THALLIUM	0 OF 7					0 OF 15				
VANADIUM	6 OF 7	0.59	0.523	1.16	0.31	9 OF 21	0.45	0.439	0.84	0.31
ZINC	7 OF 7	62.27	62.271	178.54	20.89	21 OF 21	21.32	21.160	68.03	2.95

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 6

PARAMETER	RESERVOIR 1, LARGEMOUTH BASS					RESERVOIR 1, BULLHEAD				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	1 OF 21	22.25	1.822	22.25	22.25	7 OF 8	94.28	82.882	489.93	14.72
ANTIMONY	0 OF 30					0 OF 6				
ARSENIC	4 OF 30	0.04	0.081	0.04	0.03	0 OF 9				
BARIUM	0 OF 30					0 OF 9				
BERYLLIUM	0 OF 30					0 OF 9				
CADMIUM	0 OF 30					0 OF 9				
CALCIUM	30 OF 30	234.76	234.763	730.75	87.36	9 OF 9	754.49	754.494	4189.04	232.84
CHROMIUM	5 OF 30	3 31	0.989	8.32	1.54	7 OF 9	2.06	1.686	3.94	1.17
COBALT	10 OF 30	0.15	0.366	0.53	0.04	9 OF 9	0.07	0.071	0.13	0.03
COPPER	2 OF 30	5.16	0.792	6.31	4.01	1 OF 9	4.04	1.156	4.04	4.04
IRON	10 OF 30	168.67	56.742	302.61	61.09	6 OF 9	127.14	93.194	182.76	80.18
LEAD	0 OF 29					1 OF 9	2.16	0.273	2.16	2.16
MAGNESIUM	30 OF 30	300.56	300.559	592.38	224.30	9 OF 9	334.44	334.438	461.59	236.43
MANGANESE	25 OF 30	1.75	1.487	10.68	0.09	9 OF 9	3.78	3.776	9.09	1.05
MERCURY	24 OF 30	1.47	1.225	4.19	0.71	3 OF 9	0.92	0.381	1.20	0.70
NICKEL	0 OF 30					0 OF 9				
POTASSIUM	30 OF 30	3963.73	3963.733	6335.70	2580.56	9 OF 9	5201.66	5201.658	5992.34	3879.03
SELENIUM	0 OF 30					0 OF 9				
SILVER	0 OF 30					0 OF 6				
SODIUM	30 OF 30	475.67	489.004	625.67	33.48	9 OF 9	675.83	675.828	860.79	447.38
THALLIUM	0 OF 30					0 OF 6				
VANADIUM	9 OF 30	0.81	0.582	1.57	0.36	6 OF 9	0.47	0.347	0.82	0.35
ZINC	29 OF 30	31.72	31.368	262.46	2.86	8 OF 9	64.27	57.500	161.96	25.48

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS-FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
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	SAXONVILLE IMPOUNDMENT, LARGEMOUTH BASS					SAXONVILLE IMPOUNDMENT, YELLOW PERCH				
PARAMETER	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	1 OF 23	14.01	3.930	14.01	14.01	4 OF 20	24.16	6.946	30.15	14.73
ANTIMONY	1 OF 23	0.14	0.580	0.14	0.14	0 OF 20				
ARSENIC	0 OF 23					1 OF 20	0.05	0.076	0.05	0.05
BARIUM	0 OF 23					0 OF 20				
BERYLLIUM	0 OF 23					0 OF 20				
CADMIUM	0 OF 23					0 OF 20				
CALCIUM	23 OF 23	2550.19	2550.194	19500.00	102.00	20 OF 20	2762.61	2762.609	12200.00	340.02
CHROMIUM	15 OF 23	0.39	0.317	1.74	0.14	12 OF 20	1.35	0.929	4.28	0.14
COBALT	3 OF 23	0.13	0.452	0.32	0.03	10 OF 20	0.11	0.307	0.60	0.03
COPPER	0 OF 23					3 OF 20	3.96	0.856	6.10	1.67
IRON	1 OF 23	66.90	5.823	66.90	66.90	4 OF 20	123.12	30.449	155.91	69.21
LEAD	0 OF 23					1 OF 20	0.69	0.072	0.69	0.69
MAGNESIUM	23 OF 23	267.07	267.072	414.00	202.00	20 OF 20	333.84	333.835	499.59	189.00
MANGANESE	4 OF 23	2.04	0.543	5.94	0.41	15 OF 20	5.21	4.111	19.70	0.51
MERCURY	17 OF 23	0.94	0.700	1.80	0.20	15 OF 20	0.70	0.555	1.40	0.20
NICKEL	2 OF 23	1.17	0.470	1.24	1.10	0 OF 20				
POTASSIUM	23 OF 23	3439.44	3439.440	6636.87	2540.00	20 OF 20	4348.96	4348.957	6826.89	2360.00
SELENIUM	20 OF 23	0.19	0.195	0.62	0.03	10 OF 20	0.10	0.161	0.18	0.04
SILVER	1 OF 23	0.24	0.106	0.24	0.24	0 OF 20				
SODIUM	23 OF 23	644.78	644.780	1160.00	248.50	20 OF 20	502.54	502.543	848.00	195.64
THALLIUM	0 OF 23					1 OF 20	1.19	0.130	1.19	1.19
VANADIUM	2 OF 23	0.41	0.460	0.49	0.33	4 OF 20	0.95	0.474	1.22	0.64
ZINC	23 OF 23	8.84	8.844	42.73	1.69	20 OF 20	26.36	26.364	94.79	5.54

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 8

PARAMETER	SAXONVILLE IMPOUNDMENT, BULLHEAD					FAIRHAVEN BAY, LARGEMOUTH BASS				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	2 OF 4	15.85	9.945	19.00	12.70	0 OF 20				
ANTIMONY	0 OF 4					0 OF 20				
ARSENIC	1 OF 4	0.04	0.085	0.04	0.04	0 OF 20				
BARIUM	0 OF 4					0 OF 20				
BERYLLIUM	0 OF 4					0 OF 20				
CADMIUM	0 OF 4					0 OF 20				
CALCIUM	4 OF 4	405.31	405.311	513.72	310.32	20 OF 20	3283.80	3283.800	9900.00	116.00
CHROMIUM	1 OF 4	3.47	1.202	3.47	3.47	15 OF 20	0.55	0.439	3.40	0.14
COBALT	3 OF 4	0.04	0.155	0.06	0.02	2 OF 20	0.82	0.532	1.26	0.38
COPPER	0 OF 4					7 OF 20	2.12	0.954	3.40	1.20
IRON	1 OF 4	124.09	44.963	124.09	124.09	2 OF 20	19.15	4.733	23.40	14.90
LEAD	0 OF 4					2 OF 20	3.20	0.414	5.60	0.79
MAGNESIUM	4 OF 4	373.81	373.809	511.98	261.46	20 OF 20	241.45	241.450	314.00	186.00
MANGANESE	4 OF 4	1.11	1.108	2.27	0.64	1 OF 20	0.32	0.269	0.32	0.32
MERCURY	3 OF 4	0.74	0.601	0.88	0.60	19 OF 20	1.32	1.256	3.20	0.20
NICKEL	0 OF 4					1 OF 20	2.00	0.480	2.00	2.00
POTASSIUM	4 OF 4	6247.23	6247.230	7862.15	4479.02	20 OF 20	2945.00	2945.000	3520.00	2160.00
SELENIUM	0 OF 4					17 OF 20	0.08	0.073	0.19	0.03
SILVER	0 OF 4					0 OF 20				
SODIUM	4 OF 4	625.21	625.209	779.19	429.31	20 OF 20	658.80	658.800	1100.00	496.00
THALLIUM	0 OF 4					0 OF 17				
VANADIUM	0 OF 4					0 OF 20				
ZINC	4 OF 4	29.04	29.037	52.44	15.35	19 OF 20	8.85	8.409	12.80	5.30

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
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PARAMETER	FAIRHAVEN BAY, YELLOW PERCH				
	FREQUENCY	DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM
ALUMINUM	0 OF 10				
ANTIMONY	0 OF 10				
ARSENIC	0 OF 10				
BARIUM	1 OF 10	1.10	1.910	1.10	1.10
BERYLLIUM	0 OF 10				
CADMIUM	0 OF 10				
CALCIUM	10 OF 10	9144.40	9144.400	28400.00	774.00
CHROMIUM	7 OF 10	0.64	0.480	1.40	0.20
COBALT	0 OF 10				
COPPER	3 OF 10	1.80	0.745	2.20	1.50
IRON	1 OF 10	23.80	5.195	23.80	23.80
LEAD	0 OF 10				
MAGNESIUM	10 OF 10	285.40	285.400	474.00	202.00
MANGANESE	6 OF 10	13.00	8.040	33.20	5.90
MERCURY	9 OF 10	0.72	0.650	1.80	0.33
NICKEL	0 OF 10				
POTASSIUM	10 OF 10	2887.00	2887.000	3580.00	1890.00
SELENIUM	10 OF 10	0.14	0.136	0.27	0.04
SILVER	0 OF 10				
SODIUM	10 OF 10	611.00	611.000	902.00	482.00
THALLIUM	0 OF 0				
VANADIUM	0 OF 10				
ZINC	10 OF 10	10.04	10.040	21.20	4.40

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 10

PARAMETER	SUDBURY RESERVOIR					CEDAR SWAMP POND				
	LARGEMOUTH BASS					LARGEMOUTH BASS				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride						0 of 2				
Acetone						0 of 2				
2-Butanone						0 of 2				
Toluene						0 of 2				
Styrene						0 of 2				
Total Xylenes						0 of 2				
Phenol	1 OF 7	56 000	504 286	56	56					
Bis(2-Chloroethyl) ether	0 OF 11									
Benzyl Alcohol	0 OF 11					NO SAMPLES COLLECTED IN THIS REACH				
2-Methylphenol	0 OF 7									
4-Methylphenol	0 OF 7									
Nitrobenzene	0 OF 11									
Naphthalene	0 OF 11									
Diethylphthalate	0 OF 11									
Fluorene	1 OF 11	99 000	540 000	99	99					
Di-n-butylphthalate	1 OF 11	45 000	490 909	45	45					
Butylbenzylphthalate	0 OF 11									
Bis(2-ethylhexyl)phthalate	0 OF 8									
Di-n-octylphthalate	0 OF 8									
Benzo(b)fluoranthene	0 OF 11									
Benzo(a)pyrene	0 OF 11									
Heptachlor	0 OF 7									
Aldrin	0 OF 8									
Heptachlor Epoxide	0 OF 8									
Endosulfan I	0 OF 8									
Dieldrin	4 OF 8	0 500	3 250	0 5	0 5					
4,4'-DDE	8 OF 8	19 563	19 563	41	3.5					
Endrin	1 OF 8	0 500	5 313	0.5	0.5					
Endosulfan II	0 OF 8									
4,4'-DDD	7 OF 8	3 429	3 750	7	1					
Endosulfan Sulfate	2 OF 8	2 750	5 188	4 5	1					
4,4'-DDT	5 OF 8	0 900	2.813	2	0.5					
Methoxychlor	0 OF 8									
Endrin Ketone	0 OF 8									
alpha-Chlordane	1 OF 8	1 000	26 375	1	1					
gamma-Chlordane	0 OF 8									
Aroclor-1248	0 OF 8									
Aroclor-1254	0 OF 3									
Aroclor-1260	4 OF 8	67 500	63 750	95	20					
Methylmercury	3 OF 3	485	465	652	221	0 of 2				

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 11

PARAMETER	MILL POND YELLOW PERCH FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	MILL POND LARGEMOUTH BASS FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride										
Acetone										
2-Butanone										
Toluene										
Styrene										
Total Xylenes										
Phenol	0 OF 10					0 OF 1				
Bis(2-Chloroethyl) ether	0 OF 10					0 OF 2				
Benzyl Alcohol	0 OF 10					0 OF 1				
2-Methylphenol	0 OF 10					0 OF 1				
4-Methylphenol	0 OF 10					0 OF 1				
Nitrobenzene	0 OF 10					0 OF 2				
Naphthalene	0 OF 10					0 OF 2				
Diethylphthalate	0 OF 10					0 OF 2				
Fluorene	0 OF 10					0 OF 2				
Di-n-butylphthalate	0 OF 10					0 OF 2				
Butylbenzylphthalate	0 OF 10					0 OF 2				
Bis(2-ethylhexyl)phthalate	0 OF 10					0 OF 2				
Di-n-octylphthalate	0 OF 10					0 OF 2				
Benzo(b)fluoranthene	0 OF 10					0 OF 2				
Benzo(a)pyrene	0 OF 10					0 OF 2				
Heptachlor	0 OF 10					0 OF 2				
Aldrin	0 OF 10					0 OF 2				
Heptachlor Epoxide	0 OF 10					0 OF 2				
Endosulfan I	0 OF 10					0 OF 2				
Dieldrin	0 OF 10					0 OF 2				
4,4'-DDE	2 OF 10	27	13.05	30	24	0 OF 2				
Endrin	0 OF 10					0 OF 2				
Endosulfan II	0 OF 10					0 OF 2				
4,4'-DDD	0 OF 10					0 OF 2				
Endosulfan Sulfate	0 OF 10					0 OF 2				
4,4'-DDT	0 OF 10					0 OF 2				
Methoxychlor	0 OF 10					0 OF 2				
Endrin Ketone	0 OF 10					0 OF 2				
alpha-Chlordane	0 OF 10					0 OF 2				
gamma-Chlordane	0 OF 10					0 OF 2				
Aroclor-1248	1 OF 10	500	87	500	500	0 OF 2				
Aroclor-1254	0 OF 10					0 OF 2				
Aroclor-1260	0 OF 10					0 OF 2				
Methylmercury	2 OF 10	550	150 8	730	370	2 OF 2	540	540	660	420

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 12

PARAMETER	RESERVOIR 2					RESERVOIR 2				
	YELLOW PERCH					BULLHEAD				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride										
Acetone										
2-Butanone										
Toluene										
Styrene										
Total Xylenes										
Phenol	0 OF 17					0 OF 4				
Bis(2-Chloroethyl) ether	0 OF 17					0 OF 7				
Benzyl Alcohol	0 OF 17					0 OF 7				
2-Methylphenol	0 OF 17					0 OF 4				
4-Methylphenol	0 OF 17					0 OF 4				
Nitrobenzene	0 OF 17					0 OF 7				
Naphthalene	0 OF 17					0 OF 7				
Diethylphthalate	0 OF 17					0 OF 7				
Fluorene	0 OF 17					0 OF 7				
Di-n-butylphthalate	0 OF 17					0 OF 7				
Butylbenzylphthalate	0 OF 17					0 OF 7				
Bis(2-ethylhexyl)phthalate	0 OF 14					0 OF 0				
Di-n-octylphthalate	0 OF 14					0 OF 0				
Benzo(b)fluoranthene	0 OF 17					0 OF 7				
Benzo(a)pyrene	0 OF 17					0 OF 7				
Heptachlor	0 OF 17					0 OF 7				
Aldrin	0 OF 17					2 OF 7	0.750	2.357	1	0.5
Heptachlor Epoxide	0 OF 17					0 OF 7				
Endosulfan I	0 OF 17					0 OF 7				
Dieldrin	0 OF 17					2 OF 7	0.500	4.429	0.5	0.5
4,4'-DDE	13 OF 17	22 423	20 294	62	0.5	7 OF 7	4.571	4.571	7	1
Endrin	0 OF 17					0 OF 7				
Endosulfan II	0 OF 17					1 OF 7	1.000	5.286	1	1
4,4'-DDD	4 OF 17	5 125	9 706	7	2.5	4 OF 7	3.500	4.571	5.5	1.5
Endosulfan Sulfate	0 OF 17					0 OF 7				
4,4'-DDT	4 OF 17	1.013	8 738	1 5	0.05	2 OF 7	1.750	4.786	2	1.5
Methoxychlor	0 OF 17					1 OF 7	3.500	26.214	3.5	3.5
Endrin Ketone	0 OF 17					1 OF 7	2.500	5.500	2.5	2.5
alpha-Chlordane	3 OF 17	0 833	43 971	1	0.5	0 OF 7				
gamma-Chlordane	3 OF 17	1 167	44.029	1 5	1	2 OF 7	0.750	30.214	1	0.5
Aroclor-1248	0 OF 17					0 OF 7				
Aroclor-1254	7 OF 17	201 857	122 653	730	10	3 OF 6	31.667	40.833	35	30
Aroclor-1260	5 OF 17	26 400	87 853	52	10	3 OF 5	31.667	37.000	40	20
Methylmercury	13 OF 13	1526 92	1526 92	3190	520	NO SAMPLES COLLECTED IN THIS REACH				

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 13

	RESERVOIR 2					RESERVOIR 1				
	LARGEMOUTH BASS					YELLOW PERCH				
PARAMETER	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride										
Acetone										
2-Butanone										
Toluene										
Styrene										
Total Xylenes										
Phenol	0 OF 27					1 OF 20	2300.000	447.500	2300	2300
Bis(2-Chloroethyl) ether	0 OF 27					0 OF 20				
Benzyl Alcohol	0 OF 27					0 OF 20				
2-Methylphenol	0 OF 27					0 OF 20				
4-Methylphenol	0 OF 27					0 OF 20				
Nitrobenzene	0 OF 27					0 OF 20				
Naphthalene	0 OF 27					0 OF 20				
Diethylphthalate	0 OF 27					0 OF 20				
Fluorene	0 OF 27					0 OF 20				
Di-n-butylphthalate	0 OF 27					0 OF 20				
Butylbenzylphthalate	0 OF 27					0 OF 20				
Bis(2-ethylhexyl)phthalate	0 OF 27					11 OF 17	1581.818	439.412	3300	600
Di-n-octylphthalate	0 OF 27					0 OF 17				
Benzo(b)fluoranthene	0 OF 27					0 OF 20				
Benzo(a)pyrene	0 OF 27					0 OF 20				
Heptachlor	0 OF 27					0 OF 20				
Aldrin	0 OF 27					0 OF 20				
Heptachlor Epoxide	0 OF 27					0 OF 20				
Endosulfan I	0 OF 27					0 OF 20				
Dieldrin	0 OF 27					0 OF 19				
4,4'-DDE	19 OF 27	25 763	20 500	68	5.5	9 OF 20	24.889	26.925	30	17
Endrin	0 OF 27					0 OF 20				
Endosulfan II	0 OF 27					0 OF 20				
4,4'-DDD	8 OF 27	3 625	6 963	7	1	0 OF 20				
Endosulfan Sulfate	0 OF 27					0 OF 20				
4,4'-DDT	7 OF 27	1 143	6 389	2	0.5	0 OF 20				
Methoxychlor	0 OF 27					0 OF 20				
Endrin Ketone	0 OF 27					0 OF 20				
alpha-Chlordane	3 OF 27	0 833	34.907	1	0.5	0 OF 20				
gamma-Chlordane	4 OF 27	1 125	33 870	2	0.5	0 OF 20				
Aroclor-1248	0 OF 27					0 OF 20				
Aroclor-1254	8 OF 27	95 000	83 519	350	24	0 OF 20				
Aroclor-1260	6 OF 27	60 500	76.593	93	16	0 OF 20				
Methylmercury	20 OF 21	1988	1898 57	4200	220	13 OF 13	685	685	1320	220

.E 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 14

PARAMETER	RESERVOIR 1					RESERVOIR 1				
	BULLHEAD					LARGEMOUTH BASS				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride										
Acetone										
2-Butanone										
Toluene										
Styrene										
Total Xylenes										
Phenol	0 OF 8					1 OF 30	2300	495	2300	2300
Bis(2-Chloroethyl) ether	0 OF 8					0 OF 30				
Benzyl Alcohol	0 OF 8					0 OF 30				
2-Methylphenol	0 OF 8					0 OF 30				
4-Methylphenol	0 OF 8					0 OF 30				
Nitrobenzene	0 OF 8					0 OF 30				
Naphthalene	0 OF 8					0 OF 30				
Diethylphthalate	0 OF 8					0 OF 30				
Fluorene	0 OF 8					0 OF 30				
Di-n-butylphthalate	0 OF 8					0 OF 30				
Butylbenzylphthalate	0 OF 8					0 OF 30				
Bis(2-ethylhexyl)phthalate	0 OF 8					11 OF 21	1581.818	1026.190	3300	600
Di-n-octylphthalate	0 OF 6					0 OF 20				
Benzo(b)fluoranthene	0 OF 8					0 OF 30				
Benzo(a)pyrene	0 OF 8					0 OF 30				
Heptachlor	0 OF 10					0 OF 30				
Aldrin	0 OF 10					0 OF 30				
Heptachlor Epoxide	0 OF 10					0 OF 30				
Endosulfan I	0 OF 10					0 OF 30				
Dieldrin	0 OF 10					0 OF 30				
4,4'-DDE	8 OF 10	14 375	13.300	32	3	9 OF 30	24.889	13.067	30	17
Endrin	0 OF 10					0 OF 30				
Endosulfan II	0 OF 10					0 OF 30				
4,4'-DDD	4 OF 10	11 375	7 850	20	3.5	0 OF 30				
Endosulfan Sulfate	0 OF 10					0 OF 30				
4,4'-DDT	2 OF 10	1 000	4.450	1	1	0 OF 30				
Methoxychlor	0 OF 10					0 OF 30				
Endrin Ketone	0 OF 10					0 OF 30				
alpha-Chlordane	6 OF 10	1.333	9 850	2.5	0.5	0 OF 30				
gamma-Chlordane	5 OF 10	1.000	15.600	1.5	0.5	0 OF 30				
Aroclor-1248	0 OF 10					0 OF 30				
Aroclor-1254	3 OF 10	27 667	50.300	39	19	0 OF 30				
Aroclor-1260	6 OF 10	35.500	40.800	69	15	0 OF 30				
Methylmercury	1 OF 1	913	913	913	913	22 OF 23	1215	1166.96	3760	290

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 15

PARAMETER	SAXONVILLE IMPOUNDMENT					SAXONVILLE IMPOUNDMENT				
	LARGEMOUTH BASS					YELLOW PERCH				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride	0 of 5					0 of 9				
Acetone	0 of 5					0 of 9				
2-Butanone	0 of 5					0 of 9				
Toluene	0 of 5					0 of 9				
Styrene	0 of 5					0 of 9				
Total Xylenes	0 of 5					0 of 9				
Phenol	3 of 6	63 330	155.000	120	25	5 OF 17	33.600	315.471	48	25
Bis(2-Chloroethyl) ether	0 of 8					0 OF 18				
Benzyl Alcohol	0 of 8					0 OF 14				
2-Methylphenol	0 of 6					0 OF 14				
4-Methylphenol	0 of 8					0 OF 14				
Nitrobenzene	0 of 8					0 OF 18				
Naphthalene	1 of 8	1900 000	484 688	1900	1900	0 OF 18				
Diethylphthalate	0 of 8					0 OF 18				
Fluorene	0 of 8					0 OF 18				
Di-n-butylphthalate	1 of 8	62 000	237 125	62	62	1 OF 18	28.000	324.889	28	28
Butylbenzylphthalate	0 of 8					1 OF 18	120.000	330.000	120	120
Bis(2-ethylhexyl)phthalate	5 of 5	251 800	252 000	680	28	1 OF 8	58.000	116.625	58	58
Di-n-octylphthalate	0 of 5					0 OF 8				
Benzo(b)fluoranthene	0 of 8					0 OF 18				
Benzo(a)pyrene	0 of 8					0 OF 18				
Heptachlor	1 of 8	8 000	2 250	6	6	2 OF 20	3.750	1.800	6	1.5
Aldrin	0 of 8					0 OF 20				
Heptachlor Epoxide	0 of 8					1 OF 20	4.000	1.925	4	4
Endosulfan I	0 of 8					1 OF 20	1.500	1.800	1.5	1.5
Dieldrin	0 of 8					4 OF 20	0.375	2.650	0.5	0
4,4'-DDE	8 of 8	9 359	9 311	13	3.5	16 OF 20	6.684	5.723	13.6	3
Endrin	1 of 8	2 500	2.750	2.5	2.5	2 OF 20	4.000	3.550	7.5	0.5
Endosulfan II	0 of 8					0 OF 20				
4,4'-DDD	8 of 8	4 386	4 161	8 74	2	16 OF 20	5.173	4.539	14	1
Endosulfan Sulfate	0 of 8					1 OF 20	1.000	3.500	1	1
4,4'-DDT	2 of 8	1 250	2.000	1.5	1	3 OF 20	1.167	3.025	2	0.5
Methoxychlor	0 of 8					0 OF 20				
Endrin Ketone	0 of 8					0 OF 20				
alpha-Chlordane	0 of 8					1 OF 20	2.000	17.350	2	2
gamma-Chlordane	0 of 8					3 OF 20	0.670	14.350	1	0.5
Aroclor-1248	0 of 8					0 OF 20				
Aroclor-1254	3 of 8	20 000	18 875	20	20	6 OF 17	25.000	21.176	40	15
Aroclor-1260	5 of 8	90 400	83.775	110	77.9	3 OF 15	49.700	33.940	65.1	38
Methylmercury	7 of 8	520 43	645 38	1370	340	8 of 13	356.13	253.77	542	148

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SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 16

	SAXONVILLE IMPOUNDMENT						FAIRHAVEN BAY					
	BULLHEAD						LARGEMOUTH BASS					
PARAMETER	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
	NO SAMPLES COLLECTED IN THIS REACH											
Methylene Chloride							2 OF	19	7175.000	766.447	14000	350
Acetone							5 OF	19	1128.000	466.053	1600	940
2-Butanone							0 OF	19				
Toluene							1 OF	19	5.000	12.105	5	5
Styrene							1 OF	19	2.000	11.947	2	2
Total Xylenes							1 OF	19	2.000	11.947	2	2
Phenol	0 OF	4					19 OF	19	1393.368	1393.368	8200	64
Bis(2-Chloroethyl) ether	0 OF	4					1 OF	19	40.000	117.368	40	40
Benzyl Alcohol	0 OF	4					1 OF	19	31.000	116.105	31	31
2-Methylphenol	0 OF	4					1 OF	19	33.000	116.211	33	33
4-Methylphenol	0 OF	4					13 OF	19	202.846	176.947	1900	32
Nitrobenzene	0 OF	4					1 OF	19	24.000	116.526	24	24
Naphthalene	0 OF	4					0 OF	19				
Diethylphthalate	0 OF	4					0 OF	19				
Fluorene	0 OF	4					0 OF	19				
Di-n-butylphthalate	0 OF	4					9 OF	19	41.111	84.211	110	21
Butylbenzylphthalate	0 OF	4					2 OF	19	202.000	129.158	370	34
Bis(2-ethylhexyl)phthalate	0 OF	0					2 OF	19	32.500	111.316	37	28
Di-n-octylphthalate	0 OF	0					2 OF	19	45.500	112.684	46	45
Benzo(b)fluoranthene	0 OF	4					1 OF	19	87.000	118.789	87	87
Benzo(a)pyrene	0 OF	4					1 OF	19	26.000	115.579	26	26
Heptachlor	0 OF	4					0 OF	17				
Aldrin	0 OF	4					0 OF	17				
Heptachlor Epoxide	0 OF	4					0 OF	18				
Endosulfan I	0 OF	4					0 OF	18				
Dieldrin	2 OF	4	0 000	3 250	0	0	0 OF	15				
4,4'-DDE	4 OF	4	12 000	12 000	20	8	19 OF	19	19.109	19.227	36	5
Endrin	1 OF	4	7 000	6.375	7	7	0 OF	15				
Endosulfan II	1 OF	4	0 000	4.625	0	0	0 OF	18				
4,4'-DDD	4 OF	4	6 250	6.500	8	5	0 OF	18				
Endosulfan Sulfate	0 OF	4					0 OF	18				
4,4'-DDT	1 OF	4	2 000	5.125	2	2	0 OF	14				
Methoxychlor	1 OF	4	1 000	22.750	1	1	0 OF	18				
Endrin Ketone	0 OF	4					0 OF	18				
alpha-Chlordane	0 OF	4					0 OF	18				
gamma-Chlordane	3 OF	4	1 000	6.250	1	1	0 OF	18				
Aroclor-1248	0 OF	4					0 OF	18				
Aroclor-1254	3 OF	3	23 333	23.333	25	20	19 OF	19	223.421	218.205	460	90
Aroclor-1260	4 OF	4	40 000	40 000	70	20	1 OF	18	30.000	15.833	30	30
Methylmercury	NO SAMPLES COLLECTED IN THIS REACH						19 OF	19	686.32	686.32	1200	430

TABLE 4-3
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY SPECIES
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 17

PARAMETER	FAIRHAVEN BAY				
	YELLOW PERCH				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAX	MIN
Methylene Chloride	1 OF 10	28 000	15 200	28	28
Acetone	1 OF 10	810 000	269 500	810	810
2-Butanone	2 OF 10	275 000	118.150	300	250
Toluene	1 OF 10	26 000	13.650	26	26
Styrene	0 OF 10				
Total Xylenes	0 OF 10				
Phenol	10 OF 10	481.900	481.900	950	59
Bis(2-Chloroethyl) ether	0 OF 10				
Benzyl Alcohol	4 OF 10	136.250	128.500	420	26
2-Methylphenol	0 OF 10				
4-Methylphenol	9 OF 10	61.000	66.900	100	26
Nitrobenzene	0 OF 10				
Naphthalene	0 OF 10				
Diethylphthalate	1 OF 10	33 000	113 800	33	33
Fluorene	0 OF 10				
Di-n-butylphthalate	5 OF 10	120 000	135 000	280	25
Butylbenzylphthalate	5 OF 10	989 600	629 800	3000	12
Bis(2-ethylhexyl)phthalate	2 OF 10	32 500	104 500	37	28
Di-n-octylphthalate	2 OF 10	36 000	105.700	43	29
Benzo(b)fluoranthene	0 OF 10				
Benzo(a)pyrene	0 OF 10				
Heptachlor	0 OF 10				
Aldrin	0 OF 10				
Heptachlor Epoxide	0 OF 10				
Endosulfan I	0 OF 10				
Dieldrin	0 OF 10				
4,4'-DDE	10 OF 10	15 436	15.436	35	6
Endrin	0 OF 10				
Endosulfan II	0 OF 10				
4,4'-DDD	0 OF 10				
Endosulfan Sulfate	0 OF 10				
4,4'-DDT	0 OF 10				
Methoxychlor	0 OF 10				
Endrin Ketone	0 OF 10				
alpha-Chlordane	0 OF 10				
gamma-Chlordane	0 OF 10				
Aroclor-1248	0 OF 10				
Aroclor-1254	9 OF 10	174 256	158.250	330	72
Aroclor-1260	0 OF 10				
Methylmercury	7 OF 10	420	328 5	480	330

TABLE 4

SUMMARY OF FISH ANALYTICAL RESULTS. OFFAL

NYANZA III REMEDIAL INVESTIGATION

SUDBURY RIVER STUDY

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DETECTED PARAMETER	RESULT									
	RESERVOIR 1			RESERVOIR 2			SAXONVILLE IMPOUNDMENT			SUDBURY RESERVOIR
	BASS	PERCH	BULLH	BASS	PERCH	BULLH	BASS	PERCH	BULLH	BASS
ORGANIC COMPOUNDS (ug/kg)										
ALPHA-BHC	1.50					1.00			0.50	
HEPTACHLOR						0.50			5.50	
ALDRIN	0.50			1.50	1.00	0.50			3.50	
HEPTACHLOR EPOXIDE				3.50	1.50	6.50		4.00	14.00	
DIELDRIN	1 50	1 00		0.50	2.00	5.00	0.50		7.00	
4,4'-DDE (P,P'-DDE)	280.00	55.00	29.00	170.00	80.00	64.00	35.00	24.00	240.00	74.00
ENDRIN				5.00						
ENDOSULFAN II (BETA)	18.00		1.50						2.50	
4,4'-DDD (P,P'-DDD)	57 00	20.00	4.50	44.00	39.00	28.00	6.50	16.00	100.00	12.00
ENDOSULFAN SULFATE				1.50	4.50					
4,4'-DDT (P,P'-DDT)		0.50		1.50	7.00		2.50	3.00	15.00	0.50
METHOXYCHLOR					1.00	2.00	3.00			
ENDRIN KETONE						0.50	1.00	0.50		
GAMMA-CHLORDANE /2	7.50			1.00	1.00	7.50	0.50	1.50	10.00	
ALPHA-CHLORDANE /2	9.00			1.50						
PCB-1254 (AROCLOR 1254)					140.00	110.00			260.00	
PCB-1260 (AROCLOR 1260)	760.00	120.00	60.00	700.00	150.00	210.00	90.00	50.00	630.00	110.00
MONOMETHYLMERCURY	652	399	102	2140	551	NS	598	58.3	NS	244
INORGANIC PARAMETERS (mg/kg)										
ARSENIC	0 0349								0.0318	
BARIUM		2.48	1.15		1.68		0.5598			
CALCIUM	27875.6	18454.9	7732.51	2258.044	17950.03	624.09	10494.51	3033.39	1242.82	909.35
COBALT	0 0644	0.0644	0.07		0.0753	0.031	0.0577	0.0345	0.0244	
IRON	160.21	163.84	230.15		106.33		126.72			
LEAD			0.397		0.31					
MAGNESIUM	649.88	487.95	285.85	262.51	557.5948	200.85	482.88	353.95	160.17	276.89
MANGANESE	7.24	59.13	31.66	0.5554	11.65	0.5923	2.972	6.26	1.35	
MERCURY	3 809			3.4	1.9565	1.5238	1		0.9	
POTASSIUM	2103.94	2484 3	2179.633	3399.22	2948.73	3189.56	3650.63	2994.83	2273.83	3120.72
SODIUM	2042.78	1799 96	1589.62	1173 38	1704.72	1478.93	1451.82	1356.55	907.84	1210.41
ZINC	31 95	28 71	26.99	12	25.6	13.87	26.12	45.7	15.0423	12.21

Results of the monthly water quality sampling exhibited expected seasonal variation in the concentrations of various water quality components. Results are further discussed and summarized in Appendix L.

4.1.2 Summary Tables

Data are reported from the laboratory and presented in the summary tables in micrograms/kilogram (ug/kg), milligrams/kilograms (mg/kg) and dry weight for sediment samples. These units are closely equivalent to parts per billion (ppb) and parts per million (ppm), respectively. Water samples are reported in micrograms/liter (ug/L) and milligrams/liter (mg/l). Again, the units are nearly equivalent to ppb and ppm, respectively. Data will be discussed and presented on Study Area figures in units of ppb and ppm.

Summary Tables 4-1, 4-2, and 4-3 are presented to accompany the discussion presented in this section. Table 4-1 presents a statistical summary of the results from analyses of surface water and sediment samples. Table 4-2, presents a comparison of Water Quality Criteria with contaminant levels in the Study Area. Tables 4-3 and 4-4 present summaries of contaminant concentrations in fish tissue. Table 4-7 presents a summary of the Eastern Wetlands soil and sediment analyses.

Table 4-1 presents range, frequency, and averages of contaminants detected. This table is organized by Reach, showing the statistics for each section of the Study Area as described in Section 2.0.

Two average values are presented in Table 4-1 for each contaminant detected. Average reported values reflect an average of all the laboratory data presented in Appendices A through D. A value reported by data validation process followed by a "u" is the detection limit for the analysis. The actual concentration of the contaminant is expected to be less than the detection limit and also below lab quality control limits. According to EPA Region I policy, one half of the u-qualified value is calculated into the reported average concentration for use in human health risk assessment calculations.

When this process is performed, the calculated average concentrations for some parameters are higher than the maximum concentrations reported by the laboratory. These occurrences indicate a high detection limit in some samples, and a trace of the compound positively detected in others. As a result, the average value is skewed by the high detection limits attained by the laboratory.

To compensate for this, averages of samples with positive (above detection limits) detected contaminant concentrations are also

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT

PARAMETER	SUDBURY RESERVOIR					CEDAR SWAMP POND				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	3 OF 10	13.65	6.772	14.69	13.06	0 OF 17				
ANTIMONY	0 OF 10					3 OF 17	0.420	0.568	0.820	0.190
ARSENIC	1 OF 10	0.06	0.096	0.06	0.06	0 OF 17				
BARIUM	0 OF 10					0 OF 17				
BERYLLIUM	0 OF 10					0 OF 17				
CADMIUM	0 OF 10					0 OF 17				
CALCIUM	10 OF 10	400.95	400.950	513.22	303.53	17 OF 17	2025.176	2025.176	8240.000	133.000
CHROMIUM	5 OF 10	1.89	1.114	2.84	1.33	10 OF 17	0.288	0.211	0.640	0.160
COBALT	6 OF 10	0.05	0.229	0.08	0.03	0 OF 17				
COPPER	0 OF 10					0 OF 17				
IRON	2 OF 10	82.23	29.001	93.61	70.86	0 OF 17				
LEAD	0 OF 10					1 OF 14	1.170	0.120	1.170	1.170
MAGNESIUM	10 OF 10	379.13	379.128	519.28	264.71	17 OF 17	235.882	235.882	298.000	160.000
MANGANESE	7 OF 10	1.45	1.062	2.43	0.57	0 OF 17				
MERCURY	5 OF 10	0.89	0.489	1.18	0.55	7 OF 17	1.770	0.732	9.600	0.200
NICKEL	0 OF 10					1 OF 17	6.000	0.494	6.000	6.000
POTASSIUM	10 OF 10	5432.44	5432.440	6446.94	3897.49	17 OF 17	3000.000	3000.000	3400.000	1940.000
SELENIUM	1 OF 10	1.80	0.460	1.80	1.80	14 OF 17	0.368	0.312	4.000	0.030
SILVER	0 OF 10					1 OF 17	2.200	0.164	2.200	2.200
SODIUM	10 OF 10	418.12	418.120	524.30	330.84	17 OF 17	486.706	486.706	984.000	336.000
THALLIUM	0 OF 10					1 OF 14	0.080	0.049	0.080	0.080
VANADIUM	6 OF 10	0.49	0.325	0.76	0.31	0 OF 17				
ZINC	10 OF 10	32.36	32.359	61.62	9.72	17 OF 17	9.965	9.965	56.800	3.400

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 2

PARAMETER	SOUTHVILLE POND						MILL POND					
	FREQUENCY		DETECTED AVERAGE	REPORTED AVERAGE	MAXIMUM	MINIMUM	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	0 OF	7					0 OF	30				
ANTIMONY	0 OF	7					0 OF	30				
ARSENIC	0 OF	7					0 OF	30				
BARIUM	0 OF	7					0 OF	30				
BERYLLIUM	0 OF	7					0 OF	30				
CADMIUM	0 OF	7					0 OF	30				
CALCIUM	7 OF	7	5245.714	5245.714	12000.000	700.000	30 OF	30	140.051	140.051	391.445	87.162
CHROMIUM	5 OF	7	0.316	0.254	0.700	0.200	0 OF	30				
COBALT	1 OF	7	0.480	0.497	0.480	0.480	0 OF	30				
COPPER	2 OF	7	2.350	0.877	3.100	1.600	2 OF	30	0.370	0.091	0.404	0.340
IRON	1 OF	7	14.300	5.371	14.300	14.300	0 OF	30				
LEAD	1 OF	7	0.770	0.239	0.770	0.770	0 OF	30				
MAGNESIUM	7 OF	7	291.714	291.714	376.000	228.000	30 OF	30	242.723	242.723	269.305	213.920
MANGANESE	1 OF	7	0.380	0.629	0.380	0.380	23 OF	30	0.152	0.125	0.313	0.078
MERCURY	4 OF	7	0.548	0.315	0.890	0.280	3 OF	30	1.328	0.315	1.981	0.881
NICKEL	0 OF	7					0 OF	30				
POTASSIUM	7 OF	7	3288.571	3288.571	3660.000	2980.000	30 OF	30	4427.783	4427.783	33251.955	3070.579
SELENIUM	7 OF	7	0.097	0.097	0.150	0.060	0 OF	30				
SILVER	0 OF	7					1 OF	30	0.025	0.031	0.025	0.025
SODIUM	7 OF	7	606.857	606.857	704.000	466.000	30 OF	30	529.656	529.656	614.829	459.403
THALLIUM	0 OF	0					0 OF	30				
VANADIUM	0 OF	7					15 OF	30	0.035	0.267	0.046	0.021
ZINC	6 OF	7	14.000	9.307	21.400	8.600	30 OF	30	3.288	3.288	3.912	2.592

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 3

	RESERVOIR 2					RESERVOIR 1				
PARAMETER	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	13 OF 57	19.708	5.396	57.127	12.420	12 OF 47	64.407	16.928	489.928	12.643
ANTIMONY	1 OF 54	15.499	0.552	15.499	0.030	0 OF 50				
ARSENIC	5 OF 57	0 390	0 105	1.754	0.000	5 OF 59	0.119	0.080	0.114	0.030
BARIUM	0 OF 57					1 OF 60	1.061	0.058	0.167	0.167
BERYLLIUM	0 OF 57					0 OF 60				
CADMIUM	1 OF 57	0 052	0 030	0.052	0.052	0 OF 60				
CALCIUM	51 OF 57	264 320	250.532	2393.962	68.057	60 OF 60	403.120	403.120	4189.044	87.358
CHROMIUM	13 OF 57	2 199	0 586	5.689	1.230	20 OF 60	2.420	1.099	8.318	1.174
COBALT	18 OF 56	0 067	0 361	0.240	0.027	29 OF 59	0.103	0.297	0.532	0.031
COPPER	7 OF 57	2 929	0 560	9.723	0.210	3 OF 60	4.787	0.570	6.313	0.040
IRON	11 OF 57	102 996	22 220	267.448	63.450	25 OF 60	132.847	57.576	302.612	61.086
LEAD	4 OF 57	0 406	0 048	0.529	0.290	1 OF 59	2.157	0.042	2.157	2.157
MAGNESIUM	51 OF 57	261 232	238 997	424.628	186.331	60 OF 60	306.214	306.214	592.383	223.530
MANGANESE	44 OF 57	1.053	0 826	13.752	0.075	55 OF 60	2.453	2.264	10.682	0.095
MERCURY	50 OF 57	2 451	2 185	7.600	0.784	29 OF 60	1.367	0.746	4.185	0.696
NICKEL	0 OF 57					0 OF 60				
POTASSIUM	51 OF 57	3913 867	3444 710	7109.957	3068.974	60 OF 60	4259.839	4259.839	6335.704	2580.562
SELENIUM	0 OF 57					0 OF 60				
SILVER	1 OF 54	0 444	0 060	0 444	0.444	0 OF 51				
SODIUM	51 OF 57	416 072	434.371	731.696	249.910	60 OF 60	501.721	501.721	860.792	33.482
THALLIUM	1 OF 54	1.346	0.078	1.346	1.346	0 OF 51				
VANADIUM	19 OF 57	0 450	0.322	1.161	0.020	24 OF 60	0.591	0.497	1.572	0.310
ZINC	55 OF 57	19 348	18.814	178.539	0.305	58 OF 60	32.442	31.715	262.464	2.861

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
mg/kg WET WEIGHT
PAGE 4

PARAMETER	SAXONVILLE IMPOUNDMENT					FAIRHAVEN BAY				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	7 OF 47	20.337	5.726	30.153	12.698	0 OF 30				
ANTIMONY	1 OF 47	0.140	0.284	0.140	0.040	0 OF 30				
ARSENIC	2 OF 47	0.044	0.040	0.046	0.000	0 OF 30				
BARIUM	0 OF 47					1 OF 30	1.100	0.637	1.100	1.100
BERYLLIUM	0 OF 47					0 OF 30				
CADMIUM	0 OF 47					0 OF 30				
CALCIUM	47 OF 47	2458.040	2458.040	19500.000	102.000	30 OF 30	5237.333	5237.333	28400.000	116.000
CHROMIUM	28 OF 47	0.916	0.653	4.278	0.140	22 OF 30	0.581	0.453	3.400	0.140
COBALT	16 OF 47	0.103	0.365	0.600	0.025	2 OF 30	0.820	0.355	1.260	0.000
COPPER	3 OF 47	3.960	0.364	6.100	1.670	10 OF 30	2.026	0.884	3.400	1.200
IRON	6 OF 47	113.913	19.633	155.911	66.900	3 OF 30	20.700	4.887	23.800	14.900
LEAD	1 OF 47	0.690	0.031	0.690	0.690	2 OF 30	3.195	0.276	5.600	0.790
MAGNESIUM	47 OF 47	304.566	304.566	511.977	189.000	30 OF 30	256.100	256.100	474.000	186.000
MANGANESE	23 OF 47	3.947	2.109	19.700	0.405	7 OF 30	11.189	2.859	33.200	0.320
MERCURY	35 OF 47	0.823	0.630	1.800	0.200	28 OF 30	1.129	1.054	3.200	0.200
NICKEL	2 OF 47	1.170	0.230	1.240	1.100	1 OF 30	2.000	0.320	2.000	2.000
POTASSIUM	47 OF 47	4065.429	4065.429	7862.154	2360.000	30 OF 30	2925.667	2925.667	3580.000	1890.000
SELENIUM	30 OF 47	0.159	0.164	0.620	0.030	27 OF 30	0.099	0.094	0.270	0.030
SILVER	1 OF 47	0.240	0.052	0.240	0.240	0 OF 30				
SODIUM	47 OF 47	582.588	582.588	1160.000	195.639	30 OF 30	642.867	642.867	1100.000	482.000
THALLIUM	1 OF 47	1.190	0.055	1.190	1.190	0 OF 17				
VANADIUM	6 OF 47	0.768	0.427	1.218	0.330	0 OF 30				
ZINC	47 OF 47	18.018	18.018	94.793	1.690	29 OF 30	9.261	8.953	21.200	4.400

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS, FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 5

PARAMETER	SUDBURY RESERVOIR					CEDAR SWAMP POND				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
Methylene Chloride						0 of 2				
Acetone						0 of 2				
2-Butanone						0 of 2				
Toluene						0 of 2				
Styrene						0 of 2				
Total Xylenes						0 of 2				
Phenol	1 OF 7	56 000	504 286	56 000	56.000					
Bis(2-Chloroethyl) ether	0 OF 11									
Benzyl Alcohol	0 OF 11					NO SAMPLES COLLECTED IN THIS REACH				
2-Methylphenol	0 OF 7									
4-Methylphenol	0 OF 7									
Nitrobenzene	0 OF 11									
Naphthalene	0 OF 11									
Diethylphthalate	0 OF 11									
Fluorene	1 OF 11	99 000	540 000	99.000	99.000					
Di-n-butylphthalate	1 OF 11	45 000	490.909	45 000	45.000					
Butylbenzylphthalate	0 OF 11									
Bis(2-ethylhexyl)phthalate	0 OF 6									
Di-n-octylphthalate	0 OF 6									
Benzo(b)fluoranthene	0 OF 11									
Benzo(a)pyrene	0 OF 11									
Heptachlor	0 OF 7									
Aldrin	0 OF 8									
Heptachlor Epoxide	0 OF 8									
Endosulfan I	0 OF 8									
Dieldrin	4 OF 8	0 500	3.250	0 500	0.500					
4,4'-DDE	8 OF 8	19 563	19 563	41 000	3.500					
Endrin	1 OF 8	0 500	5.313	0.500	0.500					
Endosulfan II	0 OF 8									
4,4'-DDD	7 OF 8	3 429	3.750	7.000	1.000					
Endosulfan Sulfate	2 OF 8	2.750	5 188	4 500	1.000					
4,4'-DDT	5 OF 8	0.900	2.813	2 000	0.500					
Methoxychlor	0 OF 8									
Endrin Ketone	0 OF 8									
alpha-Chlordane	1 OF 8	1 000	26.375	1 000	1.000					
gamma-Chlordane	0 OF 8									
Aroclor-1248	0 OF 8									
Aroclor-1254	0 OF 3									
Aroclor-1260	4 OF 8	87 500	63 750	95 000	20.000					
Methylmercury	3 OF 3	485	485	652	221	0 OF 2				

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS: FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 6

PARAMETER	MILL POND						RESERVOIR NO. 2					
	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
Methylene Chloride												
Acetone												
2-Butanone												
Toluene												
Styrene												
Total Xylenes												
Phenol	0 OF	11					0 OF	48				
Bis(2-Chloroethyl) ether	0 OF	12					0 OF	51				
Benzyl Alcohol	0 OF	11					0 OF	51				
2-Methylphenol	0 OF	11					0 OF	48				
4-Methylphenol	0 OF	11					0 OF	48				
Nitrobenzene	0 OF	12					0 OF	51				
Naphthalene	0 OF	12					0 OF	51				
Diethylphthalate	0 OF	12					0 OF	51				
Fluorene	0 OF	12					0 OF	51				
Di-n-butylphthalate	0 OF	12					0 OF	51				
Butylbenzylphthalate	0 OF	12					0 OF	51				
Bis(2-ethylhexyl)phthalate	0 OF	12					0 OF	41				
Di-n-octylphthalate	0 OF	12					0 OF	41				
Benzo(b)fluoranthene	0 OF	12					0 OF	51				
Benzo(a)pyrene	0 OF	12					0 OF	51				
Heptachlor	0 OF	12					0 OF	51				
Aldrin	0 OF	12					2 OF	51	0.750	0.324	1	0.5
Heptachlor Epoxide	0 OF	12					0 OF	51				
Endosulfan I	0 OF	12					0 OF	51				
Dieldrin	0 OF	12					2 OF	51	0.500	0.608	0.5	0.25
4,4'-DDE	2 OF	12	244.75	10.875	30	24	39 OF	51	20.846	18.245	68	0.5
Endrin	0 OF	12					0 OF	51				
Endosulfan II	0 OF	12					1 OF	51	1.000	0.725	1	1
4,4'-DDD	0 OF	12					16 OF	51	3.969	7.549	7	1
Endosulfan Sulfate	0 OF	12					0 OF	51				
4,4'-DDT	0 OF	12					13 OF	51	1.196	6.952	2	0.05
Methoxychlor	0 OF	12					1 OF	51	3.500	3.598	3.5	3.5
Endrin Ketone	0 OF	12					1 OF	51	2.500	0.755	2.5	2.5
alpha-Chlordane	0 OF	12					6 OF	51	0.833	33.137	1	0.5
gamma-Chlordane	0 OF	12					9 OF	51	1.056	36.755	2	0.5
Aroclor-1248	1 OF	12	500	72.5	500	500	0 OF	51				
Aroclor-1254	0 OF	12					16 OF	50	129.875	91.770	730	10
Aroclor-1260	0 OF	12					14 OF	49	42.143	76.459	93	10
Methylmercury	4 OF	12	548	215.66	730	370	33 OF	34	1806.36	1756.47	4200	220

E 4-4

SUMMARY OF FISH ANALYTICAL RESULTS, FILLET BY REACH
NYANZA II REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 7

PARAMETER	RESERVOIR NO. 1					SAXONVILLE IMPOUNDMENT				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
Methylene Chloride						0 OF 14				
Acetone						0 OF 14				
2-Butanone						0 OF 14				
Toluene						0 OF 14				
Styrene						0 OF 14				
Total Xylenes						0 OF 14				
Phenol	2 OF 58	2300.000	410.345	2300	2300	8 OF 27	44.749	233.074	120	25
Bis(2-Chloroethyl) ether	0 OF 58					0 OF 30				
Benzyl Alcohol	0 OF 58					0 OF 26				
2-Methylphenol	0 OF 58					0 OF 24				
4-Methylphenol	0 OF 56					0 OF 24				
Nitrobenzene	0 OF 58					0 OF 30				
Naphthalene	0 OF 58					1 OF 30	1900.000	129.250	1900	1900
Diethylphthalate	0 OF 58					0 OF 30				
Fluorene	0 OF 58					0 OF 30				
Di-n-butylphthalate	0 OF 58					2 OF 30	45.000	258.167	62	28
Butylbenzylphthalate	0 OF 58					1 OF 30	120.000	198.000	120	120
Bis(2-ethylhexyl)phthalate	22 OF 44	1581.818	659.545	3300	600	6 OF 13	219.500	168.692	680	28
Di-n-octylphthalate	0 OF 43					0 OF 13				
Benzo(b)fluoranthene	0 OF 58					0 OF 30				
Benzo(a)pyrene	0 OF 58					0 OF 30				
						0 OF 0				
						0 OF 0				
Heptachlor	0 OF 60					3 OF 32	4.500	1.688	6	1.5
Aldrin	0 OF 60					0 OF 32				
Heptachlor Epoxide	0 OF 60					1 OF 32	4.000	1.203	4	4
Endosulfan I	0 OF 60					1 OF 32	1.500	1.125	1.5	1.5
Dieldrin	0 OF 59					4 OF 32	0.250	2.063	0.5	0.05
4,4'-DDE	26 OF 60	21.654	17.725	32	17	28 OF 32	8.208	7.404	20	3
Endrin	0 OF 60					4 OF 32	4.375	3.703	7.5	0.5
Endosulfan II	0 OF 60					0 OF 32				
4,4'-DDD	4 OF 60	11.375	1.308	20	3.5	28 OF 32	5.102	4.689	14	1
Endosulfan Sulfate	0 OF 60					1 OF 32	1.000	2.188	1	1
4,4'-DDT	2 OF 60	1.000	0.742	1	1	6 OF 32	1.334	3.031	2	0.5
Methoxychlor	0 OF 60					1 OF 32	1.000	2.844	1	1
Endrin Ketone	0 OF 60					0 OF 32				
alpha-Chlordane	6 OF 60	1.333	1.642	2.5	0.5	1 OF 32	2.000	10.844	2	2
gamma-Chlordane	5 OF 60	1.000	2.600	1.5	0.5	6 OF 32	0.835	10.000	1	0.5
Aroclor-1248	0 OF 60					0 OF 32				
Aroclor-1254	3 OF 60	27.667	8.383	39	19	12 OF 28	23.333	20.179	40	15
Aroclor-1260	6 OF 60	35.600	6.800	69	15	12 OF 25	63.425	46.870	110	20
Methylmercury	36 OF 37	1015.22	990.75	3760	220	15 OF 12	526.13	402.95	1370	148

TABLE 4-4
SUMMARY OF FISH ANALYTICAL RESULTS FILLET BY REACH
NYANZA III REMEDIAL INVESTIGATION
SUDBURY RIVER STUDY
ug/kg WET WEIGHT
PAGE 8

PARAMETER	FAIRHAVEN BAY					
	FREQUENCY		AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
Methylene Chloride	3 OF	29	4792 667	507.397	14000	28
Acetone	6 OF	29	1075 000	398 276	1600	810
2-Butanone	2 OF	29	275 000	40.741	300	250
Toluene	2 OF	29	15 500	12.707	26	5
Styrene	1 OF	29	2 000	7 828	2	2
Total Xylenes	1 OF	29	2 000	7.828	2	2
Phenol	29 OF	29	1079 069	1079 089	8200	59
Bis(2-Chloroethyl) ether	1 OF	29	40 000	76 897	40	40
Benzyl Alcohol	5 OF	29	115 200	120 379	420	26
2-Methylphenol	1 OF	29	33 000	76 138	33	33
4-Methylphenol	22 OF	29	144 818	139.000	1900	26
Nitrobenzene	1 OF	29	24 000	76.345	24	24
Naphthalene	0 OF	29				
Diethylphthalate	1 OF	29	33.000	39.241	33	33
Fluorene	0 OF	29				
Di-n-butylphthalete	14 OF	29	69 286	101.724	280	21
Butylbenzylphthalate	7 OF	29	784 571	301.793	3000	12
Bis(2-ethylhexyl)phthalate	4 OF	29	32 500	108.966	37	28
Di-n-octylphthalate	4 OF	29	40 750	110 276	46	29
Benzo(b)fluoranthene	1 OF	29	87 000	77.828	87	87
Benzo(a)pyrene	1 OF	29	26 000	75 724	26	26
Heptachlor	0 OF	27				
Aldrin	0 OF	27				
Heptachlor Epoxide	0 OF	28				
Endosulfan I	0 OF	28				
Dieldrin	0 OF	25				
4,4'-DDE	29 OF	29	17 842	17.920	36	5
Endrin	0 OF	25				
Endosulfan II	0 OF	28				
4,4'-DDD	0 OF	28				
Endosulfan Sulfate	0 OF	28				
4,4'-DDT	0 OF	24				
Methoxychlor	0 OF	28				
Endrin Ketone	0 OF	28				
alpha-Chlordane	0 OF	28				
gamma-Chlordane	0 OF	28				
Aroclor-1248	0 OF	28				
Aroclor-1254	28 OF	29	207 618	197.531	460	72
Aroclor-1260	1 OF	28	30 000	10.179	30	30
Methylmercury	28 OF	29	814.82	562.93	1200	330

presented in Table 4-1. These values are an average of those values listed in Appendices A through D which were either unqualified or qualified with a "j". Values qualified with a "j" indicate a positive detection, although the value is approximate.

This value is used throughout this Section to compare Reach-specific data to background concentrations. For brevity, this Average Detected Concentration is abbreviated to ADC.

4.2 Potential Sources of Contamination

Section 4.2.1 presents the Nyanza Site-related contaminants identified by EPA as being discharged to the environment at the Nyanza Site. Many potential point and non-point sources which could contribute a variety of contaminants to the river system also exist within the Study Area. These "off-site" sources are discussed in Section 4.2.2 and are grouped into landfills, potential oil/hazardous material release sites, wastewater discharges, and non-point sources.

4.2.1 Nyanza Site-Related Contaminants

The US EPA has compiled a list of contaminants which are known to exist in the soils or groundwater on the Nyanza Site and have been linked to on-site discharges. The list includes:

trichloroethene
1,2-dichloroethene
chlorobenzene
nitrobenzene
dichlorobenzenes
1,2,4-trichlorobenzene
aniline
naphthalene
phenols
benzidine
antimony
cadmium
chromium
arsenic
lead
mercury

These compounds are referred to in this RI report as "Site-related contaminants" which should not be confused with "Site Specific Contaminants", a group of aniline compounds specific to the dye manufacturing process. Usage of these aniline compounds has been documented at the Site, however, were not detected in Operable Unit III investigations.

4.2.2 Contamination Documented at the Nyanza Site

The following section summarizes reported contamination in media on the Nyanza Site (Operable Unit I) and in groundwater migrating from the site (Operable Unit II). This section summarizes background sections of the Draft Final RI Report, Nyanza II (Ebasco, 1991).

Contaminants which have been identified on the Nyanza Site include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals in all media (groundwater, soils, surface water, and sediments).

Soil sampling results indicated that trichloroethene (TCE) and chlorobenzene, the primary VOC contaminants, are present in the 10^2 and 10^3 ppb range respectively. SVOC contamination was found to be limited in areal extent. Nitrobenzene, dichlorobenzenes (DCBs), 1,2,4-trichlorobenzene, aniline, and naphthalene were detected in the 10^2 to 10^4 ppb range. Chromium and lead were detected at levels up to 10^2 mg/kg and 10^3 ppm respectively.

Principal VOCs detected in onsite groundwater include TCE, 1,2-dichloroethene (1,2-DCE), and chlorobenzene. Primary SVOCs detected in groundwater include nitrobenzene, aniline and DCBs. A wide variety of additional SVOCs including 1,2,4-trichlorobenzene, phenol, naphthalene and benzidine were also detected. Cadmium, chromium, arsenic, mercury and lead were also repeatedly detected in groundwater at the Site.

A plume(s) of organic compound contamination has migrated toward the north and east approximately one-half mile downgradient of the Site, to the vicinity of the Mill Pond/Raceway area of the River. Analine, DCBs, TCE and nitrobenzene have been detected in the plume(s) which occurs both in unconsolidated overburden and bedrock. No volatiles were detected in the surface water samples in Mill Pond. Volatiles in sediments included acetone, methylene chloride, and 2-butanone.

Mercury was detected in the seep water on the eastern flank of Megunko Hill, facing the Eastern Wetlands. Other heavy metals are not commonly detected in groundwater or surface water immediately off-site.

4.2.3 Off-Site Contaminant Sources

Many potential sources of contamination to the Sudbury River exist within the Nyanza III Study Area. This section provides an overview of potential sources of contamination to the Sudbury River other than the Nyanza site. This discussion is based on information collected from DEP and EPA files, and conversations with municipal offices within the Sudbury River drainage basin. For purposes of this discussion, potential sources are grouped into landfills, potential oil/hazardous material release sites and wastewater discharges, and non-point sources. Research was not conducted to determine the historical contributors of contaminants to the River.

4.2.3.1 Landfills

A minimum of 12 active or inactive landfills are located within the Sudbury River drainage basin (Figure 4-1). Five waste disposal areas are located upstream from the Nyanza Site. Baystate Abrasives in Westborough operated seven dump sites which contain cyanide wastes and phenolic resins. These sites are currently undergoing environmental assessment by the Massachusetts DEP. Baystate Abrasives also operates a landfill for used abrasive materials west of Cedar Swamp. Two unlined, privately owned landfills have been operated by E.L. Harvey & Sons since the 1960s in the headwaters area of the Sudbury River. The eastern landfill is capped with silt, whereas the western landfill is uncapped, but a groundwater monitoring well network has been established. The former Ashland Landfill is also located upstream from the Nyanza site, adjacent to the Hopkinton Reservoir.

Seven landfills are located within the Sudbury River drainage basin downstream from the Nyanza Site. The Natick Landfill, located south of Lake Cochichuate, accepts residential and commercial solid wastes. The facility is unlined and has operated since 1946. Groundwater at the landfill has been monitored for the past eight years. The former Framingham Landfill was closed in 1985. The facility was capped and has a leachate collection and treatment system in place. An abandoned ash landfill is located west of Farm Pond in Framingham, within 300 yards of the Sudbury River. This landfill is unlined and is not monitored. Solid waste from Framingham, Southborough, and Ashland is currently hauled for incineration or landfilling elsewhere.

The Sudbury and Wayland landfills and the Joint Wayland-Sudbury septage treatment plant are located in wetlands west of the Sudbury River. The Wayland Landfill includes an unlined portion which was capped in 1988. A new, contiguous lined section of the landfill has a leachate collection system. A groundwater monitoring network has been established at the Wayland Landfill. The Sudbury Landfill is located directly south of the Wayland Landfill, and is monitored quarterly. Results of monitoring have indicated the presence of various organic and inorganic contaminants.

The Town of Concord operates a landfill located on the Sudbury River drainage divide near the confluence of the Sudbury River with the Concord River. The Concord Landfill is lined and has a

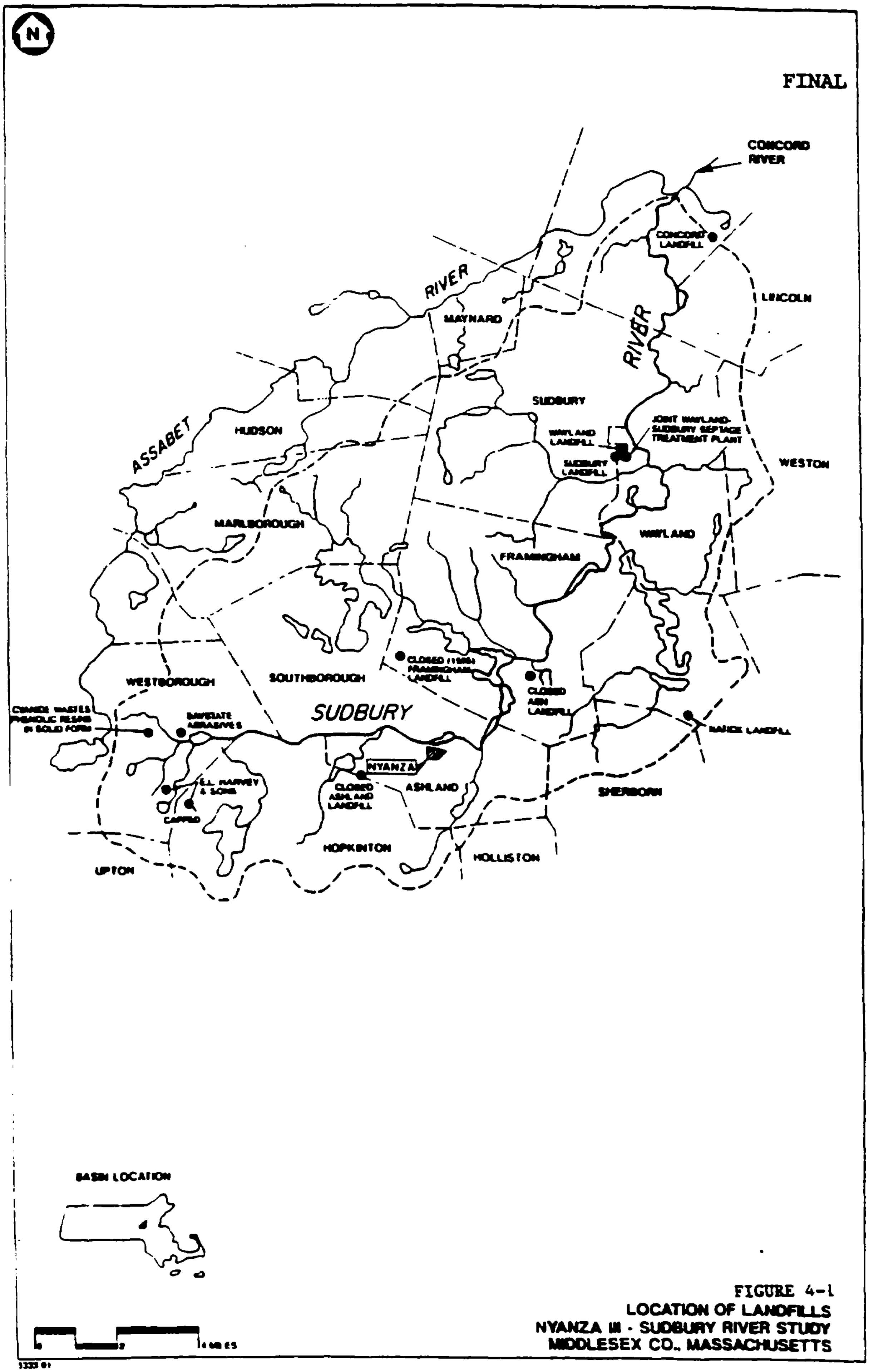


FIGURE 4-1
LOCATION OF LANDFILLS
NYANZA III - SUDBURY RIVER STUDY
MIDDLESEX CO., MASSACHUSETTS

leachate treatment system. This facility is not believed to impact the Sudbury River.

4.2.3.2 Potential Oil/Hazardous Material Release Sites and Wastewater Discharges

Numerous potential oil/hazardous material release sites and wastewater discharges are located within the Sudbury River drainage basin (Figure 4-2). The release and disposal site locations were obtained from the DEQE lists of oil/hazardous material release sites and confirmed disposal sites. The wastewater discharge locations were obtained from the DEQE Division of Water Pollution Control reports (DEQE, 1987).

The release and disposal sites represent a wide range of potential sources, including service stations; dry cleaning establishments; electronics firms; manufacturers; electroplating shops; research and laboratory facilities; and spill sites. Potential contaminant sources are located throughout the drainage basin. The majority of potential release or disposal sites are located in the more densely populated and the commercial areas of Ashland and Framingham.

Two major wastewater dischargers are located downstream from the Nyanza site. The Marlborough East Wastewater Treatment Plant is located about six miles west of the Sudbury River on Hop Brook in Marlborough. Treated wastewater is discharged to Hop Brook, which flows into Wash Brook, and then to the Sudbury River at Route 20 in Wayland. The treatment plant has a design flow of 5.5 million gallons per day. A wastewater treatment plant operated by Raytheon discharges wastewater near Route 20 in Wayland. The wastewater consists of a combination of electroplating process wastewater (design flow of 25,000 gallons per day), sanitary wastewater (design flow of 65,000 gallons per day), and cooling tower and boiler blowdown water.

4.2.3.3 Non-Point Sources

Non-point source discharges represent a third category of potential contamination sources of the Sudbury River. Non-point source discharges are generally collected in developed areas by storm-drainage systems prior to discharge to the environment. These discharges represent overland flow from commercial, industrial, and residential areas. Stormwater from communities along the Sudbury River is discharged directly to the River or to natural water bodies that ultimately discharge to the River. Stormwater from urban areas may pick up wastes ranging from fly ash and dust from industrial processes, to organic debris and litter.

The highway network throughout the study area serves as a continuing source of additional vehicular and roadwash related

FINAL

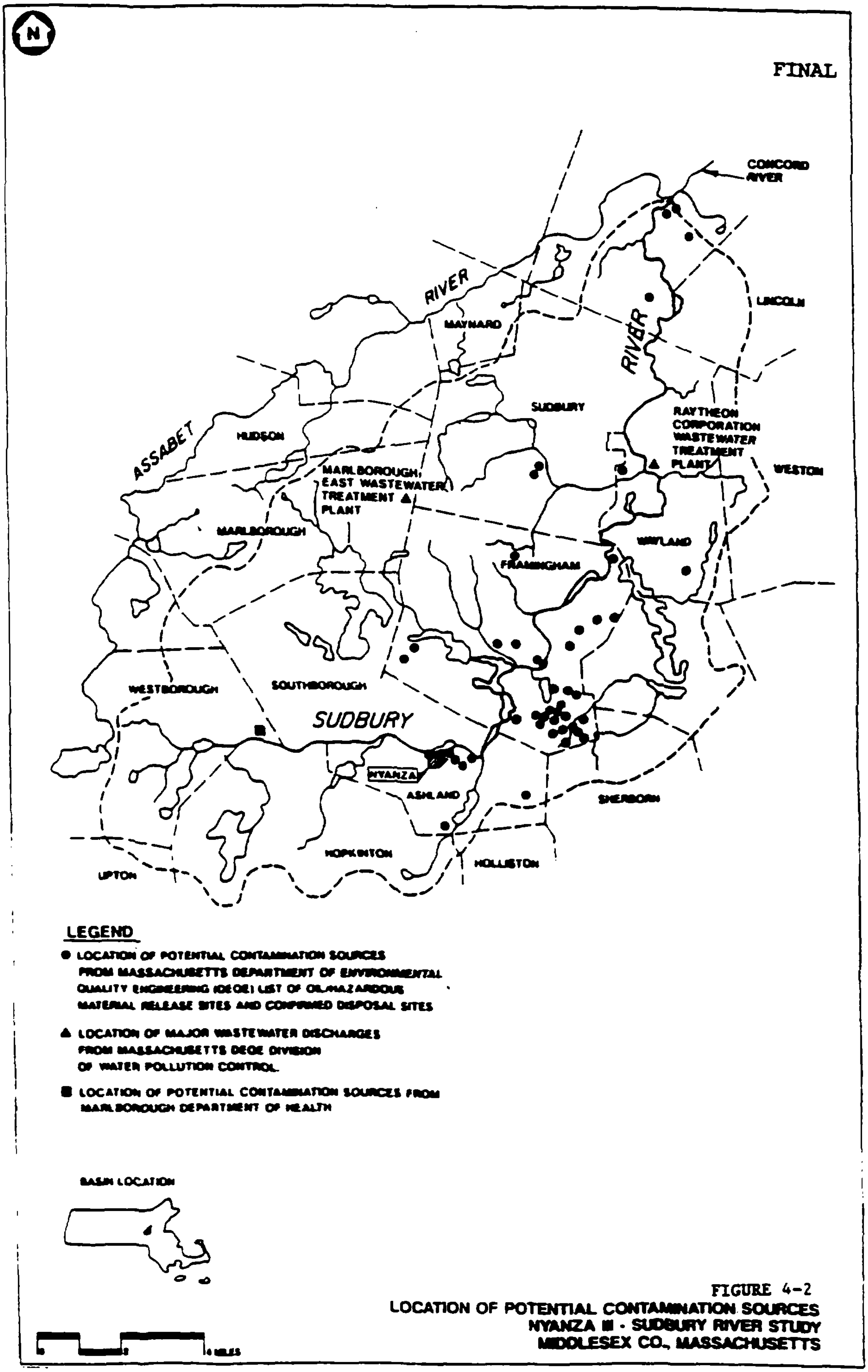


FIGURE 4-2
LOCATION OF POTENTIAL CONTAMINATION SOURCES
NYANZA III - SUDBURY RIVER STUDY
MIDDLESEX CO., MASSACHUSETTS

contaminants. Vehicular traffic contributes significant levels of lead, chromium, asbestos, slowly biodegradable petroleum products and other contaminants generated from processes such as tire wear which enter the environment as roadwash (Midwest Research Institute, 1975). Deposition rates of roadway surface contaminants have been shown to be highly correlated with total traffic (Biospherics, Inc., 1974), and would therefore be expected to be highest along the major roadways. Use of highway de-icing salts provides an additional potential source of sodium and chloride contamination to the Sudbury River.

Legally permitted direct wastewater discharges could also be significant source of contaminants in the River. In addition, it is likely that non-point runoff contributes heavy metals that are also Nyanza Site-related contaminants including lead, chromium and selenium, as well as polynuclear aromatic hydrocarbons and other organic compounds. In differentiating between Nyanza Site-related contamination and contaminants from other sources in the Study Area, the following should be noted:

- Mercury has been directly linked with the Nyanza Site; in addition, no other potential sources of this metal have been identified in the Study Area.
- The highest concentrations and frequency of mercury contaminated samples have been noted in waterbodies nearest the Site (those in Reach 2). Concentrations and detection frequencies generally decrease through Reach 10.
- Nyanza Site-related contaminants may also be discharged to the Sudbury River by numerous potential point and non-point sources throughout the Study Area.

Lead, for example, may enter the Sudbury River from Nyanza Site runoff, a direct industrial wastewater discharge, stormwater runoff from roadways or in a landfill leachate. An extensive list of non-site related contaminants were also detected in Sudbury River sediments throughout the Study Area. These contaminants include PAHs, DDT with associated degradation products, PCBs, volatile organic compounds and heavy metals.

4.2.3.4 Summary of Contaminants found in the Study Area

Not all chemical contaminants present in the river system are a result of discharges from the Nyanza Site. However, several conclusions can be drawn:

- Mercury, a major contaminant in fish, sediment, and surface water has been directly linked with the Nyanza

Site; and no other source of this metal has been identified in the Study Area. Mercury will serve as the indicator of Nyanza-related contamination.

- Methylmercury has been detected in sediments downstream of the site. While mercury is defined as a indicator, this compound can be similarly used.

- Chromium may be used as an indicator compound because it is a Nyanza Site-related contaminant which is not generally associated with most other point and non-point source discharges in the vicinity.

- Lead can be attributable to Nyanza activities, however, lead does not serve as an indicator compound because of the potential availability to the river system from other, non-point sources which cannot be accurately quantified.

- Polynuclear Aromatic Hydrocarbons cannot serve as indicator compounds because they were not found on Site and they are readily available to the river system from non-point sources.

- Organic compounds unique to dye manufacturing that have been identified at the Nyanza site cannot serve as "tracer" compounds for site-related contamination, since those compounds have not been detected in the Sudbury River.

- Volatile organic compounds are common contaminants associated with discharges and spills from fuel transfer stations, asphalt runoff, and various manufacturing and other light industry sources. These compounds degrade in the environment in a relatively short period of time, and therefore are not good indicator compounds for historic discharges.

- Pesticides are not Site-related contaminants but are present in several sediment samples in apparently unrelated occurrences. Pesticides are significant in the ecological risk assessment due to the persistence and bioaccumulation potential of these compounds.

- PCBs are not Site-related discharge compounds and are present in only one River sediment sample and two raceway sediment samples. However, PCBs are significant in the ecological risk assessment for the same reason as pesticides.

4.3 Results From Analysis of Data: Surface Water/Sediment

This Section discusses the distribution of contaminants defined by RI data collection activities. This section describes the contaminants found in sediment, surface water, and biota tissue, organized by Reach.

4.3.1 Background Sample Locations

Contaminant background values were calculated from analysis of samples collected from Reach 1, the Sudbury Reservoir and Reservoir 3. Water and sediment samples were collected in these areas. The entire length of Reach 1 is hydraulically upgradient of the Nyanza Site. Sample stations within the Reach were selected, to the extent possible, to be removed from cultural influence. The Sudbury Reservoir and Reservoir 3 were was also chosen as background locations. The Reservoirs are within the Sudbury River drainage basin, yet are removed from the influence of the Nyanza Site, as shown on Figure 2-A.

The background sediment database is comprised of nine sample locations, which include two vertical profile samples. The total number of samples, therefore, is 11, all of which were analyzed for inorganics and four for organics. As shown on Table 4-1, chromium was detected in nine of the 11 samples and the average detected concentration (ADC) of chromium sediments was 24.26 ppm. The highest detected concentration was 55.20 ppm. Mercury was detected in two of nine samples at an ADC of 1.05 ppm. The maximum detected concentration of mercury in background samples was 1.59 ppm. Low concentrations of several PAH compounds and acetone, a volatile organic compound (VOC), were also detected in the background sediment samples.

Sample locations and associated mercury and chromium results can be located on the Figure 2 series of oversized maps (Volume IV).

The background surface water database is comprised of seven samples, all of which were analyzed for inorganics and organics. Water data is presented in Table 4-1 and sample locations are shown on oversize Figure 3-A in Volume IV. Concentrations of both mercury and chromium were below detection limits for all samples. Lead concentrations in one surface water sample exceeds the MCL. Table 4-2 compares MCL and AWQC standards to detected averages of contaminants detected in surface water samples. The only organic contaminants detected were chloromethane (11 ppb) and 1,1 - dichloroethene (3 ppb in two samples). Neither compound is pervasive in the Study Area surface waters.

4.3.2 Site Drainage System and Tributaries

This section provides a summary of data collected in the Eastern Wetlands, which is the direct receptor of Site surface runoff. This section will demonstrate that the Wetlands is a source area for mercury found in the Sudbury River and is a likely source area for some organic contaminants which were detected in sediments immediately down gradient of the wetlands.

4.3.2.1 Eastern Wetland

Ten surficial sediment samples were collected (Figure 2-D) for inorganic analysis and two sediment samples were collected for organic analysis. At these two locations, water samples were collected for both organic and inorganic analyses.

Sediment samples indicated a high frequency of detectable concentrations of mercury and chromium. The average detected concentration of mercury was 44.84 ppm and 136.79 ppm for chromium. Maximum concentrations were 152.0 ppm and 462.0 ppm for the respective metals. Aluminum is also above background concentrations. Many organic compounds including 4,4′ DDD (not Site-related compound) are present in area sediments in significant concentrations. Site-related compounds include 1,2-DCE (ADC of 72.25 ppb), TCE (one detect-170 ppb), chlorobenzene (one detect - 1,600 ppb), and 1,2-dichlorobenzene (1,2 DCB) (one detect - 7,200 ppb).

Mercury was detected in surface waters above background concentrations and above MCL and AWQCs. Mercury was detected in two samples at a maximum of 3.8 ppb and chromium was detected in one sample at 79.0 ppb which is above background concentrations. Other inorganics were present comparable to background concentrations. Site-related compounds, Trichloroethene, 1,2-DCE and 1,2 DCB were detected in water at concentrations less than 10 ppb.

4.3.2.2 Chemical Brook Culvert

Two sediment samples were collected from Chemical Brook culvert. The Culvert carries outfall from the Eastern Wetlands and Chemical Brook to the Outfall Creek, which is located north of Front street and 0.2 miles east of the downtown Front St./Main St. crossings on the north side of Ashland Center. No water samples were collected from the Culvert. See Figures 2-C and 2-D for sediment sample locations and analytical results.

A broad range of organics were detected, including many compounds seen in the Eastern Wetlands. Site-related compounds include 1,2-DCE (ADC of 25.0 ppb), TCE (one detect - 72 ppb), chlorobenzene

(ADC of 52.0 ppb) and 1,2-DCB (ADC of 1650). Nitrobenzene, a Site-related compound, was detected at a concentration of 310 ppb. The only detected occurrences of Nitrobenzene in the Study Area was in the Culvert and the immediately downgradient Outfall Creek. Also of note is an occurrence of dibenzofuran (non Site-related compound) at a concentration of 92 ppb (SD3-201). Numerous PAHs were detected at concentrations over 1,000 ppb. These compounds are expected in this area, as this culvert serves as a stormwater drain for a large commercial/industrial parking area.

Inorganic contaminant concentrations in the Culvert are generally lower than those detected in the Eastern Wetlands. However, mercury and chromium were detected in both sediment samples at maximum concentrations of 7.1 ppm and 135 ppm, respectively.

4.3.2.3 Outfall Creek

Three sediment samples were collected. All were analyzed for inorganics and two for organics. One water sample was collected.

Elevated concentrations of mercury and chromium were noted in all sediment samples collected from this Creek. The ADC for mercury was 35.33 ppm with a maximum concentration of 99.20 ppm. The ADC for chromium was 341.8 ppm with a maximum concentration of 988.0 ppm. Aluminum and iron were present above background concentrations. Volatile compounds detected in the Eastern Wetlands were detected again in the Outfall Creek at concentrations less than 10 ppb. Site-related benzenes are present including the furthest downgradient occurrence of nitrobenzene (2 detects - maximum of 500 ppb); 1,2-dichlorobenzene (2 detects - maximum of 290.0 ppb); and 1,2,4 trichlorobenzene (3 detects - maximum 1300 ppb). An extensive list of PAH compounds were detected in the 10^3 ppb range.

The water sample analysis detected lead at 5.7 ppb, which was above the MCL and the chronic AWQC level. Barium, cobalt and zinc were detected above MCL and AWQC levels and background concentrations. Site-related organic compounds including 1,2-DCE, TCE, and DCBs were present at concentrations less than 15 ppb. These organic compounds have been detected in upgradient areas tracing back to the Eastern Wetlands.

4.3.2.4 Raceway

Two sediment and one surface water samples were collected from the Raceway as a part of follow-up Phase II sampling. Samples were collected upgradient of the confluence of the Outfall Creek and the Raceway (Figure 2-C). At the time of sample collection, a blue-colored light sheen was noted on the surface of the water flowing out of the culverted section of the Raceway. No source for this sheen could be identified.

Two-depth sediment samples were collected in two locations in the Raceway. Mercury and chromium were present in elevated concentrations in all samples. The ADC for mercury was .71 ppm and the maximum concentration was .97 ppm, the ADC for chromium was 155.5 ppm and the maximum concentration was 208 ppm. Other metals including arsenic, beryllium, cadmium, cobalt, lead, nickel, and vanadium were also detected at concentrations above background levels.

Several Site-related organic contaminants were present in these samples: 1,2-dichloroethene was detected at an ADC of 736.67 ppb, trichloroethene had an ADC of 17,071.25 ppb, chlorobenzene had an ADC of 5,917.5 ppb and 1,2-dichlorobenzene had an ADC of 5,200 ppb. Non-Site-related volatile organic contaminants MEK, acetone and methylene chloride were also detected at lower concentrations. An extensive list of PAH compounds were detected in the 10^3 to 10^4 ppb range.

Pesticides 4,4'-DDD and 4,4'-DDE were detected in both sample locations at an ADC of 83.2 ppb and 18 ppb, respectively. A potential localized source of these compounds is located in Mill Pond, which is upgradient of these sample locations. Similar occurrences of pesticides were noted in the main branch of the River (Reach 2) and are discussed further in Section 4.3.3.12.

One PCB compound, Aroclor 1254, was detected in both upper and lower sample intervals of one sample. A positive detection of PCBs was found at one other sample location (near the Saxonville Impoundment) in the Study Area. The source of these contaminants is not known.

Site-related contaminants including 1,2-DCE, chlorobenzene, TCE, and mercury, generally were present in higher concentrations in the deeper interval samples. This suggests that contaminants in the Raceway could be the result of discharge of contaminated groundwater in this area.

Site-related inorganic contaminants were not detected in the surface water sample. Only barium was detected above background concentrations.

Two Site-related organic contaminants, 1,2-DCE and TCE, were detected in the Raceway. Both occurred at concentrations of 2 ppb.

4.3.2.5 Cold Spring Brook

Cold Spring Brook is a tributary of the Sudbury River. It flows into the River upgradient of Reservoir 2. Two sediment samples were collected from this area and analyzed for inorganics. One water sample was collected and analyzed for inorganics and organics.

Mercury and methylmercury were not detected in the sediments of Cold Spring Brook. Chromium was detected below background concentrations. Lead was detected in sediments at a maximum of 328 ppm.

The water sample indicated the presence of one phthalate compound bis(2-ethylhexyl)phthalate, at a concentration of 56 ppb. This compound is a common contaminant associated with plastics and its presence could be an artifact from sample collection procedures.

Chromium, lead, and mercury were not detected in the surface water sample collected from this location. Other inorganics were detected at concentrations comparable to background levels. Silver exceeded AWQC levels. MCL and AWQCs have not been established for other inorganics detected in the surface water sample.

4.3.2.6 Heard Pond

Heard Pond, located west of the Sudbury River in Reach 7, is a small sized eutrophic pond surrounded in most part by Cattail Marsh and Red Maple Swamp. This pond was considered a separate reach, since it is reported to be occasionally flooded by the Sudbury River.

One sediment sample was collected from Heard Pond and analyzed for inorganics. Mercury was detected at 3.5 ppm and chromium at 40.20 ppm, both above background concentrations. Other metals were detected at concentrations comparable to background levels.

4.3.3 Sudbury River

4.3.3.1 Reach 1 (Includes Cedar Swamp Pond)

Seven sediment samples were collected for inorganic analysis and three for organic analysis. Six surface water samples were collected for both inorganic and organic analyses. Reach 1 is a background Reach, and includes all of the background samples collected within the River. Since Reach 1 samples, in part, established background levels of contaminants, only positive detections of Site-related contaminants will be discussed.

Two sediment samples contained concentrations of mercury above detectable limits, SD3-103 (1.6 ppm) and 104 (.5 ppm). Chromium was detected in concentrations of 6.6 ppm (SD3-209) to 55.2 ppm (SD3-208). These samples are less than 300 feet apart, indicating a wide variability in concentrations as a function of the sample point. Acetone was detected in one sample (SD3-152 at 10 ppb) and several PAH compounds were present. These compounds may have been introduced to the River through road run off.

Volatile compounds were detected in three water samples at concentrations below 11 ppb. None of the compounds persist into Reach 2.

No methylmercury was detected in background sediment samples.

4.3.3.2 Reach 2 (Includes Mill Pond)

Reach 2 is the potential receptor of the organic groundwater plume migrating from the Nyanza Site (Ebasco, 1991) and is the receptor, through the Outfall Creek and Raceway, of Site run-off from the Eastern Wetlands. Two distinct groupings of samples are present in Reach 2 with regard to Site-related contaminants; those above the confluence of the Raceway and the River are more characteristic of background samples; while those below this confluence generally contain Site-related contaminants above background levels.

Twelve sediment samples were collected for inorganic and thirteen for organic analyses. Seven water samples were collected for both inorganic and organic analyses.

Mercury and chromium concentrations in sediments increased sharply in this Reach. The mercury ADC was 6.81 ppm as compared to background levels of 1.04 ppm and the ADC for chromium was 36.32 as compared to the background concentration of 24.26 ppm. More significantly, maximum detected concentrations for mercury and chromium were 30.60 ppm and 216.0 (both in SD3-115), respectively, as compared to background maximums of 1.59 ppm and 55.22 ppm. Manganese was elevated above background concentrations, but other inorganics were comparable to background levels. Site-related organic contaminants which were detected in Reach 2 sediment include 1,4- and 1,2 - dichlorobenzene. Concentrations were between 440 and 1800 ppb.

A wide range of PAH compounds were detected in Reach 2, reflecting the commercial/industrial nature of the area. Concentrations were in the 10^3 to 10^4 ppb range, an order of magnitude greater than those found in the Outfall Creek, suggesting an input from an off-Site source. Dibenzofuran (2 detects) was found at a maximum concentration of 1060 ppb (SD3-204). This compound was also noted in the Chemical Brook Culvert.

4,4′-DDD and 4,4′-DDE were detected in Mill Pond sediments through to the confluence of the River and the Raceway. The highest concentration of 1400 ppb occurred in sample SD3-156, in Mill Pond. Decreasing concentrations were noted in successive samples, suggesting a source in Mill Pond and down-river transport and subsequent dispersion.

Mercury was not detected in Reach 2 water samples, however chromium was detected in one sample at 7 ppb (SW3-130). Other inorganics were sharply elevated compared to background samples. The only organic contaminant detected was 1,2 DCE (one detect) at 1.0 ppb. Mercury and selenium were not detected in surface water samples, other inorganics with established MCLs and AWQCs were present in concentrations which exceeded these levels. These organics include Beryllium, Cadmium and Lead.

Three sediment samples were analyzed for methylmercury. A concentration of 312 ppb was detected in one sample; others were below detection limits.

4.3.3.3 Reach 3 - Reservoir 2

A total of 23 sediment samples were collected for inorganics and nine for organic analyses. Five water samples were analyzed for inorganics and organics.

The highest concentrations of mercury and chromium in the River sediments were detected in this Reach (Reservoir 2). The average detected concentration for mercury is 17.43 ppm and for chromium, 305.62 ppm. Maximum detected concentrations are 49.10 ppm (SD3-122) and 2620.00 ppm (SD3-117) respectively. Also, the frequency of detection was above 90 percent for both metals. Two occurrences of Site-related organic contaminants were noted in sediments; 1,4-dichlorobenzene and 1,2,4-trichlorobenzene. The maximum concentration of both compounds was 180 ppb. Numerous PAH compounds occurred in the scattered sediment samples in the 10^3 to 10^4 ppb range.

DDD and DDE were detected in four scattered samples in concentrations up to 370 ppb.

The nature of the contamination in Reach 3 is similar to Reach 2, with the noted elevation of mercury and chromium concentrations.

Mercury and chromium were not detected in water samples collected from Reach 3. Other inorganics were detected at concentrations comparable to background with the exception of selenium, which was detected in one of five samples at a concentration of 19,300 ppb. This concentration exceeds MCL and AWQCs. There is no explanation for this occurrence of selenium. Barium, lead and zinc exceed established AWQCs. One phthalate compound was noted at trace concentrations in one water sample.

Eighteen sediment samples were analyzed for methylmercury including nine shallow sediment samples and nine deep samples. Monomethylmercury was detected in one sample, at 26.3 ppb in the SD3-130 shallow interval sediment.

4.3.3.4 Reach 4 - Reservoir 1

Thirteen sediment samples were collected and analyzed for inorganics and two for organics. Two water samples were analyzed for both inorganic and organics.

Mercury and chromium concentrations in sediments decreased from Reach 3. The ADC for mercury was 3.69 ppm and for chromium 76.26 ppm. Maximum concentrations of both metals dropped significantly, but the frequency of detection (indicating a widespread distribution) remained high. Aluminum occurred in concentrations above background levels, but other inorganics were detected at concentrations comparable to those found in background. Several common organic compounds are present in several sediment samples. Acetone, methyl ethyl keytone (MEK) and benzoic acid were present in relatively low concentrations. No Site-related organic contaminants were detected in Reach 4 sediments. PAHs were detected in the range of 90 to 400 ppb, significantly less than concentrations found in Reaches 2 and 3. This Reach is characterized by a more residential/rural setting, with less contribution from road run-off and industrial activity.

Chromium was detected in one water sample at a concentration of 6 ppb (SW3-113). Mercury was not detected. Other inorganics concentrations were comparable to background levels. Lead exceeded MCL and AWQC levels. The only organic detected in one surface water sample was MEK, at a concentration of 10 ppb.

Seven sediment samples were analyzed for methylmercury which was detected in one deep interval sample at 79.3 ppb (SD3-132).

4.3.3.5 Reach 5

Six sediment samples were collected and analyzed for inorganics and one for organic compounds. Two water samples were analyzed for both inorganic and organic compounds.

Mercury and chromium concentrations dropped from those detected in upstream Reaches, however remained above background. The ADCs for the metals are 1.17 ppm and 30.62 ppm, respectively. Frequency of detects remained high. Concentrations of lead and silver are above background levels. Other inorganics were comparable to those found in background. Scattered concentrations of PAHs and other semi-volatile compounds were detected up to 1400 ppb.

Mercury and chromium were not detected in surface water and were not detected in downgradient Reaches 6 or 7, which was the downgradient extent of water sampling. Barium and arsenic concentrations exceeded established MCLs. No organics were detected in surface water samples.

Methylmercury was not detected in sediments collected in this Reach.

4.3.3.6 Reach 6 - Saxonville Impoundment

Twenty one sediment samples were collected for inorganics and four for organics analysis. Four water samples were collected for both inorganic and organic analyses.

Mercury and chromium concentrations in sediments increased within the Saxonville impoundment. ADCs were 5.00 ppm and 69.84 ppm for the respective metals. A trend emerged; these contaminants are concentrated in the low flow velocity reservoirs and impoundments. This trend will be discussed later in this Section and in Section 5.0.

Cobalt, cadmium (frequency 4 of 4) and magnesium are present in concentrations above background levels while other inorganics concentrations were comparable to background levels. Organic contamination was present at higher concentrations than upgradient Reaches, in this more industrialized area. Acetone, MEK, benzoic acid were present in concentrations up to 630 ppb. PAH compounds were widespread, at concentrations up to 3400 ppb.

DDD was present in one sample (SD3-138) at a concentration of 700 ppb.

Inorganics concentrations in surface water were comparable to background levels. Barium and lead exceeded MCL and AWQC levels. Only one organic compound, a pesticide, Lindane, was present at a concentration of 0.015 ppb in one sample.

Methylmercury was not detected in sediment samples.

4.3.3.7 Reach 7

Thirteen sediment samples were collected for inorganic and three for organic analyses. Four water samples were collected for both inorganic and organic analyses.

Mercury and chromium concentrations in sediments dropped to ADCs of 2.08 ppm and 61.59 ppm, respectively. Frequency of detection was 62 percent for mercury and 77 percent for chromium, indicating a general decrease in the pervasive nature of contamination. Cadmium was present, again at levels above background concentrations. Acetone, MEK and benzoic acid were again detected in sediments up to 1600 ppb. The pervasive PAH compounds were present in concentrations similar to those found in the previous Reach. A pesticide, gamma chlordane 2, and a PCB, Aroclor 1254, were present at low concentrations; each was detected in one sample. Other inorganics are comparable to background. Arsenic was present in relatively low concentrations, however a maximum of 40.60 ppm was detected in one sample.

Inorganic constituents in surface water were comparable to background levels. Barium and silver were detected in concentrations above MCL and AWQCs respectively. No organic compounds were detected in surface water.

Methylmercury was not detected in sediment samples.

4.3.3.8 Reach 8 - Great Meadows Natural Wildlife Refuge

Six sediment samples were analyzed for inorganic compounds. Sediment organic analyses were not conducted in Reaches 8 through 10, nor were surface waters collected in these Reaches.

Mercury and chromium concentrations again dropped. The ADC for mercury was 1.62 ppm; chromium fell below background concentrations. Cadmium was above background levels and arsenic was detected in one sample at a concentration of 30 ppm. Other inorganics were comparable to background levels.

4.3.3.9 Reach 9 - Fairhaven Bay

This Reach includes Fairhaven Bay. Although there is no impoundment on the Bay, this part of the River exhibits characteristics of an impoundment with the associated increase in mercury and chromium concentrations.

Three sediment samples were analyzed for inorganics. The ADC of mercury and chromium were 3.15 ppm and 50.27 ppm, respectively levels twice those found in the upgradient Reach 8. Frequency of detection also rose, indicative of the relatively more widespread nature of contamination in the Bay compared to adjacent River runs. Cadmium was again present in concentrations above background levels. Arsenic was also elevated above background due to a maximum concentration of 64.60 ppm in one sample of three. Other inorganics were found at levels comparable to background.

4.3.3.10 Reach 10

This was the last Reach sampled. The downgradient end of this Reach is delineated by the confluence of the Sudbury and the Assabet Rivers.

Five sediment samples were collected and analyzed for inorganics. Mercury was detected in two of five samples with an ADC of 0.37 ppm and a maximum detection of 0.53 ppm. The background ADC for mercury was 1.05 ppm with a maximum detected concentration of 1.59 ppm. Concentrations of mercury in Reach 10 sediments were thus comparable to background levels. Chromium remained below background concentrations.

4.3.3.11 Bordering Wetlands

Ten samples were collected from six locations in the bordering wetlands within Reaches 2, 3, and 4. Four of these sample locations were in Reach 2 and one each in Reaches 3 and 4. At four of these sample locations (two in Reach 2, and Reaches 3 and 4), samples were collected from two depth intervals. All samples were analyzed for inorganic compounds, and two were analyzed for methylmercury.

The bordering wetlands samples were located above the normal River level, but within the potential seasonal flood zone. Analysis of these samples provides information regarding the presence of contaminants transported from the River bed sediments to the wetlands. This information is used in the risk assessment.

The following discussion presents a comparison of results from bordering wetlands samples and those from the open water areas of the associated reach.

> Reach 2: Three wetland areas were sampled in this Reach: one at the confluence of the Outfall Creek and the Raceway (SD-113, 114); a second at Mill Pond (sd-115), and a third downgradient of the confluence (SD-159).
>
> Mercury and chromium were present in sediments at concentrations comparable to background concentrations and below the averages for Reach 2. Other inorganics were also comparable to background concentrations. Organic analyses were not conducted on these samples.
>
> The wetland at the Raceway confluence has been impacted by Site-related inorganic contaminants. Mercury and chromium concentrations in sample SD3-113 were 7.6 and 101 ppm respectively, significantly above detected background concentrations and above average detected concentrations for

Reach 2. Mercury and chromium were below detectable limits in sample SD3-114. Concentrations of other inorganics were comparable to Reach 2.

Methylmercury was not detected in the bordering wetlands, although it was detected in one sample of three collected from Reach 2 (River) sediments.

Reach 3: Some heavy metals including copper (15.4 mg/kg), chromium (11.8 mg/kg), and cobalt (4.8 mg/kg) in the bordering wetlands samples (SD3-161) were at least one order of magnitude less than those found in Reservoir 2 sediments. Mercury, in particular, was detected at concentrations three orders of magnitude less than the average detected concentration in the reservoir.

Reach 4: Mercury was not detected in this bordering wetland, while Reservoir 1 samples showed an ADC of 3.69 ppm. Chromium was detected in the wetland at 15 ppm, compared to the reservoir ADC of 66.8 ppm. Nickel and zinc were both detected at one order of magnitude less than the average detected concentration for reservoir samples.

Four locations were sampled in discrete vertical intervals. Two upper interval mercury results did not pass data validation. Considering the remaining two samples, mercury concentrations decreased significantly with depth. Chromium showed no trend. Other heavy metal concentrations also decreased with depth.

4.3.3.12 Pesticide Analyses

Scattered occurrences of various pesticides, in particular 4,4'-DDT (DDT) and degradation products 4,4-DDD' (DDD) and 4,4-DDE' (DDE) were detected in the Study Area.

The pesticide DDT was detected in 13 sediment samples located in Reaches 2 through 6 and in the Eastern Wetlands as summarized below:

Sample	Reach	DDT	DDD	DDE	Other
SD3-156	2	1400 ug/kg			
SD3-157	2	115 ug/kg	33 ug/kg		
SD3-202	2	71 ug/kg		58 ug/kg	
SD3-204	2	105 ug/kg			
SD3-115	2		117 ug/kg		
SD3-106	EW		180 ug/kg		
SD3-118	3		53 ug/kg		
SD3-122	3		60 ug/kg		
SD3-125	3		370 ug/kg		
SD3-129	3		130 ug/kg		
SD3-138	5		700 ug/kg		
SD3-148	7				18 ug/kg*
SD3-244	Raceway		104 ug/kg	14.8 ug/kg	15.5 ug/kg**
SD3-245	Raceway			21.2 ug/kg	

* Gamma Chlordane
** Heptachlor Epoxide

The highest concentration of DDT occurred near the outlet of the Mill Pond (SD3-156), at a concentration of 1400 ppb. Consecutive down River samples SD3-157, 202 and 204 contained decreasing concentrations of DDT and DDD, suggesting a release into Mill Pond and subsequent down River transport and dilution of contaminated sediment. Pesticides were also detected in the Raceway, which is also downgradient from Mill Pond.

Other downstream occurrences of pesticides were primarily DDD, with the highest concentration of 700 ppb occurring in sample SD3-138, located in the Oxbow Lake of Reach 5. One sample, SD3-148, contained 18 ppb of Gamma Chlordane. This sample was located downstream of the Saxonville Dam in Reach 7. These detections appear to occur randomly throughout the Study Area.

One occurrence of a pesticide in a surface water sample was located in Reach 7, in the vicinity of Heard Pond. The sample, SW3-117 contained Gamma-BHC, or Lindane, at a concentration of 0.015 ppb. Lindane was not detected in sediment samples.

Pesticides are discussed in more detail in Section 5.0 and in the risk assessments, where this group of chemicals is of greater significance.

4.3.3.13 Polychlorinated Biphenyls (PCBs) Analyses

One sediment sample, SD3-150, collected in Reach 7, contained 510 ppb of PCBs. There is no obvious source of this compound in the vicinity of this sample location. PCBs were also found in two sediment samples collected in the Raceway at 589 ppb and 111 ppb.

PCBs were not detected in any surface water samples. PCBs are discussed further in the risk assessments.

4.3.3.14 Inorganic Leachability Analysis

Two extraction procedure analyses were performed, Toxicity Characteristic Leaching Procedure (TCLP) and ACOE elutriate analysis. TCLP analysis is intended to identify those wastes which pose a hazard because of their potential to leach significant concentrations of specific toxic constituents. The procedure is used to evaluate leaching potential of hazardous materials in a worst case scenario, such as disposal in a landfill.

Two separate extraction procedures are used for TCLP. In this procedure, two extracts are made, one is analyzed for volatile organic compounds, while the second is analyzed for metals and other organics. The extraction procedure takes into account sample-specific parameters such as grain size, pH and percent solids to determine the proper strength of the extraction fluid.

Specific to this study, the method is a measure of the stability of inorganics adsorbed to sediment particles. This is determined by leaching the sediment sample with an aqueous solution with a pH of 5, and quantifying the concentration of inorganics which are leached.

River water with a pH of 5 would be characteristic of a stressed river system. Measured pH values in surface water were consistently in the six to seven range throughout the monthly water quality sampling events (see Appendix L). A pH of 5 was measured once in November 1989 at sample location SD3-110 during the Phase I sampling event. This measurement is considered an outlier because other measurements collected in the vicinity, SW3-109 and 111, indicated a neutral reading of pH 7.

Mercury was detected in the leachate at a frequency of 2 of 24 TCLP samples. Concentrations of total mercury to TCLP extract mercury are presented below:

Sample #	Total Mercury	TCLP
SD3-112	99.2 ppm	.29 ppm
SD3-115	30.6 ppm	.23 ppm

Relatively small amounts of mercury were leached in less than 10 percent of the samples analyzed. This analysis also detected levels of leachable lead on the average of 91.35 ppm (all reaches tested), and chromium at 35.39 ppm (Reaches 2, 3, 4). Other metals were also detected by this procedure, including arsenic (average of 8.77 ppm), cadmium (average of 6.62 ppm), copper (average of 21.5

ppm) and silver (average of 4.8 ppm).

The results indicate that mercury and chromium are relatively stable within the River sediments and are not readily transferred to the aqueous environment under normal conditions. These results also indicate that dredged sediments would likely leach some metals in a landfill situation. This data will be further evaluated in the feasibility study process.

Mercury and chromium were also detected by ACOE elutriate analysis, which was performed on 27 shallow sediment samples during Phase I. Elutriate analysis of sediments is performed to determine the effect of turbulent river water on the associated sediments and the possibility of contaminant transfer from sediment to surface water. River water and sediment is agitated to simulate a dredging scenario. The concentrations of the analytes are measured in the water after agitation.

These results indicate that a disturbance of the sediments could cause relatively small amounts of mercury and chromium to transfer from the sediment to the surface water. These analyses resulted in maximum concentrations of 1.1 ppb of mercury at location SD3-110 and 504 ppb chromium at location SD3-150. These values exceed chronic ambient water quality criteria (2.0 ug/l, chromium; 0.012 ug/l mercury). These results will be further evaluated in the Feasibility Study.

4.3.3.15 Total and Dissolved Inorganics in Water

Several water samples were analyzed for total and dissolved metals to determine the speciation of contaminants between those being adsorbed onto particulates and those in the dissolved phase. This information will be utilized in determining contaminant transport mechanisms and is a consideration for the bioavailability of contaminants to biota.

The results indicate the presence of mercury and chromium in several water samples and the presence of these and other metals at low concentrations in the dissolved phase. Mercury was detected in three unfiltered sample locations between the Eastern Wetlands and the inlet of Reservoir 2. The highest concentration was 3.85 ppb (SW3-104). The only apparent contaminant distribution pattern is the occurrence of all samples in proximity to the Nyanza Site. Results are listed below:

Sample No.	Unfiltered Mercury	Filtered Mercury
SW3-104	3.80 ppb	0.49 ppb
SW3-105	0.37 ppb	0.37 ppb
SW3-106	0.48 ppb	0.42 ppb

Chromium was detected in four surface water samples. Samples were located in the Eastern Wetlands (SW3-104), in the Outfall Creek (SW3-106), the inlet to Reservoir 2 (SW3-113), and in Reach 2, downstream from Mill Pond (SW3-130). Sample results are summarized below:

Sample No.	Unfiltered Chromium	Filtered Chromium
SW3-104	79.0 ppb	non-detect
SW3-106	5.6 ppb	non-detect
SW3-113	6.0 ppb	no analysis
SW3-130	7.0 ppb	non-detect

The sample results are widely scattered with a random distribution. The absence of chromium in the filtered samples indicates the chromium is probably adsorbed to suspended particulates. This will be discussed further in Section 5.0.

Metals often present in unfiltered samples but noted to be absent in their dissolved fraction include barium, beryllium, cadmium, copper, cobalt, iron and vanadium.

4.3.3.16 Analysis of Vertical Distribution of Contaminants

Thirty-seven sediment samples were collected from two depth intervals, zero to six inches and six to 12 inches at selected sample stations. Sample stations were chosen to obtain a representative indication of vertical distribution of contaminants in sediments throughout the Study Area.

Mercury and chromium concentrations increased with depth in several samples collected from Mill Pond. This is shown by SD3-154, 155, and 156 in Figure 2-C. The upstream Raceway sample (SD3-244) also exhibited this pattern. In samples collected downstream and in the reservoirs, this pattern was not observed.

Samples from the deep intervals were also analyzed for organic compounds. No organics were detected in many of the samples. One sample, SD3-156 (Mill Pond), showed concentrations of 1,4-dichlorobenzene (1100 ppb) and 1,2-dichlorobenzene (580 ppb), in deep intervals as well as PAH compounds which were reported in corresponding shallow intervals. The dichlorobenzene concentrations cannot be compared to the data for the shallow interval, as the data for dichlorobenzene in the shallow interval was rejected during data validation processes.

In the Eastern Wetlands, mercury and chromium are often present in higher concentrations in the deeper interval such as samples SD3-107, 108 and 109. This is discussed further in Section 4.7.

Four vertical profile samples were collected from Mill Pond in the area where the Site related contaminated groundwater plume is projected to intersect Reach 2. One of the purposes of these samples was to determine if Site specific organics (aniline etc.) were present. These compounds were not detected in either sample.

4.4 Results from Analysis of Data: Fish Tissue

4.4.1 Summary Tables

Table 4-3 and 4-4 present frequency, average and maximum concentrations of contaminants in fish offal and fillet tissue detected during the Operable Unit III sampling work. These tables presents statistics for the Study Area as described in Section 2.0, and also present the data collected in the background area as a subset of the first group. The data are presented in wet weight.

Two average values are presented for each parameter in this table. Detected averages are calculated by averaging only the values positively detected in the samples. Reported averages were calculated by using half detection limits for results reported below detection limits.

4.4.2 Inorganic Contaminants

Most average concentrations of metals in fish tissue collected throughout the Study Area exceed by a factor of 2 the average concentrations calculated for background locations. Magnesium, copper, potassium, nickel, selenium, and sodium were exceptions, indicating that the concentrations of these metals in fish tissues downstream of the Nyanza Site are not elevated above background concentrations.

Mercury was detected in fish tissue samples from 0.1 ppm to 9.6 ppm. The detected average throughout the Study Area was 2.02 ppm. Since mercury is bioaccumulated, it tends to be found in higher concentrations in older predatory fish. The data generally support this rule, with some aberrations.

The maximum concentration of mercury (9.6 ppm) was detected in a two year old yellow perch collected from Cedar Swamp Pond (a Background location within Reach 1). This occurrence may be the result of a transcription or laboratory error, however this cannot be confirmed. Although this result seems unlikely to represent reliable data, no reason could be identified to reject this data.

This occurrence represents the difficulty posed by discussing individual data points; a discussion of data groups better represents distribution of contaminants.

Fish tissue samples contained levels of mercury in the 1 to 2 ppm range in areas downstream of the Raceway confluence. Upstream of this confluence, the detections were between 0.1 ppm and 1.0 ppm although the yellow perch discussed in the preceding paragraph raised the detected average to 1.19 ppm in Background areas. Levels of mercury in bass tended to be one order of magnitude higher than those in perch and bullhead. This may be a factor of age or feeding habits. As bass are a larger, more aggressive fish, they may feed on a higher trophic level than do perch, and actually will feed on perch. This exposes the bass to higher concentrations of bioaccumulated and bioconcentrated contaminants.

No obvious trends were exhibited by the other inorganic data in fish tissues. Other heavy metals were detected in fillet and offal samples as shown in Tables 4-3 and 4-4, including arsenic (maximum of 0.114 ppm); Colbalt (maximum of 1.26 ppm); lead (maximum of 5.6 ppm); Selenium (maximum of 4.0 ppm) and vanadium (maximum of 1.57 ppm). Antimony, cadmium, nickel, silver and thallium were detected in five or less of the 258 samples collected.

4.4.3 Organic Contaminants

As shown in Table 4-4, monomethylmercury was detected in 77 of 82 samples of fish tissue analyzed for this contaminant in ranges between 221 and 4200 ppb. Tables 4-3 and 4-4 show that ADCs for methlmercury in fish fillet are generally 50 percent of the ADCs for total mercury. Exceptions to this observation do exist, however; ADCs for these compounds were much closer in all species of fish collected from Reservoir 1, and the ADC for methylmercury actually exceeded the ADC for total mercury in yellow perch collected from Reservoir 2. This exceedence is possible because different individuals yellow perch were analyzed for each of the two parameters. Offal data shows a similar trend, but limited data points make any trend difficult to confirm.

A number of pesticides and PCB compounds were detected in fish tissues. Most significant was a repeated occurrence of PCBs Aroclor 1254 and 1260, in concentrations as high as 760 ppb. Also significant was a repeated occurrence of 4,4′ DDE, 4,4′ DDD and 4,4′ DDT. DDE was detected in over 75 percent of fish tissue samples analyzed, and concentrations ranged from detection limits to 250 ppb. Other pesticides were detected less frequently, including chlordanes, dieldrin, endrins, and endosulfan compounds.

These compounds were detected in less than 50 percent of the samples analyzed, and were generally detected at concentrations less than 10 ppb.

Very few organic compounds were detected in background samples. Compounds that were detected were pesticides, a PCB compound, a phenol and a PAH compound. Of the pesticides, DDE, DDD, DDT and dieldrin were as frequently detected as were PCBs. These compounds were most frequently detected throughout the Study Area. Average concentrations of pesticides in the Study Area were less than twice those calculated for background.

Some of these pesticide compounds are bioaccumulated in the fatty tissues of fish, rather than the muscle. Viscera (offal) was analyzed separately from fillet meat in the Phase I collection activities, and as expected, some organics, notably DDE and PCBs (1260), were found at higher levels than in the viscera samples. Bioaccumulation is discussed at length in Section 7.0.

Other organic compounds detected in fish tissue include several volatiles, several phthalate compounds, phenols, and several PAH compounds. Most notable was a frequent detection of phenol at an average concentration of 825 ppb. Most other contaminants were detected in less than 5% of the total number of samples, and these compounds were generally not detected in background samples.

All data values specific to reach and species are presented in Tables 4-3 and 4-4.

4.5 Benthic Survey Results

Results of the sorting and preliminary identification of macroinvertebrates are presented in Table 4-5. Table 4-5 indicates the total number of specimens per group and the percent occurrence of the specimens sorted at each station. Only eight samples from the first 28 sampling stations (SD3-101 to 130/Reaches 1 to 3) contained at least 100 macroinvertebrates; four of these stations were background locations or reference stations. Overall, samples from stations SD3-107 to SD3-130 (Reaches 2 and 3) contained fewer organisms (especially insect larvae), which reflect greater environmental stresses, than did samples from stations SD3-131 to 150 (Reaches 4 to 7). Table 4-6 contains grain size, TOC and dissolved oxygen data collected at river locations for evaluation purposes.

Reference station SD3 101 was dominated by Chironomidae (midges). Their presence was probably indicative of oxygen deprivation in the deep water sediment of this location behind the Sudbury Reservoir dam. Reference stations SD3-103 and 104 (Reach 1) were upstream of the Site and reflected better water quality than the most severely impacted stations of SD3-111 to 116, which contained the fewest macroinvertebrates. Two of these stations (SD3-110 and 111) contained no macroinvertebrates. Station SD3-110 was located at the confluence of Chemical and Trolley Brooks. Sample SD3-106 was collected at a surface water location in the eastern portion of the Eastern Wetlands. Data from stations SD3-106 and 110 should not be

TABLE 4-5

FINAL

BENTHIC SAMPLES SUMMARY DATA – PHASE I
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION	INSECTS (NO. / %)	MIDGES (NO. / %)	OTHERS (NO. / %)	OLIGO-CHAETES (NO. / %)	TOTAL SPECIMENS	SEDIMENT CONCENTRATE OD	M	S	G	W
SD3- 101	0 / 0	104 / 100	0 / 0	0 / 0	104	100 %	- %	- %	- %	- %
SD3- 101 -DU	0 / 0	100 / 95	0 / 0	5 / 5	105	-%	- %	100 %	- %	- %
SD3- 102	3 / 11	18 / 67	4 / 15	2 / 7	27	10 %	- %	- %	90 %	- %
SD3- 103	9 / 26	9 / 26	17 / 49	0 / 0	35	75 %	- %	25 %	- %	- %
SD3- 103 -DU	8 / 8	7 / 7	83 / 83	2 / 2	100	15 %	5 %	80 %	- %	- %
SD3- 104	24 / 36	39 / 59	3 / 5	0 / 0	66	60 %	- %	- %	40 %	- %
SD3- 105	4 / 4	27 / 25	72 / 67	4 / 4	107	70 %	30 %	- %	- %	- %
SD3- 106	0 / 0	7 / 21	4 / 12	22 / 67	33	20 %	80 %	- %	- %	- %
SD3- 106 -DU	0 / 0	0 / 0	0 / 0	25 / 100	25	35 %	65 %	- %	- %	- %
SD3- 110	0 / 0	0 / 0	0 / 0	0 / 0	0	-%	- %	50 %	50 %	- %
SD3- 111	0 / 0	0 / 0	0 / 0	0 / 0	0	30 %	- %	- %	70 %	- %
SD3- 112	1 / 8	0 / 0	0 / 0	12 / 92	13	60 %	- %	- %	- %	40 %
SD3- 115	2 / 29	0 / 0	5 / 71	0 / 0	7	100 %	- %	- %	- %	- %
SD3- 116	2 / 17	0 / 0	4 / 33	6 / 50	12	-%	- %	75 %	25 %	- %
SD3- 117	21 / 20	39 / 37	40 / 38	5 / 5	105	40 %	- %	60 %	- %	- %
SD3- 118	6 / 10	27 / 43	26 / 41	4 / 6	63	100 %	- %	- %	- %	- %
SD3- 119	0 / 0	27 / 25	71 / 67	8 / 8	106	100 %	- %	- %	- %	- %
SD3- 120	6 / 6	72 / 72	13 / 13	9 / 9	100	100 %	- %	- %	- %	- %
SD3- 121	0 / 0	78 / 72	9 / 8	21 / 19	108	100 %	- %	- %	- %	- %
SD3- 122	2 / 2	47 / 55	20 / 24	16 / 19	85	100 %	- %	- %	- %	- %
SD3- 123	0 / 0	16 / 64	8 / 32	1 / 4	25	100 %	- %	- %	- %	- %
SD3- 124	2 / 14	6 / 43	4 / 29	2 / 14	14	40 %	- %	60 %	- %	- %
SD3- 125	0 / 0	25 / 74	5 / 15	4 / 12	34	100 %	- %	- %	- %	- %
SD3- 126	1 / 4	8 / 35	0 / 0	14 / 61	23	10 %	- %	- %	90 %	- %
SD3- 127	2 / 2	67 / 83	0 / 0	12 / 15	81	100 %	- %	- %	- %	- %
SD3- 128	0 / 0	12 / 63	5 / 26	2 / 11	19	90 %	10 %	- %	- %	- %
SD3- 129	2 / 7	27 / 93	0 / 0	0 / 0	29	35 %	- %	70 %	- %	- %
SD3- 130	6 / 7	71 / 86	3 / 4	3 / 4	83	50 %	- %	50 %	- %	- %
SD3- 131	5 / 5	93 / 90	1 / 1	4 / 4	103	90 %	- %	10 %	- %	- %
SD3- 132	15 / 15	33 / 33	50 / 50	2 / 2	100	10 %	70 %	15 %	- %	- %
SD3- 133	14 / 14	58 / 56	23 / 22	8 / 8	103	100 %	- %	- %	- %	- %
SD3- 134	13 / 12	63 / 59	31 / 29	0 / 0	107	90 %	10 %	- %	- %	- %
SD3- 135	15 / 15	59 / 58	27 / 27	0 / 0	101	60 %	40 %	- %	- %	- %
SD3- 136	10 / 10	3 / 3	76 / 75	13 / 13	102	100 %	- %	- %	- %	- %
SD3- 137	6 / 4	42 / 30	92 / 66	0 / 0	140	100 %	- %	- %	- %	- %
SD3- 138	41 / 40	21 / 21	40 / 39	0 / 0	102	50 %	50 %	- %	- %	- %
SD3- 139	7 / 7	3 / 3	94 / 89	2 / 2	106	65 %	35 %	- %	- %	- %
SD3- 139 -DU	6 / 5	5 / 4	99 / 88	2 / 2	112	60 %	40 %	- %	- %	- %
SD3- 140	24 / 23	17 / 16	60 / 58	3 / 3	104	100 %	- %	- %	- %	- %
SD3- 141	5 / 5	12 / 12	78 / 76	7 / 7	102	90 %	10 %	- %	- %	- %
SD3- 142	4 / 4	20 / 19	80 / 77	0 / 0	104	40 %	60 %	- %	- %	- %
SD3- 143	14 / 13	5 / 5	85 / 82	0 / 0	104	70 %	30 %	- %	- %	- %
SD3- 144	11 / 10	62 / 59	28 / 27	4 / 4	105	25 %	75 %	- %	- %	- %
SD3- 144 -DU	7 / 6	78 / 72	20 / 18	4 / 4	109	30 %	70 %	- %	- %	- %
SD3- 145	5 / 5	14 / 13	84 / 77	6 / 6	109	25 %	75 %	- %	- %	- %
SD3- 146	8 / 7	72 / 61	32 / 27	6 / 5	118	100 %	- %	- %	- %	- %
SD3- 147	8 / 16	4 / 8	15 / 30	23 / 46	50	100 %	- %	- %	- %	- %
SD3- 148	17 / 17	46 / 45	24 / 24	15 / 15	101	100 %	- %	- %	- %	- %
SD3- 149	18 / 17	12 / 11	73 / 69	3 / 3	106	45 %	55 %	- %	- %	- %
SD3- 150	23 / 24	38 / 39	24 / 25	12 / 12	97	100 %	- %	- %	- %	- %

OTHERS = AMPHIPODA (SCUDS – SIDE SWIMMERS), GASTROPODA (SNAILS), PELECYPODA (CLAMS)

OD = ORGANIC DETRITUS
M = AQUATIC MACROPHYTES
S = SAND
G = GRAVEL
W = WOOD FRAGMENTS/STICKS

TABLE 4-6

GRAIN SIZE, TOC, DISSOLVED OXYGEN IN SEDIMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

SAMPLE IDENTIFICATION	SD3-102-0101	SD3-106-0101	SD3-106-0101	SD3-106-0101-DU	SD3-110-0101	SD3-112-0101	SD3-115-0101
TRAFFIC REPORT NUMBER	5041A-114	5041A-91	5041A-91	5041A-92	5041A-97	5041A-39	5041A-42
QC DESIGNATION			LAB DUPLICATE	DUPLICATE			
DATE SAMPLED	11/30/89	11/27/89	11/27/89	11/27/89	11/27/89	11/09/89	11/09/89
% FINER THAN							
1 1/2"	--	--	NA	100	--	--	NA
1"	--	--		98	100	100	(ORGANIC)
3/4"	--	--		98	99	91	
1/2"	--	100		98	97	55	
3/8"	100	99		98	95	40	
#4	97	99		97	88	17	
#8	95	98		96	81	4	
#10	95	97		96	79	2	
#16	93	96		96	73	1.6	
#30	89	86		94	59	1.1	
#40	87	85		92	50	0.9	
#50	85	81		90	42	0.7	
#80	83	76		84	28	0.5	
#100	82	75		83	25	0.4	
#200	74.8	73.0		75.2	15.8	0.3	
0.037 mm					4.0	0.1	
0.036 mm							
0.035 mm							
0.034 mm	32.6	37.8					
0.033 mm				44.8			
0.031 mm							
0.023 mm	13.4				4.0	0.1	
0.022 mm		29.6		33.3			
0.021 mm							
0.014 mm						0.1	
0.013 mm	9.6	23.5		26.4	4.0		
0.010 mm					4.0	0.1	
0.009.mm	8.6	20.4		22.9			
0.007 mm	5.7	15.3		16.1	3.2	0.0	
0.006 mm							
0.003 mm	2.9	9.2		11.5	3.2	0.0	
0.001 mm	1.9	5.1		5.7	3.2	0.0	
TOC (mg/kg)	NA	9500		10500	5700	27400	12100
Dissolved Oxygen (mg/l)	13	NR		NR	9	10	10

NA - Not Analyzed
NR - Not Recorded

TABLE 4-6
GRAIN SIZE, TOC, DISSOLVED OXYGEN IN SEDIMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 2

SAMPLE IDENTIFICATION	SD3-117-0101	SD3-118-0101	SD3-119-0101	SD3-120-0101	SD3-120-0101	SD3-122-0101	SD3-124-0101
TRAFFIC REPORT NUMBER	5041A-22	5041A-12	5041A-14	5041A-10	5041A-10	5041A-23	5041A-09
QC DESIGNATION					LAB DUPLICATE		
DATE SAMPLED	11/06/90	11/02/89	11/03/89	11/02/89	11/02/89	11/06/90	11/01/89
% FINER THAN							
1 1/2"	100	--	--	--	--	--	--
1"	89	--	--	--	--	--	--
3/4"	89	--	--	--	--	--	--
1/2"	79	--	--	--	--	--	100
3/8"	76	--	--	--	--	--	98
#4	68	--	--	--	--	--	84
#8	59	--	--	--	--	--	70
#10	57	100	100	--	--	100	67
#16	52	99	99	100	--	99	56
#30	47	96	97	99	100	99	44
#40	43	92	96	98	99	98	38
#50	41	87	94	97	98	98	33
#80	37	72	87	92	94	98	23
#100	35	68	83	88	90	97	20
#200	25.2	53.3	60.3	65.4	68.1	92.9	9.2
0.037 mm							3.4
0.036 mm			20.1				
0.035 mm	12.0	25.6		25.7			
0.034 mm					31.3		
0.033 mm							
0.031 mm						60.5	
0.023 mm	10.3		15.9				3.4
0.022 mm		21.5		21.6	25.3		
0.021 mm						48.2	
0.014 mm							
0.013 mm	6.9	16.4	12.7	18.5	17.2	32.8	3.4
0.010 mm							3.4
0.009 mm	5.2	15.4	8.5	14.4	15.2	23.6	
0.007 mm	4.0	12.3	6.3	12.3	7.1	17.4	2.7
0.006 mm							
0.003 mm	2.3	7.2	4.2	8.2	4.0	8.2	2.0
0.001 mm	1.7	4.1	3.2	5.1	0.0	4.1	1.3
TOC (mg/kg)	14400	2700	27000	28600	28600	15900	28500
Dissolved Oxygen (mg/L)	21	9	NR	10	10	NR	9

NA - Not Analyzed
NR - Not Recorded

TABLE 4-6
GRAIN SIZE, TOC, DISSOLVED OXYGEN IN SEDIMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 3

SAMPLE IDENTIFICATION	SD3-124-0101-DU	SD3-125-0101	SD3-129-0101	SD3-129-0101-DU	SD3-130-0101	SD3-132-0101	SD3-135-0101
TRAFFIC REPORT NUMBER	5041A-09	5041A-25	5041A-33	5041A-34	5041A-35	5041A-109	5041A-79
QC DESIGNATION	LAB DUPLICATE						
DATE SAMPLED	11/01/89	11/07/89	11/08/89	11/08/89	11/08/89	11/29/89	11/16/89
% FINER THAN							
1 1/2"	--	--	--	--	--	--	--
1"	--	--	--	--	--	--	--
3/4"	100	--	--	--	100	--	--
1/2"	96	--	--	--	97	--	--
3/8"	94	100	--	--	95	--	--
#4	83	99	--	--	87	100	--
#8	71	98	--	--	78	99	--
#10	68	97	100	100	77	99	100
#16	55	97	95	96	72	98	98
#30	33	93	88	88	62	92	96
#40	31	92	85	86	55	85	96
#50	22	91	84	85	46	76	94
#80	14	87	81	82	29	55	91
#100	13	86	80	81	26	49	89
#200	9.4	72.2	73.9	74.6	17.7	31.4	78.3
0.037 mm	2.0				7.7		
0.036 mm						10.9	
0.035 mm							24.5
0.034 mm		30.1					
0.033 mm			44.2	48.7			
0.031 mm							
0.023 mm	2.0				4.6	8.9	16.3
0.022 mm		25.9					
0.021 mm			37.9	42.5			
0.014 mm	2.0						
0.013 mm		20.8	31.5	31.1	4.6	6.9	10.2
0.010 mm	2.0				4.6		
0.009 mm		16.6	27.3	26.9		6.9	10.2
0.007 mm	2.0	13.5			2.3	5.0	6.1
0.006 mm			20.0	20.7			
0.003 mm	2.0	8.3	11.6	12.4	1.5	4.0	6.1
0.001 mm	2.0	4.2	13.7 R	4.1	0.0	3.0	1.0
TOC (mg/kg)	28500	47600	17000	15200	13400	4700	62000
Dissolved Oxygen (mg/L)	9	9.5	9	9	9.4	12	NR

NA - Not Analyzed
NR - Not Recorded

TABLE 4-6
GRAIN SIZE, TOC, DISSOLVED OXYGEN IN SEDIMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 4

SAMPLE IDENTIFICATION	SD3-136-0101	SD3-138-0101	SD3-139-0101	SD3-139-0101-DU	SD3-140-0101	SD3-146-0101	SD3-148-0101
TRAFFIC REPORT NUMBER	5041A-104	5041A-106	5041A-65	5041A-66	5041A-69	5041A-53	5041A-50
QC DESIGNATION							
DATE SAMPLED	11/28/89	11/28/89	11/15/89	11/15/89	11/15/89	11/13/89	11/13/89
% FINER THAN							
1 1/2"	--	--	NA	NA	--	--	--
1"	--	--	(ORGANIC)	(ORGANIC)	--	--	--
3/4"	--	100			--	--	--
1/2"	--	99			100	--	--
3/8"	--	98			99	--	--
#4	100	98			98	--	--
#8	99	96			98	--	100
#10	98	96			98	--	99
#16	98	96			96	100	98
#30	96	94			93	99	96
#40	93	92			90	97	95
#50	90	88			87	96	92
#80	74	82			81	93	77
#100	67	79			77	93	69
#200	45.3	68.6			57.6	83.2	34.9
0.037 mm							
0.036 mm	19.4				19.8		13.9
0.035 mm							
0.034 mm							
0.033 mm		47.3					
0.031 mm						61.3	
0.023 mm	17.3				15.8		7.9
0.022 mm							
0.021 mm		40.7				44.4	
0.014 mm							
0.013 mm	15.3	29.7			9.9	33.8	7.9
0.010 mm							6.0
0.009 mm	15.3	26.4			9.9	29.6	
0.007 mm	12.2	19.8			4.9		4.0
0.006 mm						25.3	
0.003 mm	6.1	9.9			4.0	16.9	3.0
0.001 mm	5.1	6.6			1.0	7.4	0.0
TOC (mg/kg)	5600	16892	13600	8100	8200	9650	24500
Dissolved Oxygen (mg/L)	14	11	10	10	10	10	12

NA - Not Analyzed
NR - Not Recorded

TABLE 4-6
GRAIN SIZE, TOC, DISSOLVED OXYGEN IN SEDIMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 5

SAMPLE IDENTIFICATION	SD3-149-0101	SD3-150-0101
TRAFFIC REPORT NUMBER	5041A-57	5041A-60
QC DESIGNATION		
DATE SAMPLED	11/14/89	11/14/89
% FINER THAN		
1 1/2"	NA	--
1"	(ORGANIC)	100
3/4"		95
1/2"		92
3/8"		89
#4		84
#8		81
#10		80
#16		76
#30		70
#40		66
#50		59
#80		48
#100		43
#200		19.5
0.037 mm		6.4
0.036 mm		
0.035 mm		
0.034 mm		
0.033 mm		
0.031 mm		
0.023 mm		6.4
0.022 mm		
0.021 mm		
0.014 mm		
0.013 mm		4.8
0.010 mm		4.8
0.009 mm		
0.007 mm		3.2
0.006 mm		
0.003 mm		3.2
0.001 mm		0.0
TOC (mg/kg)	20000	16700
Dissolved Oxygen (mg/kg)	7	10

NA - Not Analyzed
NR - Not Recorded

compared with data collected from River stations (these stations are not in a tributary of the Sudbury River) and should be used for reference only.

Station SD3-117, which was strongly influenced by the relative high water quality discharge of Cold Spring Brook, contained a relatively balanced macroinvertebrate community and was not as environmentally stressed as the surrounding stations.

At least 100 macroinvertebrates were found in each sample from stations SD3-131 to 150 (Reaches 4 to 7) with the exception of station SD3-147, where only 50 macroinvertebrates were present in the sample. Despite the lower number of organisms, the percent occurrence of insects at SD3-147 was similar to that of adjacent stations. All stations from stations SD3-131 to 150 contained populations of aquatic insects, Chironomidae (Diptera-midge larvae), and "others" which were composed primarily of clams (Pelecypoda), snails (Gastropoda), and scuds (Amphipoda). Aquatic worms (Oligochaeta) were dominant organisms at seven stations and absent from 11 stations.

Station SD3-138, which is located in the Oxbow Lake (Reach 5), contained the highest percentage (40 percent) of aquatic insects observed in samples from the survey. Composition of aquatic insects at stations SD3-131 to 150 ranged from 4 percent to 24 percent. This indicates the presence of stressed benthic habitats; however, the conditions were improved compared to those found at stations SD3-106 to 130 (Reach 2 and 3).

The stations in Reservoir No. 2 and areas upstream (Reaches 2 and 3), especially stations SD3-106 to 116, showed signs of the highest degrees of environmental stress. The areas with lower degrees of environmental stress (as evidenced by the overall higher occurrences of aquatic insect larvae) were at Reservoir No. 1 (stations SD3-132 to 135/Reach 4) and stations SD3-147 to 150 (Reach 7).

4.5.1 Grain Size/TOC

The results of the benthic sample analysis were compared with grain size and TOC. Grain size of the sediment affects the diversity of the organisms present in the sample zone due to the habitat available. However, the benthic samples were analyzed in a semi-quantitative manner only. Since the number of organisms were not counted beyond 100, an accurate comparison of the number of organisms present to any data cannot be precisely performed.

The data does show a general trend of few organisms present in sandy and rock areas. However, these areas tend to be those which were found to be most heavily contaminated (i.e. the Outfall Creek and the Raceway) which further complicates the issue.

TOC present in the environment is important as both a food source and habitat to the benthic organisms present.

No obvious relationship was noted between the TOC data and results of the benthic samples. This is most likely due to contaminant stress. Data for these parameters are presented in Tables 4-5 and 4-6.

4.6 Invertebrate Tissue Analysis

Biologists from the EPA Environmental Services Division (ESD) collected and analyzed larvae of the caddis fly (family Hydropsychidae) to determine the concentrations of contaminant metals in the tissues of animals in this trophic level. The collection procedures and locations used for this study are summarized in Section 2.0 of this report. These animals were selected because their feeding habits are expected to provide them with a relatively high exposure dose from contaminants in the suspended sediment.

Due to the limits of sample quantity, the organism tissue was analyzed only for three metals: mercury, chromium, and lead. Results of these analyses are included in Appendix F.

The results discussed in Appendix F show that the concentrations of mercury in the tissue of caddis fly larvae collected from the upstream Reach (ECF-01, ECF-02) may not be significantly lower than that of any other sample. The highest concentration of mercury (wet weight) was detected in ECF-03 (Reach 2) and the highest concentration of mercury (dry weight) was reported to be the same in two samples ECF-02 (background) and ECF-03 (Reach 2). However, data quality limitations make these assumptions questionable.

Chromium was reported above detection limits in one sample, ECF-04, a duplicate sample in Reach 4. Chromium was reported in the other duplicate at detection limits. Chromium was reported below detection limits at all other locations, including background.

The highest lead concentration was in the first background sample (ECF-01) by dry and wet weight analysis. Other high levels of lead were found in samples collected from Reaches 2 and 7.

Evaluation of this data indicates that the data represents a qualitative reference point. Metals were detected in the tissues of these organisms, but the concentrations of mercury and other heavy metals reported are approximated and lack significant differentiation from background values to quantify risks to these or higher organisms in the food chain. This data does, however, indicate that these organisms may act as a transport pathway for mercury to enter the food chain (Nolan, 1990).

4.7 Eastern Wetlands Soil Boring Program

4.7.1 Background

Phase I sampling located organic and inorganic contaminants in the Wetlands (see Section 4.3.2.1) at elevated concentrations. The Eastern Wetlands boring program was conducted as part of the Phase II Study Area investigation, to define the horizontal and vertical extent of contamination in the Wetlands.

Analytical data is presented in Appendix C and summarized in Table 4-7. This data has been summarized separately from the other sediment sampling data because samples were collected in a different manner and constitute a different information base.

The Wetlands are dominated by two small ponds averaging two to three feet in depth and separated by a low dike as shown on Figures 1-D and 1-E. The ponds are surrounded by a wetland inundated with up to one foot of water. A small feeder stream which drains the eastern portion of the Nyanza Site discharges to the Wetland to the southwest of the southern pond. A second feeder stream which has been redirected reportedly also drained the Nyanza Site and fed into the west side of the northern pond.

Tricil Environmental Response Company, as part of the Operable Unit I remediation effort, excavated contaminated soils and sediment from the Trolley Brook Wetlands and feeder streams, within the eastern border of the Site to the south of Megunko Road. Soils were excavated to a depth of four feet. The southern pond feeder stream was excavated during remediation to a depth of one to two feet to the extent of the Site boundary.

4.7.2 Samples

Thirty boreholes were advanced in the Wetlands using mechanized and hand-operated augers. Samples were collected to a depth of six feet in the ponds. Four sample intervals were collected: sediment surface to a depth of two feet, from four to five feet, and from five to six feet. Borings were advanced to a depth of two feet in surrounding wetland areas and samples collected from two discrete one-foot intervals. The upper sample interval often was a mixture of recent alluvial sediments and underlying soil. Any vegetation was preferentially removed prior to collecting the sample. A surface sediment sample was collected in the southern pond feeder stream and one borehole was advanced in Trolley Brook, which is the only surface water outlet for the Wetlands.

Caution should be exercised in comparing borehole data to River sediment data. Various physical and chemical processes have both accumulated and dispersed contaminants in River sediments. Contaminants are readily adsorbed onto sediments making this type of deposit a contaminant "sink". The soils underlying the Eastern Wetlands, on the other hand, are generally coarser grained. Contaminants do not accumulate in coarse grained soil to the degree as in finer grained sediments. For this reason a "background" sediment concentration cannot be compared to contaminant concentrations in coarser soils.

4.7.3 Surficial Geology

Minimal recent alluvial sediment accumulation was encountered in the ponds. This was expected considering the wetlands are less than 60 years old, formed through filling of low lying land for real estate development (EPA, 1982). The history of the Wetlands is described in Section 2.0.

A thin vegetative cover was found to overlay a peat deposit which was locally up to two feet thick (Figure 3-3). Regional glacio-fluvial soils consisting of silty fine sands were encountered beneath the peat deposits. A coarser, silty gravel underlies the northern pond. This unit was not encountered under the southern pond. The gravel may be eroded or pinched out north of the southern pond. Monitoring instruments frequently detected volatile organic vapors in the gravel unit, indicating that VOCs may be migrating preferentially through this deeper unconsolidated unit.

4.7.4 Analytical Results

Many organic and inorganic contaminants have been detected in samples throughout the Wetlands. This discussion will focus on the Site-related contaminants. The most notable contaminant occurrence is the presence of volatile organic compounds (in concentrations in the range of 10^4 ppb) in the upper sediments of the northern pond, and the pervasive high concentrations of mercury in the upper sample intervals and at lower concentrations to depths of four to six feet. Sample results are illustrated on Figure 2-D.

4.7.4.1 Organic Compounds

A number of Site-related contaminants were detected in significant concentrations in the Wetlands. Chlorobenzene was detected in the central portion of the northern pond in concentrations up to 34,000 ppb at boring SD3-235. The contamination extended into the central portion of the pond where concentrations at depth range from 23 (SD3-226) to 360 ppb (SD3-235). TCE was detected in concentrations up to 1300 ppb (SD3-233) in the general area of the chlorobenzene contamination. The highest concentrations of TCE was generally in the upper sample interval and decreased with depth. Occasionally, TCE and other volatile organic compounds were detected at slightly higher concentrations in the bottom gravel unit such as TCE in borings SD3-229, 231, 232, and 236. Chlorobenzene exhibited a similar pattern in borings SD3-229, 231, 233, and 238. A third VOC, 1,2-Dichloroethene (1,2-DCE), was also detected in the same area in concentrations up to 5500 ppb (upper interval of boring SD3-233). Contaminant levels generally decreased with depth but increased slightly in the bottom gravel unit. The vertical distribution of contaminants is illustrated in Table 4-7.

Traces of organic contaminants were also detected in the southern pond but are apparently randomly distributed.

Several semi-volatile compounds were detected in the same area as the volatile compounds, most notably 1,2-DCB. The highest concentration (13,000 ppb) was detected in the top interval of boring SD3-234. Concentrations of 1,2-DCB ranging from 1,200 to 8,300 ppb were detected in several other borings in the vicinity. Concentrations vary greatly with depth; some concentrations decreased sharply (SD3-234) while others were persistent at depth such as in borings SD3-233 and 236.

Other semi-volatile compounds detected include several PAH compounds and phthalates. As with the volatiles, the semi-volatile compounds were detected at significantly lower concentrations in the southern pond.

4.7.4.2 Inorganic Contaminants

The primary inorganic contaminants in the Eastern Wetlands were mercury and chromium. Both were widespread throughout the Wetland system and vertical distributions were similar.

The highest concentrations of both mercury and chromium found in the northern pond during this boring program were detected in the surface interval of SD3-235. At this location, mercury was present at 13.8 ppm and chromium at 101.0 ppm. Concentrations of both metals were elevated between SD3-235 and SD3-237, located to the north at the discharge Culvert. Otherwise, both metals were distributed throughout the pond in a somewhat random pattern.

The highest concentrations of mercury and chromium detected during this boring program were found in samples collected from the stream feeding the south pond (SD3-218). This sample was collected from the surface to six inches, while other top interval samples collected during the boring program were from the surface to 12 or 24 inches. The metals were likely to be present at significantly higher concentrations on the ground surface and decrease with depth. This sample may represent a high biased sample.

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS
EASTERN WETLANDS BORING PROGRAM
NYANZA III – SUDBURY RIVER STUDY

EASTERN WETLANDS SEDIMENT – TOTAL INORGANICS

UNITS: mg/kg

INORGANIC COMPOUNDS	DEPTH = 0-2FT					DEPTH = 2-4FT.					DEPTH = 4-5FT.				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	23 OF 32	9358 76	8024 22	15400 00	4570 00	23 OF 31	8831 98	7734 24	13900 00	5945 00	17 OF 21	6784 71	6065 48	11300.00	3520.00
ARSENIC	14 OF 32	2 63	1 32	7 00	0 81	17 OF 31	1 78	1 08	3 60	0.71	18 OF 21	2 04	1.79	6 10	0.84
BARIUM	32 OF 32	32 54	32 54	64 70	12 80	31 OF 31	29 58	29.58	53.10	12.00	21 OF 21	26 95	26 95	47 80	11.40
BERYLLIUM	26 OF 32	2 10	1 80	6 20	1 20	21 OF 31	1 27	1.01	1.70	1.15	14 OF 21	1.21	0 97	1.30	1.10
CADMIUM	2 OF 32	2 60	0 63	3 40	1 80	2 OF 31	1 50	0 57	1.50	1.50	2 OF 21	1.30	0 59	1.30	1.30
CALCIUM	32 OF 32	2797 81	2797 81	13400 00	1280 00	31 OF 31	2136 45	2136.45	3250.00	1330.00	21 OF 21	2318 57	2318 57	3600.00	1340.00
CHROMIUM	25 OF 32	51 71	41 82	424 00	4 80	29 OF 31	20 06	19 13	51.65	4.90	19 OF 21	21 27	19 63	93.90	7.80
COBALT	17 OF 32	12 85	7 44	74 00	3 30	25 OF 31	5 06	4 31	7 40	3 40	17 OF 21	6 25	5 31	14.10	3.70
COPPER	17 OF 32	57 18	31 80	318 00	6 10	14 OF 31	14 33	6 38	54.50	6 50	13 OF 21	16 12	11 24	45 60	8.00
IRON	25 OF 32	7841 60	6311 82	21900 00	3720 00	30 OF 31	7719 67	7596 61	11900.00	3100 00	21 OF 21	6478 57	6478 57	14100.00	4690.00
LEAD	21 OF 32	308 42	201 80	6780 00	6 30	18 OF 31	150 68	77.33	1740.00	3 20	14 OF 21	175 81	118 72	2360.00	3.20
MAGNESIUM	31 OF 32	1588 71	1554 18	2620 00	360 00	31 OF 31	2372 58	2372 58	3390 00	985 00	21 OF 21	2664 29	2664 29	4670 00	1320.00
MANGANESE	30 OF 32	80 82	88 31	478 00	30 40	31 OF 31	95 27	95 27	141.50	52 90	21 OF 21	115 32	115 32	218.00	61.00
MERCURY	26 OF 32	7 28	5 83	81 50	0 17	22 OF 31	1 45	1 03	12.00	0.17	10 OF 21	2 56	1.23	10.30	0.17
NICKEL	18 OF 32	12 74	7 50	23.4	7.3	24 OF 31	10 32	8.75	15 20	8 80	11 OF 21	12 84	8 24	21 30	8.80
POTASSIUM	32 OF 32	812 27	812 27	834 00	180 00	30 OF 31	940 90	911.61	2060 00	265 00	21 OF 21	1529 05	1529 05	3710.00	607.00
SODIUM	15 OF 32	887 73	380 11	3750 00	137 00	11 OF 31	304 85	180 66	594 00	134.50	9 OF 21	284 00	168 63	571.00	125.00
THALLIUM	2 OF 32	1 30	0 48	1 40	1 20	2 OF 31	1 35	0 46	1 60	1.10	0 OF 21		0 00		
VANADIUM	30 OF 32	13 82	13 18	22 80	6 10	31 OF 31	18 35	18 35	26 70	6 90	21 OF 21	18 69	18.69	30 40	7.50
ZINC	23 OF 32	94 34	42 85	280 00	18 20	27 OF 31	37.72	36 59	75.70	22.30	19 OF 21	47.72	45 22	81 90	20.80

FINAL

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS
EASTERN WETLANDS BORING PROGRAM
NYANZA III – SUDBURY RIVER STUDY
PAGE TWO

EASTERN WETLANDS SEDIMENT – TOTAL INORGANICS

UNITS mg/kg

INORGANIC COMPOUNDS	DEPTH = 5-6FT					DEPTH = 6-7FT.				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUNCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
ALUMINUM	17 OF 19	7846.47	7406.58	17200.00	3400.00	1 OF 1	4840.00	4840.00	4840.00	4840.00
ARSENIC	15 OF 19	1.26	1.08	2.70	0.83	0 OF 1				
BARIUM	19 OF 19	30.05	30.05	53.20	11.80	1 OF 1	18.40	18.40	18.40	18.40
BERYLLIUM	14 OF 19	1.23	1.04	1.40	1.10	0 OF 1				
CADMIUM	1 OF 19	1.30	0.54	1.30	1.30	0 OF 1				
CALCIUM	19 OF 19	2717.37	2717.37	4980.00	1310.00	1 OF 1	1680.00	1680.00	1680.00	1680.00
CHROMIUM	17 OF 19	21.08	19.27	83.60	7.20	0 OF 1				
COBALT	15 OF 19	6.88	5.71	10.80	3.30	1 OF 1	4.00	4.00	4.00	4.00
COPPER	13 OF 19	11.89	8.58	20.60	5.80	1 OF 1	6.70	6.70	6.70	6.70
IRON	19 OF 19	10381.05	10381.05	30000.00	5380.00	1 OF 1	6480.00	6480.00	6480.00	6480.00
LEAD	13 OF 19	158.65	110.88	1840.00	2.80	1 OF 1	3.00	3.00	3.00	3.00
MAGNESIUM	19 OF 19	3527.37	3527.37	8830.00	1280.00	1 OF 1	1750.00	1750.00	1750.00	1750.00
MANGANESE	19 OF 19	148.80	148.80	277.00	63.50	1 OF 1	87.00	87.00	87.00	87.00
MERCURY	13 OF 19	1.50	1.03	10.80	0.19	1 OF 1	0.33	0.33	0.33	0.33
NICKEL	11 OF 19	12.34	8.57	18.60	8.60	0 OF 1				
POTASSIUM	19 OF 19	1802.74	1802.74	3570.00	884.00	1 OF 1	1340.00	1340.00	1340.00	1340.00
SODIUM	7 OF 19	218.43	129.58	271.00	183.00	0 OF 1				
THALLIUM	0 OF 19		0.00			0 OF 1				
VANADIUM	19 OF 19	24.87	24.87	88.50	8.40	1 OF 1	12.00	12.00	12.00	12.00
ZINC	17 OF 19	48.86	46.01	78.20	25.80	1 OF 1	42.70	42.70	42.70	42.70

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS
EASTERN WETLANDS BORING PROGRAM
NYANZA III – SUDBURY RIVER STUDY
PAGE THREE

	EASTERN WETLANDS SEDIMENT – ORGANICS UNITS: ug/kg														
ORGANIC COMPOUNDS	DEPTH = 0-2 FT					DEPTH = 2-4 FT.					DEPTH = 4-5 FT.				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
VINYL CHLORIDE	2 OF 32	68.00	222.03	130.00	6.00	2 OF 31	25.25	35.39	39.00	11.50	2 OF 21	13.00	42.17	21.00	5.00
METHYLENE CHLORIDE	2 OF 32	825.50	138.82	1600.00	51.00	1 OF 31	17.00	18.15	17.00	17.00	0 OF 21				
ACETONE	6 OF 32	34.17	228.22	110.00	7.00	8 OF 31	34.63	44.10	86.00	5.00	7 OF 21	53.00	56.28	100.00	8.00
1,2-DICHLOROETHENE (TOTAL)	10 OF 32	572.03	982.13	5500.00	0.30	11 OF 31	71.55	40.48	300.00	1.00	9 OF 21	41.78	36.62	150.00	4.00
1,2-DICHLOROETHANE	0 OF 32					1 OF 31	1.00	16.84	1.00	1.00	0 OF 21				
TRICHLOROETHENE	10 OF 32	313.38	218.38	3400.00	0.30	14 OF 31	94.38	57.15	970.00	2.00	13 OF 21	37.65	41.63	200.00	0.50
BENZENE	1 OF 32	4.00	110.88	4.00	4.00	1 OF 31	3.00	16.67	3.00	3.00	1 OF 21	3.00	20.60	3.00	3.00
TOLUENE	3 OF 32	8.33	110.81	16.00	2.00	2 OF 31	1.50	16.62	2.00	1.00	1 OF 21	0.60	20.46	0.60	0.60
CHLOROBENZENE	19 OF 32	6663.73	2804.60	34000.00	3.00	14 OF 31	414.25	188.19	2600.00	5.00	12 OF 21	304.50	174.90	2100.00	4.00
ETHYLBENZENE	1 OF 32	0.70	110.70	0.70	0.70	0 OF 31					0 OF 21				
TOTAL XYLENES	3 OF 32	2.67	110.27	5.00	1.00	4 OF 31	1.20	16.77	2.00	0.80	1 OF 21	2.00	20.55	2.00	2.00
PHENOL	2 OF 32	62.00	340.75	68.00	56.00	0 OF 31					1 OF 21	35.00	228.76	35.00	35.00
2-CHLOROPHENOL	1 OF 32	20.00	345.16	20.00	20.00	0 OF 31					0 OF 21				
1,3-DICHLOROBENZENE	10 OF 32	80.40	273.75	280.00	16.00	4 OF 31	34.38	226.94	58.00	17.00	3 OF 21	57.67	213.00	76.00	33.00
1,4-DICHLOROBENZENE	13 OF 32	808.69	578.01	3100.00	48.00	11 OF 31	227.82	248.02	820.00	27.00	7 OF 21	262.29	255.06	780.00	28.00
1,2-DICHLOROBENZENE	15 OF 32	3016.73	1877.69	12000.00	33.00	12 OF 31	1215.82	630.11	4900.00	71.00	11 OF 21	968.45	633.71	5100.00	30.00
4-METHYLPHENOL	1 OF 32	74.00	347.16	74.00	74.00	1 OF 31	14.00	250.71	14.00	14.00	0 OF 21				
BENZOIC ACID	8 OF 32	101.25	1311.25	140.00	65.00	8 OF 31	52.63	1025.90	110.00	15.00	2 OF 21	171.50	1058.81	310.00	33.00
1,2,4-TRICHLOROBENZENE	13 OF 32	262.77	324.63	1600.00	21.00	11 OF 31	128.95	212.23	290.00	30.00	5 OF 21	260.60	243.95	610.00	48.00
NAPHTHALENE	6 OF 32	158.33	303.58	320.00	42.00	3 OF 31	38.83	234.65	64.00	19.00	3 OF 21	31.00	208.19	48.00	23.00
2-METHYLNAPHTHALENE	1 OF 32	62.00	362.28	62.00	62.00	1 OF 31	16.50	248.10	16.50	16.50	1 OF 21	27.00	228.38	27.00	27.00
ACENAPHTHYLENE	1 OF 32	60.00	351.58	60.00	60.00	1 OF 31	63.50	250.68	63.50	63.50	1 OF 21	150.00	235.24	150.00	150.00
ACENAPHTHENE	3 OF 32	31.33	329.66	45.00	21.00	1 OF 31	16.00	248.10	16.00	16.00	1 OF 21	29.00	229.48	29.00	29.00
DIBENZOFURAN	1 OF 32	43.00	351.03	43.00	43.00	1 OF 31	23.50	248.42	23.50	23.50	1 OF 21	32.00	228.62	32.00	32.00
FLUORENE	1 OF 32	60.00	351.56	60.00	60.00	1 OF 31	79.00	252.73	79.00	79.00	1 OF 21	53.00	230.62	53.00	53.00
4,6-DINITRO-2-METHYLPHENOL	0 OF 32					0 OF 31					0 OF 21				
N-NITROSODIPHENLYAMINE	5 OF 32	53.60	308.38	75.00	25.00	2 OF 31	52.00	242.47	66.00	38.00	1 OF 21	19.00	229.00	19.00	19.00
PENTACHLOROPHENOL	0 OF 32					1 OF 31	60.00	1244.66	60.00	60.00	0 OF 21				
PHENANTHRENE	12 OF 32	42.77	223.04	120.00	10.00	1 OF 31	310.00	257.66	310.00	310.00	2 OF 21	187.50	232.14	350.00	25.00
ANTHRACENE	7 OF 32	76.14	310.22	270.00	23.00	2 OF 31	65.75	245.69	67.50	64.00	1 OF 21	110.00	233.33	110.00	110.00
DI-N-BUTYLPHTHALATE	3 OF 32	49.00	329.83	81.00	21.00	1 OF 31	17.00	248.21	17.00	17.00	2 OF 21	20.50	219.33	21.00	20.00
FLUORANTHENE	14 OF 32	70.57	236.33	270.00	15.00	2 OF 31	333.50	264.06	650.00	17.00	2 OF 21	511.50	263.00	990.00	33.00
PYRENE	10 OF 32	88.60	188.90	280.00	10.00	2 OF 31	277.25	255.78	540.00	14.50	2 OF 21	494.50	261.38	960.00	29.00
BUTYLBENZYLPHTHALATE	1 OF 32	25.00	360.31	25.00	25.00	1 OF 31	11.00	251.63	11.00	11.00	1 OF 21	25.00	226.10	25.00	25.00
BENZO(a)ANTHRACENE	2 OF 32	83.00	348.68	140.00	26.00	1 OF 31	270.00	256.37	270.00	270.00	1 OF 21	490.00	251.43	490.00	490.00
CHRYSENE	2 OF 32	125.50	348.83	190.00	61.00	1 OF 31	350.00	258.95	350.00	350.00	1 OF 21	620.00	257.62	620.00	620.00
BIS(2-ETHYLHEXYL)PHTHALATE	3 OF 32	78.33	338.22	100.00	62.00	5 OF 31	64.20	223.66	86.00	38.00	3 OF 21	62.67	208.71	81.00	41.00
DI-N-OCTYLPHTHALATE	2 OF 32	22.50	337.07	36.00	9.00	1 OF 31	6.50	247.87	6.50	6.50	1 OF 21	12.00	228.67	12.00	12.00
BENZO(b)FLUORANTHENE	4 OF 32	96.50	320.04	180.00	41.00	1 OF 31	270.00	256.37	270.00	270.00	1 OF 21	490.00	251.43	490.00	490.00
Benzo(k)fluoranthene	0 OF 32					0 OF 31					1 OF 21	730.00	262.86	730.00	730.00
BENZO(a)PYRENE	10 OF 32	280.00	334.22	680.00	41.00	7 OF 31	65.00	220.16	290.00	18.00	2 OF 21	318.00	248.48	570.00	66.00
INDENO(1,2,3-cd)PYRENE	1 OF 32	120.00	353.44	120.00	120.00	1 OF 31	200.00	254.11	200.00	200.00	1 OF 21	270.00	240.95	270.00	270.00
DIBENZ(a,h)ANTHRACENE	0 OF 32					1 OF 31	26.00	252.03	26.00	26.00	1 OF 21	94.00	232.57	94.00	94.00
BENZO(ghi)PERYLENE	1 OF 32	120.00	353.44	120.00	120.00	1 OF 31	210.00	254.84	210.00	210.00	1 OF 21	260.00	240.48	260.00	260.00

TABLE 4-7

SUMMARY OF ANALYTICAL RESULTS
EASTERN WETLANDS BORING PROGRAM
NYANZA III – SUDBURY RIVER STUDY
PAGE FOUR

EASTERN WETLANDS SEDIMENT – ORGANICS
UNITS ug/kg

ORGANIC COMPOUNDS	DEPTH = 0-6 FT					DEPTH = 6-7 FT.				
	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM	FREQUENCY	AVERAGE DETECTED	AVERAGE REPORTED	MAXIMUM	MINIMUM
VINYL CHLORIDE	1 OF 19	10.00	6.79	10.00	10.00	0 OF 1				
METHYLENE CHLORIDE	0 OF 19					0 OF 1				
ACETONE	8 OF 19	37.00	10.34	100.00	7.00	1 OF 1	170	170	170	170
1,2-DICHLOROETHENE (TOTAL)	9 OF 19	37.29	18.71	95.00	2.00	1 OF 1	17	17	17	17
1,2-DICHLOROETHANE	0 OF 19					0 OF 1				
TRICHLOROETHENE	12 OF 19	29.40	19.01	110.00	0.80	1 OF 1	79	79	79	79
BENZENE	1 OF 19	4.00	3.29	4.00	4.00	0 OF 1				
TOLUENE	2 OF 19	3.00	3.37	4.00	2.00	0 OF 1				
CHLOROBENZENE	10 OF 19	140.00	74.61	380.00	11.00	1 OF 1	250	250	250	250
ETHYLBENZENE	0 OF 19					0 OF 1				
TOTAL XYLENES	1 OF 19	0.80	3.23	0.80	0.80	0 OF 1				
PHENOL	2 OF 19	83.50	210.42	120.00	47.00	0 OF 1				
2-CHLOROPHENOL	1 OF 19	45.00	221.04	45.00	45.00	0 OF 1				
1,3-DICHLOROBENZENE	0 OF 19					0 OF 1				
1,4-DICHLOROBENZENE	2 OF 19	48.50	211.95	54.00	43.00	1 OF 1	40	40	40	40
1,2-DICHLOROBENZENE	8 OF 19	182.17	207.79	600.00	48.00	1 OF 1	240	240	240	240
4-METHYLPHENOL	0 OF 19					0 OF 1				
BENZOIC ACID	2 OF 19	14.50	1012.05	17.00	12.00	0 OF 1				
1,2,4-TRICHLOROBENZENE	1 OF 19	89.00	223.11	89.00	89.00	0 OF 1				
NAPHTHALENE	0 OF 19					0 OF 1				
2-METHYLNAPHTHALENE	0 OF 19					0 OF 1				
ACENAPHTHYLENE	0 OF 19					0 OF 1				
ACENAPHTHENE	3 OF 19	22.33	199.84	23.00	21.00	0 OF 1				
DIBENZOFURAN	0 OF 19					0 OF 1				
FLUORENE	0 OF 19					0 OF 1				
4,6-DINITRO-2-METHYLPHENOL	0 OF 19					0 OF 1				
N-NITROSODIPHENLYAMINE	0 OF 19					0 OF 1				
PENTACHLOROPHENOL	0 OF 19					0 OF 1				
PHENANTHRENE	0 OF 19					0 OF 1				
ANTHRACENE	0 OF 19					0 OF 1				
DI-N-BUTYLPHTHALATE	1 OF 19	31.00	210.79	31.00	31.00	0 OF 1				
FLUORANTHENE	0 OF 19					0 OF 1				
PYRENE	3 OF 19	27.33	200.63	31.00	22.00	0 OF 1				
BUTYLBENZYLPHTHALATE	1 OF 19	74.00	222.38	74.00	74.00	0 OF 1				
BENZO(a)ANTHRACENE	0 OF 19					0 OF 1				
CHRYSENE	0 OF 19					0 OF 1				
BIS(2-ETHYLHEXYL)PHTHALATE	0 OF 19					0 OF 1				
DI-N-OCTYLPHTHALATE	0 OF 19					0 OF 1				
BENZO(b)FLUORANTHENE	0 OF 19					0 OF 1				
Benzo(k)fluoranthene	0 OF 19					0 OF 1				
BENZO(a)PYRENE	0 OF 19					0 OF 1				
INDENO(1,2,3-cd)PYRENE	0 OF 19					0 OF 1				
DIBENZ(a,h)ANTHRACENE	0 OF 19					0 OF 1				
BENZO(ghi)PERYLENE	0 OF 19					0 OF 1				

From the point where the feeder stream enters the south pond, both metals displayed high correlation within samples, following what is probably an ancestral stream bed. The series of samples included, from south to north, SD3-224, 240, 221 and 223. The last sample in the series was located at the channelway through the dike. A sample collected at the channel discharge in the north pond, SD3-213 also exhibited elevated mercury and chromium concentrations. The ancestral stream bed was not positively identified in the northern pond, but based on elevated mercury and chromium concentrations can be speculated to extend from SD3-213 to 228, 233, 235, 236, 226, and 237.

4.7.4.3 Eastern Wetlands Discussion

The horizontal distribution of contaminants suggests that two different waste streams were introduced to the Wetlands from two distinct locations. The first an obvious source, is the south pond feeder stream, where elevated levels of Site-related metal contaminants occur. Site-related organic contaminants are not present in this area. A second feeder stream transporting a mixed metals - organic compound wastes, may have discharged into the north pond in the vicinity of SD3-235. This theory is supported by the detection of the highest Site-related organic contamination in the Wetlands coincident with the occurrence of metals.

Concentrations of representative contaminants noted on Figure 2-D can be followed from the Wetlands to SD3-200 and 201 in Chemical Brook Culvert. The more persistent contaminants can be traced further downstream through the Outfall Creek (Figure 2-C) to the Sudbury River. Further discussion of contaminant distribution is found in Sections 4.8 and 5.0.

4.8 Summary and Discussion of Distribution of Contaminants in the Study Area

Both organic and inorganic wastewater and sludge discharges have been documented at the Nyanza Site and various organic and inorganic contaminant constituents are well documented as occurring in River sediments throughout the Study Area.

This section summarizes the nature and extent of contaminants in the Study Area, from the Site source area through to Reach 10 of the Sudbury River. The discussion will focus on mercury in sediments, since this contaminant is most clearly linked to the Nyanza Site. Chromium in sediments will also be discussed. Like mercury, it is linked to the Site, is persistent in the environment, and displays the same trends as mercury.

4.8.1 Inorganic Contaminants in the Study Area

4.8.1.1 Sediments

Figure 4-3 illustrates the average detected concentrations of mercury and chromium from Reach 1, which represents background, through the Study Area to Reach 10.

Results of the Eastern Wetlands drilling program are not considered in the graphic analysis since they constitute a separate base of information. Phase I samples collected from this area are comparable, and are included in Figure 4-3 (see the discussion in Section 4.7.2).

Mercury contamination in sediments displays a distinctive pattern. High Average Detected Concentrations (ADCs) are associated with slow water flow and depositional areas such as within an impoundment. River runs with relatively high water flow velocities exhibit low ADCs. This is well illustrated in Figure 4-3.

Maximum concentrations follow a similar general trend. However, these results cannot exhibit a reliable pattern because they represent single sample points.

The highest concentrations of mercury in sediments occur in the Eastern Wetlands area, which drains the eastern flank of the Nyanza Site (Figure 2-A and 2-C). The ADC is 44.84 ppm (maximum of 152 ppm), compared to a background ADC of 1.05 ppm (maximum of 1.59 ppm).

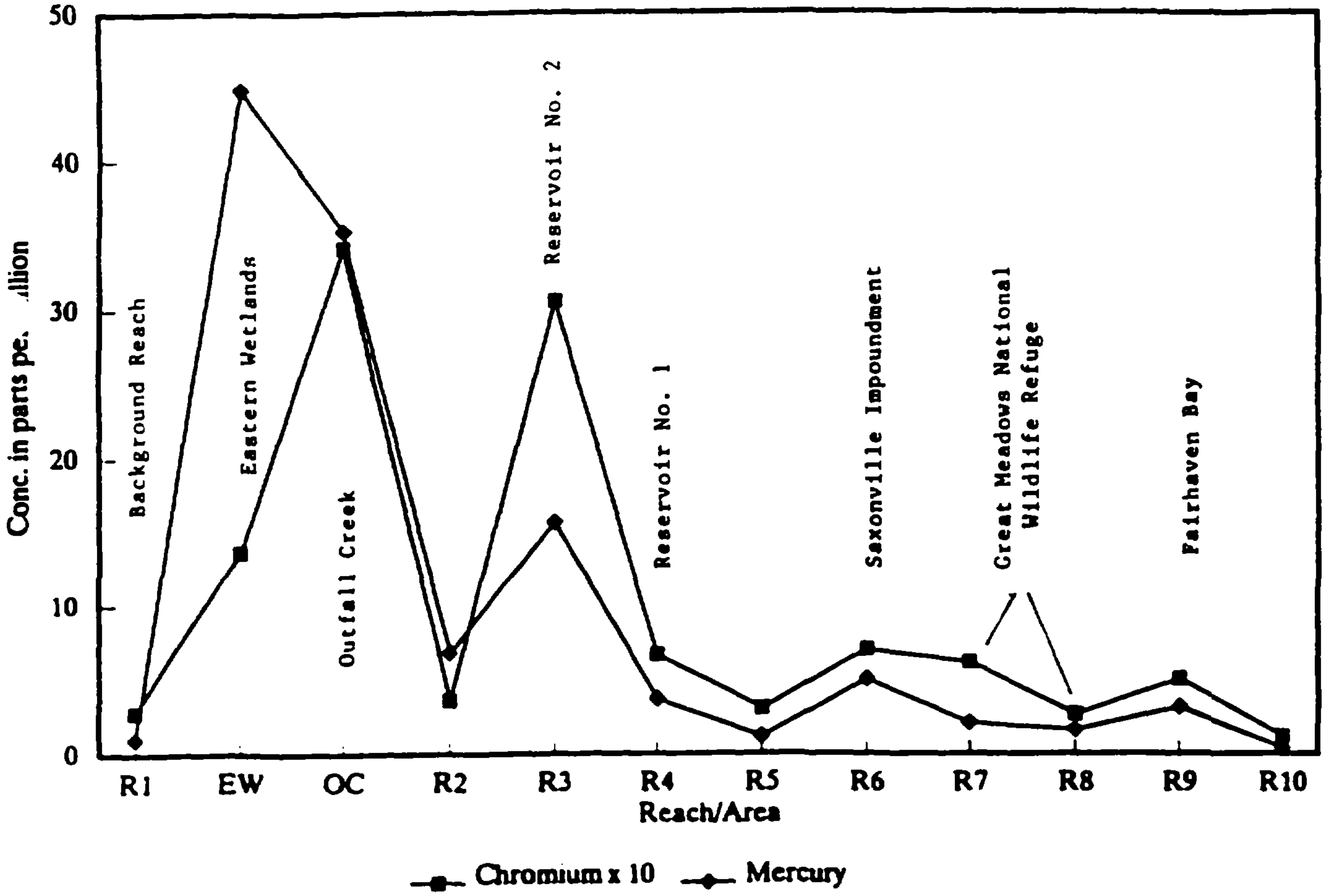
As the sediment bed load is transported downstream through Chemical Brook Culvert to the Outfall Creek, and thus to the raceway and river sediment from other sources begins to mix with contaminated sediments from the Eastern Wetlands and formerly, the Site. This mixing results in a decrease in mercury concentration as the Site-related sediment enters the Raceway and subsequently, the Sudbury River. However, there is a dramatic rise in mercury concentrations in River sediment at the Raceway confluence. Concentrations of mercury in samples upgradient of this confluence are at or below background levels, while the samples below the confluence exhibit average detected concentrations above background.

Samples collected from the Raceway also show low concentrations of mercury in the sediment due to the lack of depositional areas resulting from high water flow velocities.

Mercury concentrations in Reach 3 rise sharply. Reach 3 consists of a short River run and Reservoir 2. Within the Sudbury River, Reservoir 2 contains the highest concentrations of inorganic contaminants. The ADC and maximum concentration drop in Reach 4

FIGURE 4-3

MERCURY AND CHROMIUM AVERAGE CONCENTRATIONS IN SEDIMENTS
Nyanza III – Sudbury River Study – Remedial Investigation



R = Reach #, EW = Eastern Wetlands, OC = Outfall Creek but remain at relatively high levels. The average and maximum drop considerably in Reach 5, a swift flowing River run.

The ADC and maximum concentration of mercury rises in Reach 6, the impoundment above the Saxonville Dam. These values drop again in Reaches 7 and 8, which are slow, meandering River runs. Mercury concentration rises again in Reach 9, Fairhaven Bay, before dropping below background concentrations in Reach 10, a River run.

Chromium, another Site-related contaminant, was also detected in Eastern Wetland sediments, however, was detected in the Outfall Creek and Reach 3 (Reservoir 2) sediments in higher concentrations than in the Eastern Wetlands. Otherwise, chromium follows a similar pattern as mercury; lower concentrations in River runs and higher in impoundments. Chromium was detected below background levels in Reach 10.

Lead is another site-related inorganic contaminant and is found at elevated levels throughout the Study Area. However, lead may be attributed to the existence of point and non-point sources described in Section 4.2.3.

The pattern of lead distribution in the study area does not follow that of mercury and chromium. ADCs and maximum concentrations in the Eastern Wetlands are lower than those in background area, and are highest in the Raceway. These levels drop to background concentrations in Reach 2 (ADC=58, Max 295) and remain in that range in Reaches 3 and 4. Concentrations in Reaches 5 and 6 are significantly higher (ADCs=237, 285 ppm; and maximum=809, 876 ppm, respectively), and then drop to background levels in Reach 8.

4.8.1.2 Surface Water

Mercury and chromium occurred at low concentrations in several surface water samples. These samples were located from the Eastern Wetlands to the inlet of Reservoir 2. The only apparent distribution pattern is that all samples are in proximity of the Site.

Lead was also detected in surface water samples throughout Reaches 1 through 5, the Eastern Wetlands, and the associated discharge culvert. No distribution pattern was apparent.

4.8.2 Organic Contaminants in the Study Area

Several organic compounds identified as Site-related contaminants were found in several Study Area media.

Site-related organic contaminants were detected in Eastern Wetlands sediments in the range of 10^1 to 10^4 ppb. These include chlorobenzene, dichlorobenzene, trichloroethene, and dichloroethene. Concentrations decreased within a short distance downstream of the Wetlands and these organics were not detected in significant concentrations in the River Reaches. Minimal concentrations (less than 13 ppb maximum concentration) of volatile organic compounds were detected in River water samples.

Eight organic compounds were identified in the Final Work Plan as being used by the dye industry during the history of production at Nyanza. These compounds were referred to as "Site-specific organics" and include 1-napthalamine, 2-napthalamine, aniline, p-nitrotoluene, o-nitrochlorobenzene, benzidine, o-tolidine and o-dianisidine. This designation should not be confused with "Site-related contaminants" as defined by EPA (Section 4.2.1).

Sediment and surface water samples were collected and analyzed for these compounds during both Phase I and II. Detailed shallow and deep interval sediment sampling was conducted in an area in Reach 2, extending from Mill Pond to the confluence of the Raceway and the Outfall Creek. A groundwater plume with elevated concentrations of aniline mapped by Ebasco is projected to intersect the Sudbury River at this point. None of the Site-specific organic compounds were detected in the river.

The groundwater - surface water relationship was not investigated as part of this study, however, several possibilities exist to explain the absence of the Site-specific organics in the River:

- these organic compounds are unstable in the environment and readily breakdown in the alluvial environment
- the groundwater plume discharges to the River, but not at a sufficient rate to contribute measurable quantities of the contaminants to the River
- the groundwater plume does not discharge to the River
- contaminants are discharged to the River and are rapidly diluted

Polynuclear Aromatic Hydrocarbon compounds were also detected in sediments in the Study Area. PAHs are primarily formed during incomplete combustion or pyrolysis of organic materials. As such, the compounds are typically found in areas impacted by roadways, railways and other urban runoff. This trend is evidenced by their presence in Reaches located near these features, including the Culvert and Outfall Creek, and Reaches 2, 3 and the upper portions of Reach 7. These contaminants were detected less frequently and at lower concentrations in the Eastern Wetlands. None of these compounds were detected in the surface waters.

Mercury can be transformed by various bacterial processes to methylmercury (mono- and di-methylations), but this organo-metallic compound is very unstable in the environment. Samples collected from the Study Area indicate very low levels of methylmercury in the sediment; none was detected in the water. Methylmercury in these media is generally dependent on the pH of the waters. Waters with a low pH (less than 5) are more likely to allow methylation of mercury (Bloom, 1989). The Study Area waters generally maintain a pH greater than 6.0 and methylmercury will not be a stable compound in sediment or surface water. Methylmercury tends to be more prevalent in fish tissue than is mercury in its elemental form.

Scattered occurrences of pesticides and PCBs are noted in sediments throughout the Study Area. One pesticide, Lindane, was detected in one water sample at a concentration of 0.015 ppb. Pesticides and PCBs readily bioaccumulate in biota, and sampling analyses indicate that these compounds have accumulated in Study Area fish and benthic biota. This will be discussed further in Section 7.0.

The final group of organic compounds detected in the Study Area are the phthalate compounds. These chemicals are generally considered to be derived from manufacturing and breakdown of plastics. These compounds were principally detected in Reaches 3, 6, and in the Outfall Creek. Only one phthalate compound, bis(2-ethylhexyl) phthalate, was detected in three surface water samples at a maximum concentration of 56 ppb.

5

5.0 CONTAMINANT FATE AND TRANSPORT

The occurrence of Site-related contaminants in the River in concentrations above background in several media (including water, sediment, and biota) indicates that these contaminants are migrating and accumulating in the environment. After a chemical is released to the environment, it can be accumulated, transported, or transformed. Accumulation and transport of contaminants have occurred in the River. Mercury, in particular, has accumulated in sediments and has been bioaccumulated in biota and upper trophic-level fish. This section focuses on the primary contaminant fate and transport processes occurring in the River, including the bulk transport of contaminated sediments by the River and fate processes that play a role in contaminant uptake by biota. This section also includes process and contaminant-specific discussions.

5.1 Sediment Transport in Aquatic Systems

Many contaminants are readily adsorbed onto and transported with sediments. The most hazardous Study Area contaminants, such as mercury and pesticides, are among those most likely to be found in high concentrations in and transported with sediments because of the high partitioning coefficients associated with such contaminants. For this reason, sediment transport is considered the primary process for movement of contaminants in the Study Area.

Sediments originate from River inflows, shore erosion, and, to a lesser extent, waste disposal. Once introduced into water, sediments are dispersed primarily by currents and are either deposited to the bottom, where they can become a permanent part of bed sediments, or resuspended and further transported. Deposition to bottom sediments depends on particle size, settling rates, and flocculation. Particle diameters can range over two orders of magnitude, and settling rates can range over four orders of magnitude (Lick, 1984). Thorough knowledge of particle sizes, settling rates, and flocculation effects is important for determining settling and deposition rates and contaminant release from sediments to overlying waters. An in-depth analysis of sediment transport processes requires extensive sediment characterization that is beyond the scope of this study; however, this section presents some generalizations on sediment transport.

The net flux of sediment (NF) at the sediment/water interface can be described as the difference between the entrainment rate (E) and the deposition rate (D).

$$NF = E - D$$

D and E are considered to be independent processes, and NF = E when there is no suspended sediment and, therefore, no deposition is present (Lick, 1984). Conversely, NF = D in the absence of entrainment. Entrainment depends on: turbulent stress at the sediment/water interface, water content of the deposited sediments, grain size and specific gravity of the sediments, density of compacted sediment, and the activity of benthic biota and bacteria (Lick, 1984).

Currents and, to a lesser degree, wind- or boat-generated wave action at reservoir shorelines are the most important sediment transport processes because they are directly responsible for the transport of sediments, cause turbulence resulting in dispersion, and cause shear stress which results in sediment transport at the sediment/water interface (Lick, 1984).

Based on partitioning coefficients, many of the chemicals of concern (COCs) in this study including mercury, PCBs, and DDT are likely to be concentrated in River sediments. This assumption is supported by the relatively low surface water concentrations compared to relatively high sediment concentrations. Under calm conditions, surface water concentrations are likely to remain relatively low; however, release of some contaminated sediments to surface waters is likely during periods of turbulence at the sediment/water interface. Currents, bioturbation, and wave action are likely to result in the resuspension and transport of contaminated sediments. Except for those COCs expected to biomagnify in food chains, such as mercury, high concentrations of COCs adsorbed to sediment particles are not likely to be the primary hazard to site biota because of decreased bioavailability. It is more critical that sediments containing high concentrations of COCs may continue to be important sources of contamination to surface waters whenever the sediment/water interface is disturbed, such as during high water flows resulting from spring runoff and rain events.

An important element of sediment transport is the speciation or forms of contaminants being transported both into and out of aquatic systems. Forms of chromium and mercury are highly toxic and different forms of some organic chemicals, such as DDT, DDD, and DDE, are associated with different degrees of toxicity. For example, inorganic mercury introduced into aquatic systems can be deposited to bed sediments without change. In the bed sediments, bacterial methylation of inorganic mercury may occur, potentially increasing the hazards associated with those sediments. The relative concentrations of methylmercury and inorganic mercury are usually considered to be critical for evaluating sediment toxicity. However, concentrations of chemicals in sediments might not be in equilibrium, and inorganic mercury/ methylmercury concentrations that contribute to total sediment mercury are probably rarely static. Because of the dynamics associated with sediment mercury contamination, all mercury in sediments is often assessed as methylated or potentially methylated.

Speciation of chromium was investigated through laboratory analysis. Six sediment samples were analyzed for hexavalent chromium. Concentrations of total chromium ranged from nondetectable to 2,620 ppm; hexavalent chromium was not detected in any of these samples.

5.2 Persistence ($T_{1/2}$)

Ultimate chemical fate is commonly expressed as overall environmental half-life ($T_{1/2}$). Overall aqueous half-lives are based on the maximum degradation rates associated with the most important degradation processes in an aqueous medium (Howard et al., 1991). These processes include photolysis, hydrolysis, aerobic biodegradation, and anaerobic biodegradation. Table 7-5 lists overall half-lives for the final Ecological Risk Assessment COCs for surface waters, sediments, and biota.

Overall half-lives are media-dependent; therefore, soil and sediment half-lives are likely to differ from surface water half-lives. Biodegradation is the dominant degradation process in soil, except for those chemicals that undergo rapid hydrolysis. Biodegradation is the dominant degradation process in surface water (Howard et al., 1991).

5.3 Partitioning Coefficients

Interstitial water ingestion by organisms is a primary entry point of contaminants into the food chain. Partitioning coefficients are useful for estimating interstitial water concentrations of organic chemicals from measured sediment concentrations. The coefficients used in the ecological risk assessment (Section 7.0) include Kd, Koc, and Kow. These coefficients are defined as follows (EPA, 1989a):

$$Kd = Koc * foc$$

where

$$Kd = \frac{\text{conc. of chemical in soil or sediment (ug/kg)}}{\text{conc. of chemical in water (ug/L)}}$$

and

Koc = partitioning coefficient for chemical/organic carbon

foc = fraction of organic carbon in sediment/soil

Koc values are available in the accepted literature for most organic chemicals. Kd values are often estimated from general Koc values and from site-specific foc values. The resulting Kd values can be used to estimate water concentrations from measured sediment concentrations, or vice versa. If Koc values are unavailable for a chemical of concern, they can be estimated from the octanol/water partition coefficient, Kow. Octanol is considered to be a surrogate for lipid.

$$Kow = \frac{\text{concentration of chemical in octanol}}{\text{concentration of chemical in water}}$$

Regression equations relate Kow to Koc, and are chemical class-specific. The following equation is appropriate for Koc estimations for pesticides and all other chemicals for which no specific equation exists (EPA, 1988b):

$$\text{Log Koc} = 0.544 \text{ log Kow} + 1.377$$

For polynuclear aromatic hydrocarbons (PAHs), the following equation is appropriate (EPA, 1988b):

$$\text{Log Koc} = 0.937 \text{ log Kow} - 0.006$$

5.4 Bioconcentration Potential (BCF)

Chemicals can be transported from sediments, interstitial waters, or surface waters to biota. The chemical uptake rate can exceed the depuration rate, resulting in bioconcentration in biota exposed to those chemicals. The site of bioconcentration is chemical- and organism-specific, and many organic chemicals have an affinity for lipid; therefore, these chemicals are deposited in fatty tissue. Chemicals that are partitioned to lipid might not be available to cause adverse effects to host organisms until these lipids are metabolized. Metals can be partitioned to nearly any tissue depending on the metal and the exposed organism. The fact that metals can be partitioned to muscle tissue is of special concern for contaminants stored in a particularly toxic form (methylmercury) in edible fish tissue.

The bioconcentration factor is used to relate chemical uptake to chemical depuration; it is defined as the net accumulation of a chemical via aqueous uptake in excess of depuration, or

$$BCF = \frac{\text{chemical concentration in biota}}{\text{chemical concentration in water}}$$

BCFs are most commonly based on whole-body values (wet weight); however, BCFs are often determined for edible portions of fish and shellfish for which human consumption is a consideration. BCFs are based on uptake through water only and do not include uptake through dietary means. If both dietary and water uptake routes are considered, the term is defined as bioaccumulation factor (BAF). Generally, BAFs exceed BCFs for the same species and the same chemical. Therefore, BAFs are preferred over BCFs for assessing overall uptake and food chain effects. In general, however, BAF data are lacking for most chemicals and most species. Therefore, bioaccumulation potential is more commonly expressed as BCF (EPA, 1985h). For this assessment, BCF values were used to assess bioaccumulation potential because BAF data were lacking for many species and chemicals of concern. The food chain model used to estimate bioaccumulation in the aquatic food chain predicts BAFs; these predicted BAF values were used to estimate tissue concentrations in aquatic biota.

Reported BCFs used in this study, which were obtained primarily from EPA Ambient Water Quality Criteria Documents (1980-88), are based on lipid-normalized BCFs. This adjustment is intended to make all measured BCFs for a material comparable, regardless of species or tissue with which the BCF was measured (EPA, 1985h).

There is general agreement on the significance of BCF values. Most commonly, BCF values less than 1,000 are not considered to be significant. Recently, EPA (1991) recommended that chemicals with log Kow values of 3.5 or less be considered to have low potential to bioconcentrate. Log Kow is directly related to log BCF, and the EPA cutoff value of 3.5 (log Kow) reflects unadjusted BCFs of approximately 3,000. Therefore, COCs associated with BCFs greater than 3,000 were considered candidates for final media-specific COCs.

A few highly lipophilic (attracted to lipid) chemicals, such as methylmercury, DDT, and PCBs, tend to biomagnify in food chains or food webs. Biomagnification is defined as increasing biotic chemical concentration in successively higher trophic levels. For chemicals with high biomagnification potential, top-level predators commonly present the highest tissue concentrations of chemicals in food chains. Biomagnification also appears to be correlated to exposure duration. Long-lived species, and especially older individuals of long-lived species, tend to have the highest tissue concentrations of such biomagnified chemicals as mercury or PCBs. The ingestion of contaminated prey is considered the primary route of exposure for chemicals with high biomagnification potential. Other exposure routes, such as water intake, are considered to be likely but of little concern in comparison to the ingestion of food contaminated with highly lipophilic chemicals.

The preferred method for determining biomagnification of chemicals of concern is by measuring contaminant concentrations in tissue samples of several representative food chain organisms encompassing the primary trophic levels of the food chain. However, analytical considerations (methodology limitations, expense, and time constraints) often preclude complex food chain sampling. An appropriate alternative method for evaluating biomagnification is through the combined use of selective tissue sampling and food chain modeling. Computer-based food chain models, such as those of Thomann (1989), are useful for predicting organic chemical distribution in some aquatic food chains.

5.5 Fate and Transport Modeling

Sampling results specific to the Study Area include extensive laboratory- measured sediment and surface water COC concentrations and measured tissue concentrations of the primary COCs. Because data are extensive and the chemicals of concern are so well characterized, complex computer modeling of chemical fate and transport is considered unnecessary for this study. The decision not to use computer modeling fate and transport is based on a primary assumption that extensive measured data in sediments, surface water, and biota, are associated with lower levels of uncertainty than predicted values based on generalized computer models.

The prediction of future exposure concentrations in the various media clearly dictates the use of computer-based fate and transport models. However, future exposure scenarios are not the focus of this study, and the simple fate and transport models described above (Kd, $T_{1/2}$, BCF), in addition to the extensive sample data available, should adequately describe chemical fate and transport for this study.

5.6 Sediment Transport

5.6.1 Introduction

This section discusses sediment transport based on stream flow velocity data obtained during monthly sampling events from November 1989 through December 1990. Flow velocities were not measured at all sampling locations during each month. All flow velocities were obtained using the "6/10" method of measurement; this method obtains flow velocities from a point above the stream bed that is approximately 6/10 of the total stream depth. The average depth at the points of stream flow measurement in Reach 1 through Reach 7 was two to three feet; therefore, flow velocities referenced in this section were obtained at a depth of 0.8 to 1.2 feet beneath the surface. Particle size data for each respective Reach were obtained during Phase I and Phase II sampling events; this work occurred during a time-frame that was suitable for making comparisons.

Contaminants are most likely to be adsorbed onto silts and clays;

however, these particles generally require higher flow velocities than sands to become entrained in the stream. The most mobile particles are fine sands that do not possess the high absorption tendencies of silts and clays. The following sections discuss contaminant transport entrainment, the resuspension of bed-load sediment, and traction and transport of bed-load along the River bottom. The maximum recorded flow velocities and the highest recorded percentages of fine sand, silt, and clay were used to determine a "worst-case" scenario of the viability of contaminant transport by sediment entrainment and bed-load traction. Table 5-1 summarizes the data discussed in the following sections. A description of each Reach is presented in Section 1.2.1 and illustrated in Figures 1-A and 1-B.

5.6.2 Reach 1

This section of the Sudbury River is approximately 6.5 miles long and drops 100 feet in elevation along its course. Stream flow velocities were calculated from Southville Pond to the Nyanza Site. Flow velocity in the Southville Pond was below measurable limits; however, immediately downstream of the Cordaville Dam, which impounds the pond, maximum velocities of 15.24 cm/sec were measured. Flow velocities of 39.62 cm/sec were recorded 500 feet downstream from Cordaville Dam. Stream flow decreased to 3.05 cm/sec approximately 2,000 feet upstream from the Nyanza Site; however, approximately 1,400 feet upstream of the Nyanza Site, flow velocities reached a maximum of 91.44 cm/sec. Stream flow velocities reached entrainment levels (over 30 cm/sec) during April, June, August, October, November, and December. (Velocities above 30 cm/sec will begin the entrainment of fine sand and approach the point at which silt and clay will become fully mobile in the stream) (Friedman and Sanders, 1978).

Sediment size data for Reach 1 were obtained from only the downstream half of the Reach beginning at Southville Pond. The sediments in the pond and immediately downstream of the pond's spillway consist of predominantly coarse to medium sand with minor accumulations of small pebbles. Approximately 1,500 feet upstream from the Nyanza Site, the Sudbury River bed consists of fine sand grading to coarse silt.

Velocities greater than 90 cm/sec will entrain coarse pebbles and are more than sufficient to entrain clay. Maximum flow velocities exceeding 90 cm/sec were measured. Flow velocities of 30 cm/sec or greater were measured during several months in 1990. Contaminant transport by sediment entrainment and bed-load traction will occur under these conditions.

Table 5-1. Summary of Hydraulic Data for the Sudbury River

Stream Reach	Length in Miles	Elevation Drop	Flow Velocity (cm/sec)		Sediment Size	
			Min	Max.	Upstream	Downstream
1	6.5	100	3.05	91.44	NA	medium to coarse sand
2	1.16	minimal	1.00	9.14	medium to very fine	fine sand, coarse silt
3	1.83	NA	<1.00	30.48	pebbles to fine sand coarse to medium silts	very fine sand to coarse silt
4	0.73	minimal	<1.00	NA	very fine sands, silts and clays	NA
5	1.59	locally steep	NA	9.14	various sizes of sand	NA
6	1.23	minimal	<1.00 or below measurable limits	3.05	coarse sand to coarse silt	coarse silt, very fine sand
7	3.37	minimal	<1.00 or below measurable limits	NA	coarse to fine sand	very fine sands, coarse to medium silts

5.6.3 Reach 2

This section of the River, stretching from Mill Pond to the confluence of Cold Spring Brook and the River, exhibits a very low gradient, much less than that of Reach 1. The wetlands bordering this reach suggest a stream flow velocity low enough to allow the accumulation of vegetative growth. Measured flow velocities in Mill Pond were less than 1.00 cm/sec. Velocities near the end of this reach measured between 3.05 and 9.14 cm/sec.

Bottom sediments in Mill Pond ranged from medium to very fine sand (upstream) to fine sand/coarse silt (downstream). The rest of the reach was characterized by a stream floor consisting of pebbles and coarse sand, with less than ten percent of the sediments analyzed smaller than medium sand.

The maximum flow velocity of 9.14 cm/sec was observed twice during 1990. Such a velocity is insufficient to entrain fine sand, the most mobile sediment size. Contaminant transport by traction of fine sand along the stream floor is an uncommon event. Traction within Reach 2 would require an unusually smooth stream bed and consistent bottom currents greater than those measured. The occurrence of this phenomenon is highly unlikely. A wide range of measured flow velocities indicates that portions of this Reach, particularly Mill Pond, are depositional.

The channelized portions of the Reach have measured flow velocities sufficient to maintain sediment in suspension.

5.6.4 Reach 3

This section of the Sudbury River consists of Reservoir 2 and a short length of River channel before Reservoir 2. Reservoir 2 consists of two separate surface water bodies connected by a channel-way. Velocities of water flowing into the southern section of Reservoir 2 reached a maximum of 30.48 cm/sec, while flow at the downstream end was measured at 3.05 cm/sec. At the farthest downstream sampling location (upstream of the Reservoir 2 spillway), flow velocity was less than 1.00 cm/sec. Maximum flow velocities in this Reach were observed during April 1990.

Just before the River enters the upstream section of Reservoir 2, the bed-load consists of a wide range of sediment sizes, from pebbles to fine sand (SD3-117 and 158). Throughout the upstream section of Reservoir 2, bottom sediments are dominated by coarse and medium silts (SD3-118 and 120). The downstream section of Reservoir 2 contains a large percentage of coarse to very fine sand. Minor coarse silt also occurs.

Before entering Reservoir 2, water velocities reached a maximum of

30.48 cm/sec, which would indicate the beginning stages of fine sand entrainment. However, both sections of Reservoir 2 consistently exhibited maximum flow velocities of 3.05 cm/sec, which will not support any entrainment or bed-load traction. Therefore, contaminant transport by entrainment and traction is viable only in the short length of stream channel upstream of Reservoir 2.

The River portion of this Reach will maintain sediment in suspension. The low-flow conditions in Reservoir 2 indicate a depositional environment.

5.6.5 Reach 4

This section of the Sudbury River consists of Reservoir 1 and several associated wetland areas. No data on flow velocities of water in this reach were available; however, it can be assumed that water velocities in this reservoir would be similar to those observed at other surface water impoundments along the Sudbury River (less than 1.00 cm/sec).

Sediments in Reach 4 were silts and clays with some fine sand size particles. Transport by sediment entrainment or traction is not possible in Reach 4 under normal flow conditions. This Reach is also likely to be depositional in nature.

5.6.6 Reach 5

This Reach consists of slightly meandering open waterway. Immediately downstream of Reach 4, the River gradient increases, resulting in greater flow velocity. The only stream flow velocity measurement available was obtained immediately downstream of the dam that impounds Reservoir 1. The flow velocity at this sampling location was 9.14 cm/sec.

Pebbles are the dominant sediment of the River floor approximately 2,000 to 4,000 feet downstream of the dam. Over the entire length of the Reach, sands make up the largest percentage of River sediment deposits.

A flow of 9.14 cm/sec is probably not representative of the entire Reach. However, the extent of Reach 5 is narrow and well-defined, suggesting that average stream flow velocity is sufficiently high that host lithologies are resistant enough to decrease the meandering of the stream. Because sand of various sizes is the predominant sediment, and since the maximum flow velocities reported are too low to entrain fine sand, contaminant migration by sediment entrainment is not possible under normal flow conditions. However, as stated in earlier sections, 9.14 cm/sec can support the traction of finer sands if physical conditions of the stream floor are conducive to the traction process. Therefore, traction should not be eliminated as an occasional method of transporting contaminant-laden sediment downstream.

Velocities in the range of 9 cm/sec are sufficient to keep fine sand and smaller size fractions in suspension. Any sediment in suspension, therefore, is likely to be transported through Reach 5. This is supported by the low percentage of finer grained size fractions in sediment samples along this reach, including SD3-136, 174, 175, and 176.

Sediments in the Oxbow Lake in Reach 5, including samples SD3-138, 177, and 178, are classified as medium to coarse sand and sandy silts. The Oxbow Lake is a cut-off meander of the River. The finer grain sizes found here are probably a result of an infilling process, including bank erosion and slumping that has occurred since the oxbow was cut off from the River.

5.6.7 Reach 6

Reach 6 consists of two impoundments contained by the Fenwick Street and Saxonville Dams. This Reach is choked with submerged and floating leafy vegetation.

Flow data collected at the Fenwick Street Dam impoundment indicate a maximum flow of 3.05 cm/sec. Flow velocity measured in the Saxonville Dam impoundment consistently was below measurable limits.

No sediment grain size data were available for the surface water impoundment behind the Fenwick Street Dam due to the high organic content of the sample. Bottom sediments within the Saxonville Dam impoundment ranged from coarse sand to coarse silt, with the coarse silt and very fine sand predominant in the downstream sections.

Low-flow velocities and fine sediments collected in this Reach indicate that water flowing through these impoundments cannot maintain sediment in suspension. This Reach is a depositional area.

5.6.8 Reach 7

Reach 7 of the Sudbury River represents a large floodplain. In characteristic nature, this section consists of broad meanders created as the gradient flattens considerably and approaches horizontal. Stream flow velocities were recorded as below measurable limits or 0 cm/sec. Again, the River is covered by lush growths of floating vegetation suggestive of extremely slow-moving water.

Coarse to fine sand dominated the bottom sediments in the upstream third of this reach. The presence of small pebbles was reported in one sample location, SD3-183. Further downstream of this section, coarse and medium sands were replaced by very fine sands and coarse to medium silts.

It is likely that both sediment entrainment and traction of bed-load are not possible under normal stream flow conditions in this Reach, and that large portions are depositional areas, with water flow velocities too slow to maintain sediments in suspension.

No grain-size samples were collected from reaches 8,9, or 10.

5.6.9 Eastern Wetlands

The Eastern Wetlands received runoff and lagoon discharges from the Nyanza Site for many years. This wetland area might be a continuing source of contamination to the Sudbury River.

The Eastern Wetlands are impounded by an old trolley bed to the west, an exposed bedrock knob to the east, and Megunko Road to the north (Figure 2-D). The Wetlands consist of several acres of ponded water that discharges to a culvert passing under Megunko Road to Trolley Brook, which subsequently enters Chemical Brook Culvert.

Water flow in the Wetlands is not measurable. Flow velocity and volume at the discharge point ranges from negligible during dry periods to substantial during rain events and spring runoff. Most contaminant (and sediment) transport will occur during these events.

Recharge of the Wetlands by groundwater occurs seasonally, however, the interaction of the surface water and groundwater was not the focus of this investigation. Groundwater recharge as a potential contaminant pathway is addressed by Ebasco (1991) in the Operable Unit II groundwater study.

5.6.10 Chemical Brook Culvert/Outfall Creek

The transport of contaminants through Chemical Brook Culvert was investigated through a visual and remote video inspection. Appendix H contains details of the Culvert video inspection.

An attempt was made to quantify water flow using a current meter; however, the data may not accurately reflect flow velocities due to turbulent water flow at most Culvert access points. Water flow velocities exiting sections of Culverts into manholes appeared to be sufficient to keep fine grained sediments in suspension and to transport them through the Culvert. However, minor accumulations of fine sediments were noted in manholes at the upstream end of the Culvert.

The Culvert is a constructed series of pipes and connected catch basins. Because the catch basins are deeper and larger in diameter than the Culvert pipe, water entering them will flow turbulently. Sediment will be deposited in the backwater eddy of the turbulent flow. Several inches of silt-size sediment were noted in two manholes in the upstream end of the Culvert. Sediment in other manholes consisted of sandy gravel with cultural debris. No other significant accumulations of sediment were noted during the video inspection.

Much of the downstream portion of the Culvert has an open, stream bed-type bottom. The Culvert discharges to the Outfall Creek before it empties into the Raceway. The Outfall Creek is a swift-moving channelized stream. No accumulations of sediments were noted in the Creek.

The surface water/groundwater relationship was not the focus of this study, so information is not available to determine if the Culvert and Outfall Creek are receiving or recharging groundwater.

5.6.11 Raceway

The Raceway is a channelized, fast-moving waterway built to drive power-generating equipment and to supply water to historic mill sites (Figure 2C).

Coarse sand and gravel characterize the Raceway bottom. Some well-established deposits of fine-grained sediments are present in limited areas throughout the length of the Raceway.

No flow velocity data were collected here. Visual estimates indicate that the water velocity is sufficient to transport fine sand and smaller sediments through the length of the Raceway under normal flow conditions. Seasonal flooding conditions can cause the influx of sediments and redistribute fine-grained sediment deposits through the length of the Raceway; however, this feature is not considered a depositional area under normal flow conditions.

5.7 Chemical-Specific Fate and Transport

Results of sampling indicate that several chemicals or classes of chemicals are expected to dominate both the human health and ecological risk assessments. These chemicals include mercury, chromium, lead, polynuclear aromatic hydrocarbons, chlorinated benzenes, pesticides (DDT, DDE, chlordane), and possibly other organic chemicals such as acetone and trichloroethene. In general, fate and transport of a chemical in a given chemical class (polynuclear aromatic hydrocarbons, metals, pesticides) are likely to follow similar processes as other chemicals within that class. The following sections contain a generalized review of fate and transport processes for chemicals or classes of chemicals, of potential concern.

5.7.1 Chromium

Chromium is an essential element for mammals and possibly other organisms, and in nearly all environmentally important compounds it exists as either hexavalent (Cr^{+6}) or trivalent (Cr^{+3}) chromium (FWS, 1986a). Hexavalent chromium in the environment is usually the result of domestic and industrial discharges, while trivalent chromium is the form generally found in biological tissues. Under certain conditions, hexavalent chromium is reduced to trivalent chromium, thereby reducing potential toxicity. Under these conditions, trivalent chromium exists as an essentially nontoxic precipitate.

Hexavalent chromium is many times more soluble (and hence more bioavailable) than trivalent chromium; therefore, high surface water concentrations of hexavalent chromium pose a significant hazard to aquatic life. In contrast, trivalent chromium has a low solubility, and thus significant surface water concentrations are extremely unlikely.

Hexavalent chromium analyses were performed on six sediment samples collected in the Study Area. The results of these analyses indicate hexavalent chromium concentrations are below detection limits (10 ug/L) for all samples.

Because sediments contaminated with chromium are likely to contain primarily trivalent chromium, chromium toxicity is unlikely under naturally occurring conditions unless surface water chromium concentrations approach levels considered toxic.

Aqueous transport processes of chromium include surface water transport (primarily dissolved toxic hexavalent chromium) and sediment/suspended solids transport (primarily less toxic trivalent chromium). Chromium speciation and behavior in soils is not well known, but chromium adsorbed to soil particles is readily transported during surface runoff to aqueous systems. Chromium adsorbed to soil and sediment should be considered persistent, but the dynamics of chromium oxidation/reduction under natural conditions are not well studied; the potential toxicity of contaminated systems can change over time or under certain conditions. Whether oxidation of trivalent chromium (to Cr^{+6}) or reduction of hexavalent chromium (to Cr^{+3}) is the dominant process appears to depend on aeration and pH. Environmental fate processes for most metals, including chromium, are limited in number, and neither hexavalent nor trivalent chromium significantly bioconcentrates in fish or invertebrates (EPA, 1985c).

Four of 33 unfiltered water samples (SW3-103, 104, 106 and 113) contained chromium above detectable limits. The highest concentration of chromium in these samples was 79 ppm (SW3-104, Eastern Wetlands). Three of the unfiltered water samples that contained chromium above detectable levels were filtered and then analyzed (see Section 4.3.3.15.). Chromium was not detected in the filtered samples, indicating it is not readily desorbing from sediments and entering the aquatic environment.

5.7.2 Lead

Lead is similar to most metals except mercury in fate and transport properties, including expected sorption to sediments and soils, low bioconcentration potential and environmental persistence (EPA, 1985f). Although lead appears to have an affinity for soils and sediments, surface water concentrations of lead which are known to result in adverse chronic effects to aquatic life, are relatively common. The most environmentally important form of lead is Pb^{+2}, but several other forms are both soluble and toxic.

Lead is most soluble and bioavailable under conditions of low pH, low organic content, low concentration of suspended solids and low concentrations of calcium, iron, manganese, zinc, and cadmium (FWS, 1988). The water quality criteria measured in the Study Area were above these thresholds of concern. If aqueous lead and lead compounds are present, they tend to concentrate in the water surface microlayer. However, most lead entering natural waters is precipitated to bed sediments as hydroxides or carbonates (FWS, 1988). Desorption from bed sediments is slow. Water flow rate affects both lead speciation and migration. At low stream flow, lead is likely to be removed rapidly from the water column by adsorption onto sediment particles and subsequent sedimentation (FWS, 1988). As with many metals, lead is mobilized and released from sediments when pH decreases rapidly.

Lead adsorbed to sediment particles is likely to be transported to and in aquatic systems by processes similar to those described for chromium. Possible fate processes for lead in aquatic systems include: long-term sorption to bed sediments; desorption and release from sediments under low pH conditions; uptake by aquatic organisms; and possibly methylation by fish and other aquatic life. The mechanism and potential biological effects of lead methylation are unclear (FWS, 1988). Freshwater bioconcentration factors for lead suggest a relatively low potential for significant bioconcentration. Lead does not biomagnify in food chains.

5.7.3 Mercury

Mercury occurs in the natural environment primarily as inorganic mercury (Hg^{+2}). Its sources can include the direct industrial discharge of inorganic mercury or the oxidization of elemental mercury to inorganic mercury. Inorganic mercury, in turn, can be methylated by both aerobic and anaerobic bacteria that are present in freshwater sediments and in the slime coat, intestines, and liver of fish (FWS, 1987a). Methylmercury is more toxic to biota than inorganic mercury; therefore, the conversion of inorganic mercury to methylmercury is a critical process. Analyses performed on 22 surface water samples collected in the Study Area revealed methylmercury concentrations below detection limits in all the samples. Similar analyses were performed on 64 sediment samples; less than eight percent of the sediment samples exhibited detectable concentrations of monomethylmercury. Dimethylmercury was detected in only one sediment sample.

Primary fate processes of mercury include adsorption to sediments and suspended particulates; relatively rapid biotic uptake (especially methylmercury) through ingestion of contaminated sediments, prey, and water; methylation of inorganic mercury; slow depuration (elimination and metabolism); bioconcentration in tissue; and biomagnification in the food chain. Freshwater bioconcentration factors for inorganic mercury range from 1,800 to nearly 5,000, while similar factors for methylmercury range from 10,000 to 85,700 (EPA, 1984g).

Mercury is transported to and within aquatic systems by processes generally similar to those described for the other metals of concern. Results of TCLP tests performed on sediments collected in the Study Area suggest that sediment-bound mercury is likely to remain bound to sediment particles. Even at pH 5.0, which is less than pH values expected in the Study Area, aqueous mercury was below detection limits using TCLP methodology. The relatively low concentrations of mercury in surface water samples measured from the Study Area, compared to the relatively high sediment concentrations detected, support this assumption. Because of the potential for methylation, rapid uptake, and slow depuration, mercury is transported in significant concentrations through food chains. The high degree of both bioaccumulation (uptake through food and water) and toxicity, results in the classification of mercury as one of the most toxic chemicals in the environment.

5.7.4 Polynuclear Aromatic Hydrocarbons

Polynuclear or polycyclic aromatic hydrocarbons (PAHs) are a diverse class of compounds consisting of substituted and unsubstituted polycyclic and heterocyclic aromatic rings. PAHs are naturally occurring, but most PAHs found in the environment today are the result of the incomplete combustion of organic compounds. PAHs are widely distributed in the environment, and have been detected in air, groundwater, surface water, soil, sediments, and plant and animal tissue (EPA, 1980h).

PAHs generally sorb strongly to soil and, in aquatic systems, adsorption to sediments, suspended particulates, and biota is likely. Photolysis is likely to be the primary degradation process in surface waters; however, photolysis rates of specific compounds vary widely within the class of PAHs. In addition, PAHs in surface waters can evaporate, disperse into the water column, or undergo chemical oxidation. Experimental evidence indicates that the ultimate fate of PAHs adsorbed to sediments is biodegradation and biotransformation by benthic organisms (EPA, 1980h). Complete degradation times are reported to range from less than one day to six weeks for particulate-bound PAHs (FWS, 1987b). Biotic uptake of PAHs from water and food is generally fairly rapid, yet bioconcentration in most freshwater organisms, especially fish, is low because of rapid metabolism. Mammals, fish, and possibly other organisms are efficient metabolizers of PAHs, yet mammalian and recent fish studies suggest that intermediate metabolites might be highly toxic, mutagenic, or carcinogenic to the host. Therefore, even though bioconcentration potential is considered low, unacceptable carcinogenic and noncarcinogenic risk levels might be associated with elevated environmental concentrations of PAHs.

Run-off from roadways is a significant contributor to surface water and sediment PAH contamination. PAHs that are transported to surface waters from run-off are likely to adsorb to sediment particles and be transported downstream. Thus, PAHs are transported by sediment transport processes. Resuspension of sediments release PAH-contaminated sediments to the water column, where photolytic processes are likely to result in degradation of these compounds. In addition, releases of sediment-adsorbed PAHs to surface waters can increase PAH bioavailability and potential for adverse effects to aquatic life. While surface water concentrations of PAHs remained low in samples collected in the Study Area, sediment samples revealed significant contamination with a variety of PAH compounds.

5.7.5 Chlorinated Benzenes

Chlorinated benzenes include 1,2-, 1,3-, 1,4-dichlorobenzene, and nine other chlorinated benzenes identified by the degree and location of chlorination on the benzene rings (EPA, 1980c, 1980e). Environmental persistence varies with the type of compound. Compounds that are more halogenated tend to be more resistant to biodegradation and, therefore, are more persistent (EPA, 1980c). Chlorinated benzenes are not likely to biomagnify within food chains. However, a 1972 report of hexachlorobenzene in the eggs of common terns that had apparently eaten contaminated fish, suggests that hexachlorobenzene can biomagnify (EPA, 1980c). The implications associated with this finding are unclear and further study is warranted.

Dichlorobenzenes are readily soluble in lipids and are relatively volatile (EPA, 1980e). The log Kow for 1,4-dichlorobenzene is 3.37 (EPA, 1980e), suggesting that this compound is not likely to bioconcentrate significantly in biota. Reported freshwater BCFs are less than 100 (EPA, 1980e). However, mammalian studies suggest that excretion of dichlorobenzenes is quite slow, indicating a cause for concern under conditions of long exposure durations.

Transport of chlorinated benzenes is not well characterized. Based on partitioning coefficients, aqueous transport is likely under natural conditions. Dichlorobenzenes are relatively immobile compounds in the environment and tend to be adsorbed and transported with sediments. Chlorinated benzenes in sediments and soils can be relatively persistent if these compounds are highly chlorinated; therefore, sediment-bound compounds may or may not contribute significantly to surface water contamination. Chlorinated benzenes were measured above detection limits in three surface water samples and 24 sediment samples collected in the Study Area. The contaminated sediments in the Study Area are likely to serve as potential sources of aqueous contamination.

5.7.6 Pesticides

Pesticides of potential concern include DDT and its metabolites (primarily DDD and DDE) and chlordane. DDT and its metabolites are highly persistent in soil and water; they are also widely dispersed by erosion, runoff, and volatilization, and have low water solubility and high lipophilicity, resulting in bioaccumulation in wildlife and humans (EPA, 1980d). The log Kow for DDT and its metabolites ranges from approximately 4.0 to over 6.1, which explains the relatively high lipophilicity of these compounds. Measured freshwater BCFs range from approximately 2,000 (Procambarus alleni, crayfish) to greater than 4 million (kiyi, a freshwater fish) (EPA, 1980d).

The maximum estimated biodegradation half-life of DDT in soil and under aerobic conditions in surface water is 15.6 years (Howard et al., 1991). The use of DDT has been banned in the United States for nearly 20 years, yet it is still observed in significant concentrations in both soils and waters from a variety of sites. This might indicate that the estimated half-life is too conservative. Thirteen sediment samples from the Study Area contained DDT or its metabolites at concentrations above detection limits. Because of the properties stated above, DDT and its metabolites are likely to be transported with sediments and within biota. Aqueous transport is probably unlikely under most conditions, and surface water samples collected in the Study Area did not contain detectable concentrations of DDT, DDD, or DDE.

Chlordane is a broad-spectrum pesticide that was produced in a variety of formulations from 1947 until 1983, when its use in the United States was restricted to termite control. Although the aqueous half-life of some chlordane isomers is short (<18 hours), soil half-lives can exceed 14 years (FWS, 1990). In general, biomagnification of chlordane in freshwater environments is unexpected. Chlordane is absorbed readily by mammals and birds through skin, diet, and inhalation. The potential for chlordane absorption by other groups of animals is unknown. Data are also unavailable on the degradation of chlordane by photolysis, photooxidation, or reduction. A hydrolysis half-life of nearly 200,000 years has been estimated (Howard et al., 1991), indicating that hydrolysis is not a primary degradative process.

Chlordane transport is likely to be similar to that of DDT and its metabolites; therefore, the transport of suspended sediments contaminated with chlordane might be the primary route of surface water transport. Concentrations of chlordane in surface waters with low suspended solids are likely to remain low. In support of this argument, chlordane was not detected in any surface water samples collected within the Study Area. Sediment half-lives for chlordane are likely to be similar to those of soils; therefore, chlordane is likely to be relatively persistent in aerobic sediments. Only one sediment sample collected in the Study Area contained chlordane above detection limits.

5.7.7 Polychlorinated Biphenyls

PCBs consist of a mixture of chlorinated biphenyls that contain a varying number of substituted chlorine atoms on the aromatic rings (EPA, 1980g). PCBs are classified according to the degree of chlorination, and are designated by the manufacturer as Aroclors. Less chlorinated Aroclors include 1016, 1221, 1232, 1242, and 1248. Increasing chlorination is designated by higher Aroclor numbers (1254, 1260, 1262, 1268, and 1270). In addition to being toxic and environmentally persistent, PCB mixtures can contain small quantities of highly toxic contaminants, such as polychlorinated dibenzofurans (PCDFs). PCDFs may be responsible for certain toxic effects in humans and animals that are associated with PCBs (EPA, 1980g).

Fate and transport of PCBs depends on specific properties associated with degree of chlorination, which can differ significantly (the water solubility ranges from less than 3 ug/L to 200 ug/L;) (EPA, 1980g). Long-range atmospheric transport of PCBs by wind, rain, and snow is well documented (FWS, 1986b). Volatilization is apparently rapid in aqueous systems, but PCB sorption to sediments limits the rate of volatilization. Adsorption to bed sediments is likely under most naturally occurring freshwater aquatic conditions, and PCBs can remain in sediments for at least eight to 15 years (FWS, 1986b). Reported Kows for PCBs range from 10,000 to 20,000 (EPA, 1980g), suggesting a moderate to high bioconcentration potential and a relatively high degree of lipophilicity. Reported freshwater BCFs range from 2,700 (midge) to 274,000 (fathead minnow) (EPA, 1980g). Most BCF data is based on moderately chlorinated Aroclors such as 1242, 1248, and 1254. PCBs are included with the few chemicals (DDT and methylmercury) that are known to biomagnify in food chains; therefore, low aqueous concentrations of PCBs in surface waters can pose serious hazards to aquatic life and organisms that consume contaminated aquatic species.

In general, PCB transport processes are likely to be similar to those of DDT (aqueous transport is most likely limited to transport of contaminated suspended sediment and uptake and transport through food chains). The primary fate processes of PCBs include deposition to bed sediments and biotic uptake and deposition to fatty tissue. PCBs were measured above detection limits in three sediment samples, and were not detected in any surface water samples collected in the Study Area. However, concentrations of PCBs were detected in fish tissue; this subject is discussed in Section 7.0.

5.7.8 Chemical Fate and Transport Summary

The primary transport processes for Study Area contaminants include seepage from soils, overland transport in surface runoff, and in-stream transport. Contaminants associated with suspended particulate matter probably will be transported in flowing waters, settle out in quiet waters, and ultimately be deposited in bed sediments. Because of this cycle, impoundment sediments in the Study Area are generally more contaminated than River sediments. Sediments in Reservoirs Nos. 1 and 2 are more contaminated than those in downstream impoundments. Contaminant release or mobilization from bed sediments are likely only under certain conditions, such as low pH or significant disturbance of upper layer sediments.

All Site contaminants are expected to have an affinity for sediments and soil and, in general, concentrations of contaminants in these media greatly exceed those of surface water. Contaminants that occur at relatively elevated concentrations in surface water should be considered the most hazardous because exposure duration is constant for aquatic life. Evaluating the bioavailability of contaminants is critical for an accurate assessment of the potential for adverse effects to biota, and contaminants dissolved in surface water are more likely to be bioavailable than those sorbed to sediments or soil.

Contaminated sediments can be a long-term source of surface water contamination for persistent chemicals such as metals, pesticides, and, under anaerobic conditions, some PAHs. However, chromium, mercury, and lead are not desorbed readily from sediments, as indicated by the frequency of nondetectable concentrations in TCLP and filtered sample analyses. Desorption is unexpected unless conditions of low pH (lower than has been measured in the River) or significant sediment perturbation exist. Ingestion of contaminated sediments or soils is generally considered a minor exposure pathway for most aquatic or terrestrial biota in comparison to aqueous exposure, but it can be a potentially significant exposure route for humans, especially children. Exposure sources, pathways, and routes are discussed in detail in the appropriate sections for the human health and ecological risk assessments.

The distribution of contaminants, as discussed in Section 4.0, supports the conclusions of this Fate and Transport discussion. Contaminants that have an affinity for sediment particles are found in much higher concentrations in the reservoirs than in the River runs. In addition, sediments in Reservoir 2 generally exhibit higher concentrations of contaminants than Reservoir 1. Contaminant concentrations in reservoir sediments were consistently lower down-River; contaminant concentrations in River segments where relatively high water flow velocities were measured were lower than those encountered in slower moving reaches of the River and considerably lower than those in reservoirs.

6

6.0 BASELINE PUBLIC HEALTH RISK ASSESSMENT

6.1 Objectives

Section 6.0 presents the methodology for and the results of a baseline public health risk assessment conducted for the Sudbury River Study Area. The objective of the risk assessment is to predict potential current and future risks to the public from the organic and inorganic chemicals detected in surface waters, sediments, and fish tissues. Site-related and study area contaminants were considered separately in the risk assessment to evaluate the contribution of the risk posed by Site-related risks to the overall study area risks. The baseline public health risk assessment for the Study Area was conducted according to guidelines presented in the following references:

- Supplemental Risk Assessment Guidance for the Superfund Program, EPA Region I, June 1989 (EPA 901/5-89-001).
- Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA, December 1989 (EPA 540/1-89-002).

The baseline risk assessment is organized according to the following outline:

- Hazard Identification/Selection of Chemicals of Potential Concern. A subset of all chemicals detected in environmental samples collected from the Study Area is selected to represent Study Area contaminants in the risk assessment. These chemicals are frequently referred to as "indicator chemicals" or "chemicals of concern." Chemicals of concern are selected based on contaminant occurrence and distribution, persistence, toxicity, and mobility. Information on the known or suspected adverse noncarcinogenic or carcinogenic health effects of each indicator compound is presented.
- Dose-Response Assessment. Available health-based standards and criteria and dose-response parameters (toxicity criteria) are summarized for each chemical of concern.
- Exposure Assessment. The Study Area is described with respect to the receptors who are potentially exposed to the contaminated environmental media. The risk assessment identifies exposure mechanisms by which human

receptors potentially contact the chemicals of concern. Exposure scenarios are developed which allow a quantitative estimation of the "dose" to which an individual may theoretically be exposed as a result of contact with Study Area chemicals of concern.

- Risk Characterization. Toxicity criteria, such as Carcinogenic Slope Factors and Reference Doses are used to estimate the potential for adverse health effects that may occur as a result of human exposure to Study Area contaminants. Separate risk calculations were performed for site-related and study area contaminants. These calculations were performed to provide an indication of whether risks posed by site related contaminants were a major contribution to overall study area risks.

6.2 Hazard Identification

This section provides the rationale for the selection of contaminants of concern (COC). The COCs will be used to characterize the potential for noncarcinogenic effects and the carcinogenic risks associated with the exposure to surface water and sediments and the consumption of fish taken from the Study Area. The chemical occurrence and distribution tables presented in Section 4.0 of the RI provide a basis for selection of contaminants of concern.

6.2.1 Selection of Study Area Chemicals of Concern

The following factors were considered in selecting the COCs for the Study Area:

- Occurrence and distribution of the chemicals
- Environmental fate and mobility of the chemicals
- Chemical toxicity
- Chemical persistence

The concentration-toxicity screening procedure presented in the Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A) (EPA, December 1989) was used to identify those chemicals that are most likely to contribute significantly to risks associated with human exposure to contaminated environmental media. Each chemical detected was assigned a risk factor (or chemical score), based on the maximum concentration of the chemical in the environmental medium and the toxicity criteria for the chemical. The toxicity criteria used to conduct the concentration-toxicity screening are presented on Table 6-1. The primary reference for the toxicity criteria is the

TABLE 6-1
TOXICITY CRITERIA FOR CHEMICALS OF CONCERN SELECTION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Chemical	Reference Dose Oral Route of Exposure (mg/kg/day)	Cancer Slope Factor Oral Route of Exposure $(mg/kg/day)^{-1}$
Acetone	1.0E-01(1)	
Benzene		2.9E-02 A(1)
2-Butanone	5.0E-02(2)	
Chlorobenzene	2.0E-02(1)	
Chloromethane		1.3E-02 B2(2)
1,1-Dichloroethene	9.0E-03(1)	6.0E-01 C(1)
1,2-Dichloroethene	1.0E-02(2)	
Ethylbenzene	1.0E-01(1)	
Methylene chloride	6.0E-02(1)	7.5E-03 B2(1)
Styrene	2.0E-01(1)	3.0E-02 B2(1)
Tetrachloroethene	1.0E-02(2)	5.1E-02 B2(2)
Toluene	2.0E-01(1)	
Total Xylenes	2.0(1)	
Trichloroethene		1.1E-02 B2(2)
Vinyl chloride		1.9 A(1)
Acenaphthene	6.0E-02(1)	
Acenaphthylene**	4.0E-03(2)	
Anthracene	3.0E-01(1)	
Benzo(a)anthracene*		5.8 B2(4)
Benzo(a)pyrene		5.8 B2(4)
Benzo(b)fluoranthene*		5.8 B2(4)
Benzo(g,h,i)perylene	4.0E-03(2)	
Benzo(k)fluoranthene*		5.8 B2(4)
Benzoic Acid	4.0(1)	
Benzyl alcohol	3.0E-01(2)	
Bis(2-chloroethyl)ether		1.1 B2(2)
Bis(2-ethylhexyl)phthalate	2.0E-02(2)	1.4E-02 B2(1)
Butybenzylphthalate	2.0E-01(1)	

TABLE 6-1
TOXICITY CRITERIA FOR CHEMICALS OF CONCERN SELECTION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

Chemical	Reference Dose Oral Route of Exposure (mg/kg/day)	Cancer Slope Factor Oral Route of Exposure $(mg/kg/day)^{-1}$
2-Chlorophenol	5.0E-03(1)	
Chrysene*		5.8 B2(4)
Dibenz(a,h)anthracene*		5.8 B2(4)
Dibenzofuran	4.0E-03(3)	
1,3-Dichlorobenzene	3.0E-2	
1,4-Dichlorobenzene		2.4E-02 B2(2)
1,2-Dichlorobenzene	9.0E-02(1)	
Diethylphthalate	8.0E-01(1)	
Di-N-Butylphthalate	1.0E-01(1)	
Di-n-octylphthalate	2.0E-02(2)	
Fluoranthene	4.0E-02(1)	
Fluorene	4.0E-02(1)	
Indeno(1,2,3-cd)pyrene*		5.8 B2(4)
2-Methylnaphthalene	NA	NA
2-Methylphenol	5.0E-02(1)	
3-/4-Methylphenol	5.0E-02(1)	
Naphthalene	4.0E-03(2)	
Nitrobenzene	5.0E-04(1)	
N-Nitrosodiphenylamine		4.9E-03 B2(1)
Phenanthrene**	4.0E-03(2)	
Phenol	6.0E-01(1)	
Pyrene	3.0E-02(1)	
1,2,4-Trichlorobenzene	1.31E-03(2)	
Aldrin	3.0E-05(2)	1.7E+1 B2(2)
Chlordane	6.0E-05(1)	1.3 B2(1)
4,4'-DDD		2.4E-01 B2(2)
4,4'-DDE		3.4E-01 B2(1)

TABLE 6-1
TOXICITY CRITERIA FOR CHEMICALS OF CONCERN SELECTION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE THREE

Chemical	Reference Dose Oral Route of Exposure (mg/kg/day)	Cancer Slope Factor Oral Route of Exposure $(mg/kg/day)^{-1}$
4,4'-DDT	5.0E-04(1)	3.4E-01 B2(1)
Dieldrin	5.0E-05(1)	
Endosulfan	5.0E-05(1)	
Endrin	3.0E-04(1)	
Endrin Ketone	NA	NA
Heptachlor	5.0E-04(2)	4.5 B2(2)
Heptachlor epoxide	1.3E-05(1)	9.1 B2(1)
Lindane	3.0E-04(1)	1.3 B2(2)
Methyoxychlor	5.0E-03(1)	
Polychlorinated biphenyls		7.7 B2(1)
Aluminum	NA	NA
Antimony	4.0E-04(1)	
Arsenic	3.0E-04(1)	1.8A(1)(5)
Barium	5.0E-02(2)	
Beryllium	5.0E-03(1)	4.3A(1)
Cadmium	5.0E-04(1)	
Calcium	NA	NA
Chromium (+3)(6)	1.0(2)	
Cobalt	NA	NA
Copper	NA	NA
Iron	NA	NA
Lead	NA	NA
Magnesium	NA	NA
Manganese	1.0E-01(1)	
Mercury	3.0E-04(2)	

TABLE 6-1
TOXICITY CRITERIA FOR CHEMICALS OF CONCERN SELECTION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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Chemical	Reference Dose Oral Route of Exposure (mg/kg/day)	Cancer Slope Factor Oral Route of Exposure $(mg/kg/day)^{-1}$
Nickel	2.0E-02⁽¹⁾	
Potassium	NA	NA
Selenium	5.0E-03⁽¹⁾	
Silver	3.0E-03⁽²⁾	
Sodium	NA	NA
Vanadium	7.0E-03⁽²⁾	
Zinc	2.0E-01⁽²⁾	
Thallium	7.0E-05⁽²⁾	

NA Neither RfDs or CSFs are available for these chemicals.

(1) U.S. EPA Integrated Risk Information System (12-3-91).

(2) U.S. EPA Health Effects Assessment Summary Tables, Annual FY-1991 (EPA, January 1991).

(3) U.S. EPA, ECAO provisional RfD for Nyanza.

(4) U.S. EPA Drinking Water Health Advisory Memorandum (EPA, April 1991).

(5) Based on a unit risk of 5 x $10^{-5}/\mu g/L$.

(6) Sediment samples collected at the Nyanza Site were analyzed for Total Chromium and hexavalent chromium. Hexavalent chromium was not detected in the sediments; thus, the RfD for trivalent chromium is used in this risk assessment.

* According to EPA Region I guidance, the reference dose for naphthalene is used as a surrogate for the noncarcinogenic PAH compounds.

** According to EPA Region I guidance, a 5.8 $(mg/kg/day)^{-1}$ cancer slope factor is used to evaluate carcinogenic PAHs.

A blank space indicates that either a CSF or RfD is not available for this compound.

EPA's Integrated Risk Information System (IRIS) (EPA, December 1991). Toxicity criteria available from EPA Region I, the EPA Health Effects Assessment Summary Tables (HEAST) FY 1991, and the EPA Drinking Water Health Advisory Memorandum (EPA, April 1991) were used when toxicity criteria were not available on IRIS.

The concentration-toxicity screen uses the following expression to develop a risk factor for each chemical:

Ri = Ci x Ti

Where:

Ri = Risk factor for chemical i in the environmental medium

Ci = Maximum concentration of chemical i in the environmental medium

Ti = Toxicity value for chemical i in the environmental medium (i.e., either the Cancer Slope Factor (CSF) or 1/[Reference Dose (RfD)])

The ratio of the risk factor for each chemical to the total risk factor (ERi) for all chemicals is designated the relative risk for that chemical.

Tables 6-2, 6-3, and 6-4 present the results of the toxicity screen and the contaminant occurrence and distribution statistics (range of positive detections, number of positive detections/number of samples) that support the selection of COCs listed on Table 6-1. As a general guidance, Study Area chemicals meeting the following criteria were selected as chemicals of concern:

- Chemical demonstrated a relative risk factor greater than 0.001 <u>and</u> was detected more than once in an environmental medium.
- Chemical demonstrated a relative risk factor greater than 0.0001 and was detected in at least five percent of the environmental samples.

Additionally, any chemical listed as a Class A (Human Carcinogen) or Class B-1 (Probable Human Carcinogen: Limited evidence of carcinogenicity in human from epidemiologic studies) carcinogen in IRIS was selected as a COC.

The EPA has identified the following chemicals as Nyanza site-specific contaminants:

o	Trichloroethene	o	Phenols
o	1,2-Dichloroethene	o	Benzidene
o	Chlorobenzene	o	Antimony
o	Nitrobenzene	o	Cadmium
o	The Dichlorobenzenes	o	Chromium
o	1,2,4-Trichlorobenzene	o	Arsenic
o	Aniline	o	Lead
o	Naphthalene	o	Mercury

These contaminants are considered to be site related. They were detected at the Nyanza Site and/or in groundwater underlying or downgradient of the site. All Nyanza site-specific contaminants were selected as COCs.

The following subsections provide a detailed discussion of the COC selection rationale.

6.2.1.1 Volatile Organic Chemicals of Concern

According to CLP analytical results, the following Class A carcinogens were detected in environmental media sampled in the Study Area:

Chemical	Carcinogen Class	Surface Water Statistics	Sediment Statistics(1)	Fish Statistics
Vinyl chloride	A	ND	2.7%	ND
Benzene	A	ND	2.7%	ND

ND: Not detected.

(1) Number of positive detections/number of samples collected, expressed as a percentage.

Although these chemicals were detected infrequently, benzene and vinyl chloride are selected as COCs since they are both known human (Class A) carcinogens.

The following volatile organics were selected as COCs because they were detected in at least five percent of the samples analyzed and demonstrated a relative risk value greater then 0.0001.

Chemical	Surface Water Statistics(1)	ERi	Sediment Statistics(1)	ERi	Fish Statistics(1)	ERi
1,2-Dichloroethene	11%	$3x10^{-4}$(N)	26%	$5.8x10^{-4}$(N)	ND	-
Trichloroethene	8.3%	$3.52x10^{-3}$(C)	34%	$1.3x10^{-4}$(C)	ND	-
Chlorobenzene	ND	-	32%	$1.81x10^{-3}$(N)	ND	-
Methylene chloride	ND	-	9%	$3x10^{-6}$(C)	6.5%	$5.21x10^{-3}$(C)
Acetone	ND	-	34%	$3x10^{-5}$(N)	13%	$1.4x10^{-4}$(N)

N = Noncarcinogenic relative risk value.
C = Carcinogenic relative risk value.
ERi = Relative Risk
(1) Number of positive detections/number of samples collected, expressed as a percentage.

It should also be noted that 1,2-dichloroethene, trichloroethene, and chlorobenzene have been identified by the EPA as Nyanza site-specific contaminants.

1,1-Dichloroethene is selected as a COC because the relative risk calculated for this chemical (ERi = 4.43×10^{-2}, surface water) exceeds 1×10^{-3} and it was detected in surface water samples twice. However, it should be noted that the maximum concentration of 1,1-dichloroethene in surface waters was detected at a background sample location.

Based on the selection criteria previously discussed, the following volatile organic chemicals were not selected as COCs:

- Chloromethane
- 2-Butanone (methyl ethyl ketone)
- Toluene
- Styrene
- Total xylenes

The occurrence and distribution statistics and toxicity screen results that support the decision not to select these chemicals as COCs are presented in Tables 6-2, 6-3, and 6-4.

6.2.1.2 Semivolatile Organic Chemicals of Concern

Semivolatile organic chemicals (semi-VOCs) detected in environmental media samples collected in the Study Area included several polyaromatic hydrocarbons (PAHs), chlorinated benzene compounds, nitrobenzene, phenolics, and phthalates. As detailed in Section 4, these compounds were particularly prevalent in sediments.

None of the semi-VOCs detected in the Study Area are classified as Class A or B-1 carcinogens. The carcinogenic PAHs are classified as B-2 carcinogens (probable human carcinogen: sufficient evidence of carcinogenicity in animals; inadequate evidence of carcinogenicity in humans).

The following semi-VOCs were selected as COCs because they were detected in at least five percent of the samples analyzed and demonstrated a relative risk value greater than 0.0001 (Note: Some chemicals have both cancer and non-cancer toxicity values):

TABLE 6-2
SELECTION OF CHEMICALS OF CONCERN FOR SEDIMENTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg)$^{(1)}$	Background Concentration Range [Avg] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
VOLATILE ORGANIC CHEMICALS										
Methylene chloride	7/77	0 004 - 1 6 [0 133]	ND	$2.67x10^{-1}$	$3x10^{-5}$	$1 2x10^{-2}$	$3x10^{-5}$,B2	Eastern Wet.	No**	Selected for fish.
Vinyl chloride	2/74	0 006 - 0 13 [0 068]*	ND			$2.47x10^{-1}$	$6 4x10^{-4}$,A	Eastern Wet.	Yes	Class A carc
Acetone	26/77	0 010 - 2 6 [0 304]	0 01 [0 01]*	$2 6x10^{-1}$	$3x10^{-5}$			Reach 4	No**	Selected for fish.
1,2 Dichloroethene	19/73	0 0003 - 5 5 [0 21]	ND	$5 5x10^{-2}$	$5.8x10^{4}$			Eastern Wet.	Yes	Nyanza***
2-Butanone (methyl ethyl ketone)	15/69	0 017 - 0 45 [0 127]	ND	9	$1x10^{-5}$			Eastern Wetlands	No	Low toxicity score
Trichloroethene	25/74	0 0003 - 44 [1 755]	ND			$4.84x10^{-1}$	$1.3x10^{-3}$,B2	Raceway	Yes	Nyanza***
Benzene	2/74	0 002 - 0 004 [0 003]*	ND			$1 16x10^{-4}$	$<1x10^{-5}$,A	Eastern Wet	Yes	Class A carc.
Tetrachloroethene	2/74	0 0008 - 0 002 [0 0014]*	ND	$2x10^{1}$	$<1x10^{5}$	$1.02x10^{-4}$	$<1x10^{-5}$,B2	Culvert	No	Low concentration
Toluene	4/74	0 0004 - 0 016 [0 0064]*	ND	$8x10^{-2}$	$<1x10^{-5}$			Eastern Wet	No	Low toxicity score
Chlorobenzene	24/74	0 003 - 34 [2 22]	ND	$1 7x10^{-3}$	$1 81x10^{-3}$			Eastern Wet	Yes	Nyanza***
Ethybenzene	1/74	0 0007 [0 0007]*	ND	$7x10^{3}$	$<1x10^{5}$			Eastern Wet.	No	Low toxicity score
Total xylenes	3/74	0 001 - 0 005 [0 0027]*	ND	$2.5x10^{-3}$	$<1x10^{-5}$			Eastern Wet.	No	Low toxicity score
SEMIVOLATILE ORGANIC CHEMICALS										
Phenol	2/74	0 056 - 0 068 [0 062]*	ND	$1 13x10^{-1}$	$<1x10^{5}$			Eastern Wet.	No**	Selected for fish.
1,3 Dichloro benzene	11/74	0 018 - 0 29 [0 289]	ND	9 67	$<1x10^{5}$			Eastern Wet.	Yes	Nyanza***
1,4 Dichlorobenzene	19/74	0 048 - 3 1 [0 695]	ND			$7 44x10^{2}$	$1 9x10^{-4}$,B2	Eastern Wet.	Yes	Nyanza***
1,2 Dichlorobenzene	25/74	0 033 - 13 [1 875]	ND	$1 44x10^{-2}$	$1 5x10^{4}$			Eastern Wet.	Yes	Nyanza***
3/4-Methyl phenol	3/74	0 074 - 0 26 [0 154]*	ND	5 2	$1x10^{-5}$			Eastern Wet.	No**	Selected for fish.
2 chlorophenol	1/74	0 020 [0 020]*	ND	4	$<1x10^{5}$			Eastern Wet.	No	Low det freq
Nitro benzene	12/74	0 065 - 0 65 [0 205]*	ND	$1 3x10^{-3}$	$1 38x10^{3}$			Eastern Wet.	Yes	Nyanza***

TABLE 6-2
SELECTION OF CHEMICALS OF CONCERN FOR SEDIMENTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg)$^{(1)}$	Background Concentration Range [Avg] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				R_i	ER_i	R_i	ER_i			
SEMIVOLATILE ORGANIC CHEMICALS (CONTINUED)										
Benzoic acid	22/74	0 021 - 1 6 [0 332]*	ND	4 0x10^{-1}	< 1x10^{-5}			Eastern Wet.	No	Low toxicity score
1,2,4 Trichlorobenzene	20/74	0 042 3 1 [0 579]	ND	2 37x10^{+3}	2 52x10^{-3}			Eastern Wet.	Yes	Nyanza***
Napthalene	11/74	0 082 - 6 7 [0 785]	ND	1 68x10^{+3}	1 76x10^{-3}			Raceway	Yes	Nyanza***
2-Methyl napthalene	5/74	0 06 - 0 41 [0 396]	ND					Reach 2	Yes	No toxicity criteria
Acenapthylene	14/74	0 021 - 0 88 [0 425]	ND	2.2 x 10^{+2}	2.3x10^{-4}			Reach 3	Yes	(2)
Acenapthene	7/74	0 043 1 235 [0 636]	ND	2 06x10^{+1}	2x10^{5}			Reach 2	No	Low toxicity score
Dibenzofuran	3/74	0 15 1 06 [0 503]	ND	2 65x10^{+2}	2 8x10^{4}			Reach 2	No	Low det freq
Diethyl phthalate	2/74	0 06 - 0 66 [0 382]	ND	8 25x10^{-1}	< 1x10^{5}			Outfall Creek	No	Low toxicity score
Fluorene	16/74	0 025 - 2 8 [0 754]	ND	7x10^{+1}	7x10^{-5}			Raceway	No	Low toxicity score
N-nitrosodiphenylamine	20/74	0 01 0 29 [0 104]*	ND			1.42x10^{-3}	< 1x10^{-5}, B2	Outfall Creek	No	Low toxicity score
Phenanthrene	47/77	0 023 - 16 [1 353]	0 14 - 0 16 [0.15]*	4x10^{+3}	4 5x10^{-3}			Raceway	Yes	(2)
Anthracene	25/75	0 021 - 3 1 [0 76]	ND	1 03x10^{+1}	1x10^{-5}			Raceway	No	Low toxicity score
Di-n-butyl phthalate	16/74	0 015 - 5 2 [0 545]	ND	5 2x10^{+1}	6x10^{-5}			Reach 3	No	Low toxicity score
Fluoranthene	62/77	0 01 - 20 [1 647]	0 067 - 0 32 [0 219]*	5x10^{+2}	5 3x10^{-4}			Raceway	Yes	(2)
Pyrene	43/77	0 025 - 13 [1 481]	0 052 - 0 27 [0 181]*	4 33x10^{+2}	4 6x10^{-4}			Raceway	Yes	(2)
Butyl benzyl phthalate	7/74	0 026 0 63 [0 582]	ND	3 15	< 1x10^{5}			Reach 5	No	Low toxicity score
Benzo (a) anthracene	35/76	0 055 11 [0 963]	ND			6 38x10^{+1}	0.17,B2	Raceway	Yes	(2)
Chrysene	41/77	0 062 - 8 6 [1 099]	0 14 - 0 18 [0 16]*			4 99x10^{+1}	0.13,B2	Raceway	Yes	(2)
Bis(2-ethylhexyl) phthalate	25/74	0 009 2 5 [0 78]	ND	1 25x10^{+2}	1 3x10^{-4}	3 5x10^{-2}	9x10^{-5},B2	Raceway	Yes	(2)

TABLE 6-2
SELECTION OF CHEMICALS OF CONCERN FOR SEDIMENTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE THREE

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg)$^{(1)}$	Background Concentration Range [Avg] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
SEMIVOLATILE ORGANIC CHEMICALS (CONTINUED)										
Di-n-octyl phthalate	5/74	0 041 - 0 22 [0 108]*	ND	$1.1x10^{+1}$	$1x10^{-5}$			Reach 6	No	Low toxicity score
Benzo(b)fluoranthene	39/77	0 11 - 5 2 [1 421]	0 17 - 0 20 [0 185]*			$3\ 02x10^{+1}$	0.08, B2	Raceway	Yes	(2)
Benzo(k)fluoranthene	40/75	0 041 - 6 3 [0 949]	ND			$3\ 65x10^{+1}$	0.09, B2	Raceway	Yes	(2)
Benzo(a)pyrene	34/75	0 072 - 4 7 [0 897]	0 091 [0 091]*			$2\ 73x10^{+1}$	0 07, B2	Raceway	Yes	(2)
Indeno(1,2,3-cd)pyrene	18/74	0 051 - 1 8 [0 401]	ND			$1\ 04x10^{+1}$	0.027, B2	Reach 3	Yes	(2)
Dibenz(a,h)anthracene	5/74	0 093 - 0 31 [0 147]*	ND			1.8	$4\ 67x10^{3}$, B2	Reach 3	Yes	(2)
Benzo(g,h,i)perylene	19/74	0 055 - 1 6 [0 786]	ND	$4x10^{+2}$	$4\ 2x10^{-4}$			Reach 3	Yes	(2)
PESTICIDES AND POLYCHLORINATED BIPHENYL COMPOUNDS										
DDE	4/74	0 06 [0 022]	ND			$2.04x10^{-2}$	$5x10^{-5}$,B2	Reach 3	No	Selected for fish.
DDD	8/74	0 053 - 0 7 [0 104]	ND			$1.68x10^{-1}$	$4\ 4x10^{-4}$, B2	Reach 6	Yes	(2)
DDT	4/75	0 071 - 1 4 [0 172]	ND	$2.8x10^{+3}$	$2.98x10^{-3}$	$4.76x10^{-1}$	$1.24x10^{-3}$, B2	Reach 2	Yes	(2)
Gamma chlordane	1/74	0 018 [0 018]*	ND	$3.0x10^{+2}$	$3.2x10^{-4}$	$2.34x10^{-2}$	$6x10^{-5}$, B2	Reach 7	No	Low det. freq.
Arochlor 1254	3/74	0 112 - 0 589 [0 404]*	ND			4.54	$1.18x10^{-2}$, B2	Raceway	Yes	(2)
METHYLATED MERCURY COMPOUNDS										
Monomethyl mercury	5/46	0 026 - 0 312 [0 082]	ND	$1\ 04x10^{+3}$	$1\ 11x10^{-3}$			Reach 2	Yes	Nyanza***
Dimethyl mercury	1/46	0 019 [0 007]	ND	$6\ 33x10^{+1}$	$7x10^{-5}$			Reach 3	Yes	Nyanza***

TABLE 6-2
SELECTION OF CHEMICALS OF CONCERN FOR SEDIMENTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE FOUR

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg)$^{(1)}$		Background Concentration Range [Avg] (mg/kg)		Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
						Noncarcinogens		Carcinogens/WOE				
						Ri	ERi	Ri	ERi			
METALS												
Aluminum	168/177	1,840 - 22,900	[10,339 1]	2,870 - 16,600	[9200 9]					Reach 4	No	(3)
Antimony	3/154	6 7 - 18	[4 05]	6 9	[6 1]	4 5x10^{-4}	0 047			Reach 3	Yes	(2)
Arsenic	134/177	0 75 - 64 6	[9 5]	2 5 - 21 1	[8 7]	2 13x10^{+5}	0.22	1 15x10^{+2}	0 3, A	Reach 9	Yes	Nyanza***
Barium	175/177	11 4 - 272	[67 1]	13 3 - 178	[66 7]	5 44x10^{+3}	5.79x10^{-3}			Reach 7	Yes	(2)
Beryllium	98/157	0 1 - 10 15	[1 5]	0 37 - 1 8	[0 85]	2 03x10^{+3}	2.16x10^{3}	4 36x10^{+1}	0 11, A	Raceway	Yes	(2)
Cadmium	27/160	1 3 - 19 9	[4 3]	ND		3 98x10^{+4}	0 042			Reach 3	Yes	Nyanza***
Calcium	176/177	326 18 400	[3136 7]	588 - 4,020	[2161 9]					Eastern Wet.	No	(3)
Chromium (III)	153/177	4 8 - 2.620	[98 8]	6 6 - 55 2	[22 4]	2 62x10^{+3}	2 8x10^{-3}			Reach 3	Yes	Nyanza***
Cobalt	101/167	2 6 - 235	[13 6]	3 7 - 18 8	[10 7]					Raceway	No	(3)
Copper	131/177	8 1 - 454	[99]	8 9 - 340 4	[73 0]					Reach 3	Yes	No toxicity criteria
Iron	170/77	1,980 110,000	[16,739 7]	4,110 - 110,000	[22,124 1]					Background	No	(3)
Lead	166/177	2 4 - 5,760	[159 3]	5 - 248	[85 1]					Eastern Wet.	Yes	Nyanza***
Magnesium	176/177	195 - 5,030	[2,267 8]	762 0 - 3,280	[1877 8]					Reach 3	No	(3)
Manganese	174/177	28 4 5,860	[475 3]	65 8 - 1,640	[434 5]	5 86x10^{+4}	0 062			Reach 8	Yes	(2)
Mercury	124/164	0 13 - 152	[7 8]	0 5 - 1 59	[0 27]	5 07x10^{+5}	0 539			Eastern Wet	Yes	Nyanza***
Nickel	85/174	2 3 - 186	[19 2]	3 2 - 51	[11 4]	9 3x10^{-3}	0.01			Raceway	Yes	(2)
Potassium	147/177	92 2 2,260	[696 7]	224 - 1,365	[672 6]					Reach 3	No	(3)
Selenium	43/156	0 3 - 7 2	[1 33]	2 9 - 3 1	[1 0]	1 44x10^{+3}	1 5x10^{3}			Reach 7	Yes	(2)
Silver	1/125	6 4	[1 9]	ND		2 13x10^{+3}	2.27x10^{3}			Reach 5	No**	Selected for Surface Water

TABLE 6-2
SELECTION OF CHEMICALS OF CONCERN FOR SEDIMENTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE FIVE

Parameter	No. of Positive Detections/ No. of Samples Collected	Range of Positive Detects [Avg.] (mg/kg)(1)	Background Concentration Range [Avg.] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
METALS (CONTINUED)										
Sodium	97/177	20 2 - 4,630 [384 6]	389 - 72 [186.2]					Reach 3	No	(3)
Vanadium	166/176	4 6 - 83 [28 7]	48 45 - 10 2 [20 2]	$1\ 19\times10^{-4}$	0.012			Reach 6	Yes	(2)
Zinc	152/177	10 5 - 765 [157 3]	629 - 13 5 [133 5]	$3\ 83\times10^{-3}$	$4\ 07\times10^{-3}$			Reach 5	Yes	(2)
Thallium	2/138	1 2 - 1 4 [0 46]	ND	2×10^{-4}	0 021			Eastern Wet.	Yes	(2)

ND = Not detected
Avg = Average
Ri = Risk factor
ERi = Ratio of risk factor for chemical to total of risk factors for all chemicals
WOE = Carcinogenic weight of evidence
COC = Chemical of concern

(1) Range of positive detections and average concentration for sediment samples collected during the RI (background samples as well as samples downstream of the Nyanza Site). The average concentration presented is calculated using one half the sample quantitation limit (or one half the contract required detection limit) for nondetect values. Data for all reaches with at least one positive detection were used to calculate the average. If the average is greater than the maximum detected concentration, the average of positive detections(*), only, is presented.

(2) Chemical meets COC selection criteria

(3) No toxicity criteria is available for this chemical. With the exception of aluminum and cobalt, these chemicals are macronutrients.

** Although this chemical does not meet the selection criteria for a COC in sediments, it is listed as a COC for surface waters and/or fish. Conservatively, the chemical will be evaluated in the risk assessment.

*** This chemical has been identified by the EPA as a Nyanza site specific contaminant

TABLE 6-3
SELECTION OF CHEMICALS OF CONCERN FOR SURFACE WATER
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (ug/L)(1)	Background Concentration Range [Avg] (ug/L)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
VOLATILE ORGANIC CHEMICALS										
Chloromethane	1/36	11 [5 9]	11 [5.9]			1.43×10^{-1}	$3\ 52\times10^{-3}$B2	Background	No	(2) Low det. freq.
1,1-Dichloroethene	2/36	3 [2 6]	3 [2 6]	$3.33\times10^{+2}$	8×10^{-5}	1.8	4.43×10^{-2}C	Background	Yes	(2)(3)
1,2-Dichloroethene	4/36	1 12 [3 7]	ND	$1\ 2\times10^{+3}$	3×10^{-4}			Outfall Creek	Yes	Nyanza***
2-Butanone (methyl ethyl ketone)	1/32	10 [7 5]	ND	$2\times10^{+2}$	5×10^{-5}			Reach 4	No	Low det. freq. Low toxicity score
Trichloroethene	3/36	2 - 13 [6]	ND			$1\ 43\times10^{-1}$	$3\ 52\times10^{-3}$B2	Outfall Creek	Yes	Nyanza***
SEMIVOLATILE ORGANIC CHEMICALS										
1,4 Dichlorobenzene	1/36	1 [1]	ND			2.4×10^{-2}	5.9×10^{-4}C2	Outfall Creek	Yes	Nyanza***
1,2 Dichlorobenzene	2/36	3 4 [3 5]*	ND	$4\ 44\times10^{+1}$	1×10^{-5}			Outfall Creek	Yes	Nyanza***
Bis(2-ethyl, hexyl) phthalate	3/36	1 - 58 [11 4]	ND	$2\ 9\times10^{+3}$	$7\ 2\times10^{-4}$	$8\ 12\times10^{-1}$	2×10^{-2} B2	Cold Spring Brook	Yes	(3)
PESTICIDES										
Gamma BHC (Lindane)	1/36	0 02 [0 02]	ND	$6.67\times10^{+1}$	2×10^{-5}	2.6×10^{-2}	6.4×10^{-4}B2	Reach 6	No	Low det freq.
METALS										
Aluminum (T) (F)	19/36 10/26	82 - 3,220 [254] 41 - 174 [63 6]	209 - 231 [84] ND					Reach 2	No	(4)
Antimony (T) (F)	0/36		ND					ND	No**	Selected for sediments
Arsenic (T) (F)	2/36 2/26	1 1 - 3 [2 05]* 1 2 - 50 9 [10 5]	ND ND	$1\times10^{+4}$	$2\ 48\times10^{-3}$	5.4	0.133 A	Reach 2	Yes	Nyanza***
Barium (T) (F)	23/36 18/26	7 6 - 132 [15 02] 5 5 - 33 6 [15 8]	9 8 - 23.1 [15.7] 14 8 - 19 7 [17 5]	$2.64\times10^{+3}$	$6\ 5\times10^{-4}$			. Reach 2	Yes	(3)
Beryllium (T) (F)	1/36 0/26	7 5 [2 61	ND ND	$1\ 5\times10^{+3}$	$3\ 7\times10^{-4}$	$3\ 23\times10^{+1}$	0.794 A	Reach 2	Yes	(3)

TABLE 6-3
SELECTION OF CHEMICALS OF CONCERN FOR SURFACE WATER
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

Parameter		No. of Positive Detections/ No. of Samples Collected	Range of Positive Detects [Avg.] (ug/L)$^{(1)}$		Background Concentration Range [Avg.] (ug/L)		Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
							Noncarcinogens		Carcinogens/WOE				
							Ri	ERi	Ri	ERi			
METALS (CONTINUED)													
Cadmium	(T) (F)	1/36 0/26	7 2 -	[2 8]	ND ND		1 44x10^{+4}	3 57x10^{-3}			Reach 2	Yes	Nyanza***
Calcium	(T) (F)	36/36 26/26	6.140 - 17,700 6 240 - 17,900	[9822 2] [10,546 5]	6,200 - 12,400 9,680 - 12,400	[10,217] [11,676]					Outfall Creek	No	(4)
Chromium	(T) (F)	4/36 0/26	5 6 - 79 -	[17 5]	ND ND		7 9x10^{+1}	2x10^{-5}			Eastern Wet.	Yes	Nyanza***
Cobalt	(T) (F)	2/36 0/26	2 3 - 27 7 -	[22 5]	ND ND						Reach 2	No	(4)
Copper	(T) (F)	3/36 0/26	3 1 - 27 7 -	[9 3]	3 1 ND	[3.1]*					Reach 2	Yes	No toxicity criteria
Iron	(T) (F)	27/36 16/26	311 - 16,100 281 - 860	[1206 73] [384 5]	750 - 1,640 352 - 502	[765 5] [410]					Reach 2	No	(4)
Lead	(T) (F)	11/36 3/26	1 0 - 66 5 1 5 - 8 7	[5 2] [4 4]	21 1 ND	[4]					Reach 2	Yes	Nyanza***
Magnesium	(T) (F)	36/36 26/26	1,130 - 3,030 1,290 - 2,960	[2137 6] [2192 7]	1,610 - 2,900 2,290 - 2,960	[2,450] [2,776]					Reach 2	No	(4)
Manganese	(T) (F)	33/36 21/26	48 6 - 9,840 24 6 - 208 5	[372 5] [76 7]	75 8 - 111 24 6 - 87	[80 8] [55 7]	9 84x10^{+4}	2 44x10^{-2}			Reach 2	Yes	(3)
Mercury	(T) (F)	3/32 3/26	0 37 - 3 8 0 37 - 0 49	[1 6] [0 43]	ND ND		1 27x10^{+4}	3.14x10^{-3}			Eastern Wet.	Yes	Nyanza***
Nickel	(T) (F)	2/36 1/26	17 7 - 77 4 7 0	[13 6] [3 8]	17 7 7	[5 1] [3 8]	3 87x10^{+3}	9.6x10^{-4}			Reach 2	Yes	(2)(3)

TABLE 6-3
SELECTION OF CHEMICALS OF CONCERN FOR SURFACE WATER
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE THREE

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (µg/L)(1)	Background Concentration Range [Avg] (µg/L)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
METALS (CONTINUED)										
Potassium (T) (F)	36/36 26/26	864 - 3,100 [2013 3] 829 - 3,010 [2053]	1,810 - 3,100 [2481 4] 2,470 - 3,010 [2,646]					Background	No	(4)
Selenium (T) (F)	1/36 0/26	19,300 [3,861 5] -	ND ND	$3\ 86 \times 10^{+6}$	9.57×10^{-1}			Reach 3	No**	Selected for Sediments.
Silver (T) (F)	7/36 1/26	6 5 - 68 9 [6 8] 8 [3 9]	16 9 [4 74] ND	$2.3 \times 10^{+4}$	5.69×10^{-3}			Reach 2	Yes	(3)
Sodium (T) (F)	35/36 26/26	6,080 - 38,200 [24,378 6] 2,100 - 39 000 [25,593 5]	16,000 - 38,200 [28,887] 26,600 - 39,000 [34,140]					Background	No	(4)
Thallium (T) (F)	0/36	-	ND					ND	No**	Selected for Sediments.
Vanadium (T) (F)	2/36 0/26	12 6 - 16 1 [14 4] -	ND ND	$2.3 \times 10^{+3}$	5.7×10^{-4}			Reach 2	Yes	(3)
Zinc (T) (F)	4/36 6/26	6 2 - 125 [16 1] 10 - 46 1 [18 5]	6 2 [6.2]* [12 1]	$6\ 25 \times 10^{+2}$	1.5×10^{-4}			Reach 2	Yes	(3)

T	=	Total (unfiltered) metals results
F	=	Filtered metals results
ND	=	Not detected
Avg	=	Average
Ri	=	Risk factor
ERi	=	Ratio of risk factor for chemical to total of risk factors for all chemicals
WOE	=	Carcinogenic weight of evidence
COC	=	Chemical of concern

(3) Chemical meets COC selection criteria.

(4) No toxicity criteria is available for this chemical. With the exception of cobalt and aluminum, these chemicals are macronutrients.

** Although this chemical does not meet the selection criteria for a COC in surface waters, it was selected as a COCs for sediments or fish. Conservatively, the chemical will be evaluated in the risk assessment.

*** This chemical has been identified by EPA as a Nyanza site-specific contaminant.

(1) Range of positive detections and average concentration for surface water samples collected during the RI (i e , background samples as well as samples downstream of the Nyanza Site). The average concentration presented is the average calculated using one half the sample quantitation limit (or one half the contract required detection limit) for nondetect values. Data for all reaches with at least one positive detection were used to calculate the average. If the average is greater than the maximum detected concentration, the average of positive detections(*), only, is presented.

(2) Chloromethene, 1,1-Dichloroethene, and nickel (filtered) were detected at background sample locations, only

TABLE 6-4
SELECTION OF CHEMICALS OF CONCERN FOR FISH (FILLETS)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg) (1)	Sudbury Reservoir Concentration Range [Avg] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
VOLATILE ORGANIC CHEMICALS										
Methylene chloride	3 of 45	0 028 14 [0 507]		2 33x10^{+2}	2.02x10^{-3}	1.05x10^{-1}	7.27x10^{-3} B2	Fairhaven Bay	Yes	(2)
Acetone	6 of 45	0 810 - 1 6 [0 398]		1 6x10^{+1}	1 4x10^{-4}			Fairhaven Bay	Yes	(2)
2-Butanone	2 of 45	0 250 - 0 3 [0 041]		6	5x10^{-5}			Fairhaven Bay	No	Low toxicity score
Toluene	2 of 45	0 005 - 0 026 [0 013]		1 3x10^{1}	< 1x10^{-5}			Fairhaven Bay	No	Low toxicity score
Styrene	1 of 45	0 002 [0 002]*		1x10^{-2}	< 1x10 ^{5}	6x10^{-5}	< 1x10^{-5} B2	Fairhaven Bay	No	Low toxicity score
Total Xylenes	1 of 45	0 002 [0 002]*		1x10^{-3}	< 1x10^{-5}			Fairhaven Bay	No	Low toxicity score
SEMIVOLATILE ORGANIC CHEMICALS										
Phenol	40 of 180	0 025 - 8 2 [0 536]	0 056 [0.056]*	1 37x10^{+1}	1 2x10^{-4}			Fairhaven Bay	Yes	(2)
Bis(2 chloroethyl)ether	1 of 191	0 04 [0 04]*				4.4x10^{-2}	3.05x10 ^{3} B2	Fairhaven Bay	No	Low det. frequency
Benzyl alcohol	5 of 186	0 026 - 0 42 [0 120]		1 4	1x10^{-5}			Fairhaven Bay	No	Low toxicity score
2-Methyl phenol	1 of 177	0 033 [0 033]*		6 6x10 ^{1}	1x10^{-5}			Fairhaven Bay	No	Low toxicity score
4-Methyl phenol	22 of 177	0 026 - 1 9 [0 139]		3.8x10^{+1}	3 3x10^{-4}			Fairhaven Bay	Yes	(2)
Nitro benzene	1 of 191	0 024 [0 024]		4 8x10^{+1}	4 2x10^{-4}			Fairhaven Bay	Yes	Nyanza***
Napthalene	1 of 191	1 9 [0 129]		4 75x10^{+2}	4 12x10^{-3}			Saxon. Res	No**	Selected for sediments
Diethylphthalate	1 of 191	0 033 [0 033]*		4 13x10^{-2}	< 1x10^{-5}			Fairhaven Bay	No	Low toxicity score
Fluorene	1 of 191	0 099 [0 099]*	0 099 [0.099]*	2.48	2x10^{-5}			Sudbury Res.	No	Low toxicity score
Di-n-butyl phthalate	17 of 191	0 021 - 0 280 [0 23]	0 045 [0 045]*	2 8	2x10 ^{5}			Fairhaven Bay	No	Low toxicity score
Butyl benzyl phthalate	8 of 191	0 012 - 3 0 [0 249]		1 5x10^{+1}	1 3x10 ^{4}			Fairhaven Bay	No	Low det. frequency
Bis(2-ethyl hexyl) phthalate	32 of 145	0 028 - 3 3 [0 4]		1 65x10^{+2}	1 43x10^{-3}	4 62x10^{-2}	3 2x10^{-3} B2	Reservoir 1	Yes	(2)

TABLE 6-4
SELECTION OF CHEMICALS OF CONCERN FOR FISH (FILLETS)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE TWO

Parameter	No. of Positive Detections/ No. of Samples Collected	Range of Positive Detects [Avg.] (mg/kg) (1)	Sudbury Reservoir Concentration Range [Avg.] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
SEMIVOLATILE ORGANIC CHEMICALS (CONTINUED)										
Di(n-octyl)phthalate	4 of 144	0 029 - 0 046 [0 040]*		2 3	2x10^{-5}			Fairhaven Bay	No	Low toxicity score
Benzo(b)fluoranthene	1 of 191	0 087 [0 078]				5 05x10^{-1}	0.035 B2	Fairhaven Bay	No**	Selected for sediments
Benzo(a)pyrene	1 of 191	0 026 [0 026]*				1.51x10^{-1}	1.04x10$^{-2\,B2}$	Fairhaven Bay	No**	Selected for sediments
PESTICIDES/PCBs										
Heptachlor epoxide	1 of 191	0 004 [0 001]		3 08x10^{+2}	2 67x10^{-3}	3.64x10^{-2}	2.52x10$^{-3\,B2}$	Saxon Res.	No	Low det. frequency
Endosulfan I	1 of 191	0 0015 [0 001]						Saxon Res.	-	See total Endosulfan
Dieldrin	10 of 187	0 00005 - 0 0005 [0 0004]*	0 0005 [0.0005]*	1x10^{+1}	9 0x10^{-5}	8x10^{-3}	5 5x10$^{-4\,B2}$	Saxon Res.	Yes	(2)
4,4 DDE	132 of 192	0 0005 - 0 068 [0 016]	0 0035 - 0 041 [0.019]			2.31x10^{-2}	1 6x10$^{-3\,B2}$	Reservoir 2	Yes	(2)
Endrin	5 of 188	0 0005 - 0 0075 [0 004]	0 0005 [0 0005]*	2 5x10^{+1}	2 2x10^{-4}			Saxon Res.	No	Low toxicity score
Endosulfan II	1 of 191	0 001 [0 001]						Reservoir 2	-	See total Endosulfan
4,4 DDD	55 of 191	0 001 - 0 02 [0 004]	0 001 - 0.007 [0.004]			4 8x10^{-3}	3 3x10$^{-4\,B2}$	Reservoir 1	Yes	(2)
Endosulfan sulfate	3 of 191	0 001 - 0 0045 [0 003]	0 001 - 0 0045 [0.0027]*					Sudbury Res	-	See total Endosulfan
4,4 DDT	26 of 187	0 00005 - 0 002 [0 0012]*	0 0005 - 0 002 [0 0009]*	4	3x10^{-5}	6.8x10^{-4}	5x10$^{-5\,B2}$	Sudbury Res.	No**	Selected for sediments
Methoxychlor	2 of 191	0 001 - 0 0035 [0 0033]		7x10^{-1}	1x10^{5}			Reservoir 2	No	Low toxicity score
Endrin ketone	1 of 191	0 0025 [0 001]						Reservoir 2	No	Low det. frequency
Alpha chlordane	14 of 191	0 00050 0025 [0 001]*	0 001 [0.0001]*					Reservoir 1	-	See total chlordane
Gamma chlordane	20 of 191	0 0005 - 0 002 [0 001]*						Reservoir 2	-	See total chlordane
Aroclor 1248	1 of 191	0 5 [0 073]						Mill Pond	-	See total PCBs
Aroclor 1254	59 of 182	0 01 - 0 73 [0 068]						Reservoir 2	-	See total PCBs
Aroclor 1260	37 of 182	0 01 - 0 11 [0 036]	0 020 - 0 095 [0 064]					Saxon Res.	-	See total PCBs
Heptachlor	3 of 189	0 0015 - 0 006 [0 002]		1 2x10^{+1}	1 0x10^{4}	2.7x10^{-2}	1 87x10$^{-3\,B2}$	Saxon Res.	Yes	(2)
Aldrin	2 of 190	0 0005 - 0 001 [0 0003]		3 33x10$^{+'}$	2 9x10^{4}	1 7x10^{-2}	1 18x10$^{-3\,B2}$	Reservoir 2	Yes	(2)

TABLE 6-4
SELECTION OF CHEMICALS OF CONCERN FOR FISH (FILLETS)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE THREE

Parameter	No. of Positive Detections/ No. of Samples Collected	Range of Positive Detects [Avg.] (mg/kg) (1)	Sudbury Reservoir Concentration Range [Avg.] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
PESTICIDES/PCBs (CONTINUED)										
Total PCBs	-	-	-			$1.03x10^{+1}$	$7.1x10^{-1}$ B2	-	Yes	(2)
Total Endosulfan	-	-	-	$1.6x10^{+2}$	$1 4x10^{-3}$			-	Yes	(2)
Total Chlordane	-	-	-	$8 33x10^{+1}$	$7 2x10^{-3}$	$6.5x10^{-3}$	$4.5x10^{-4}$ B2	-	Yes	(2)
METALS/METHYL MERCURY										
Aluminum	35 of 245	12 4 - 489 93 [8 944]	13 06 - 14 69 [6 77]					Reservoir 1	No	(3)
Antimony	5 of 245	0 03 - 15 5 [0 448]		$3 87x10^{+4}$	$3 35x10^{1}$			Reservoir 2	Yes	(2)
Arsenic	13 of 257	0 03 - 1 75 [0 078]	0 06 [0 06]*	$5 83x10^{+3}$	$5 06x10^{-2}$	3.16	$2.19x10^{-1}$ A	Reservoir 2	Yes	Nyanza***
Barium	2 of 258	0 17 - 1 1 [0 251]		$2.2x10^{+1}$	$1 9x10^{-4}$			Fairhaven Bay	No**	Selected for sediments
Cadmium	1 of 258	0 05 [0 030]		$1x10^{+2}$	$9x10^{-4}$			Reservoir 2	Yes	Nyanza***
Calcium	*252 of 258*	*68 06 - 28,400 [1,513 47]*	*303 5 - 513.2 [400.1]*					*Fairhaven Bay*	*No*	*(3)*
Chromium	103 of 258	0 14 - 8 32 [0 702]	1 3 - 2 8 [1.14]	8.32	$7x10^{-5}$			Reservoir 1	Yes	Nyanza***
Cobalt	72 of 256	0 02 - 1 26 [0 341]	0 03 - 0 08 [0 05]*					Fairhaven Bay	No	(3)
Copper	*27 of 258*	*0 04 - 9 72 [0 514]*						*Reservoir 2*	*Yes*	*No toxicity criteria*
Iron	48 of 258	14 3 - 302 61 [28 996]	70 9 - 93 6 [29 0]					Reservoir 1	No	(3)
Lead	10 of 254	0 29 - 5 60 [0 085]						Fairhaven Bay	Yes	Nyanza***
Magnesium	*252 of 258*	*160 - 592 38 [275 65]*	*264 7 - 519 3 [379.1]*					*Reservoir 1*	*No*	*(3)*
Manganese	160 of 258	0 075 - 33 81 [1 604]	0 57 - 2 4 [1.06]	$3 32x10^{+2}$	$2 88x10^{-3}$			Fairhaven Bay	Yes	(2)
Mercury	161 of 258	0 2 - 9 6 [6 821]	0 55 - 1 20 [0 89]*	$3.2x10^{+4}$	$2 77x10^{-1}$			Cedar Pond	Yes	Nyanza***
Nickel	*4 of 258*	*1 1 - 6 0 [0 285]*		$3x10^{+2}$	$2 60x10^{-3}$			*Cedar Pond*	*Yes*	*(2)*

TABLE 6-4
SELECTION OF CHEMICALS OF CONCERN FOR FISH (FILLETS)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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Parameter	No of Positive Detections/ No of Samples Collected	Range of Positive Detects [Avg] (mg/kg) (1)	Sudbury Reservoir Concentration Range [Avg] (mg/kg)	Toxicity Screen				Location of Maximum Positive Detection	Selected as a COC?	Comments
				Noncarcinogens		Carcinogens/WOE				
				Ri	ERi	Ri	ERi			
METALS (CONTINUED)										
Potassium	252 of 258	1,890 - 33,251 [3,844 81]	3,097 5 - 6,446 9 [5,432 4]					Mill Pond	No	(3)
Selenium	79 of 258	0 03 - 4 0 [0 190]	1 8 [0 46]	$8 \times 10^{+2}$	6.93×10^{-3}			Ced.Sw.Pond	Yes	(2)
Silver	4 of 246	0 03 - 2 2 [0 063]		$7\ 33 \times 10^{+2}$	6.36×10^{-3}			Ced.Sw.Pond	Yes	(2)
Sodium	252 of 258	33 5 - 1,160 [519 86]	330 8 - 524 3 [418 1]					Saxon Res.	No	(3)
Thallium	3 of 223	0 08 - 1 35 [0 065]		$1.93 \times 10^{+4}$	1.67×10^{-1}			Reservoir 2	Yes	(2)
Vanadium	70 of 258	0 02 - 1 57 [0 390]	0 31 - 0 76 [0 325]	$2.25 \times 10^{+2}$	1.95×10^{-3}			Reservoir 1	Yes	(2)
Zinc	252 of 258	0 31 - 262 46 [18 401]	9 7 - 61 6 [32 35]	$1\ 31 \times 10^{+3}$	1.14×10^{-2}			Reservoir 1	Yes	(2)
Methyl mercury	117/129	0 370 - 4 2 [0 957)	0 221 - 0 652 [0 485]	$1\ 4 \times 10^{+4}$	1.21×10^{-1}			Reservoir 2	Yes	Nyanza***

ND = Not detected
Avg = Average
RI = Risk factor
ERi = Ratio of risk factor for chemical to total of risk factors for all chemicals
WOE = Carcinogenic weight of evidence
COC = Chemical of concern

(1) Range of positive detections and average concentration for fish samples collected during the RI (i.e., background samples as well as samples downstream of the Nyanza Site) The average concentration presented is calculated using one half the sample quantitation limit (or one half the contract required detection limit) for nondetect values. Data for all reaches with at least one positive detection were used to calculate the average If the average is greater than the maximum detected concentration, the average of positive detections(*), only, is presented.

(2) Chemical meets COC selection criteria

(3) No toxicity criteria is available for this chemical With the exception of aluminum and cobalt, these chemicals are macronutrients Conservatively, the chemical will be evaluated in the risk assessment.

** Although this chemical does not meet the selection criteria for a COC in fish, it was selected as a COC for surface waters and/or sediments.

*** This chemical has been identified by EPA as a Nyanza site specific contaminant

Chemical	Surface Water Statistics(1)	ERi	Sediment Statistics(1)	ERi	Fish Statistics(1)	ERI
1,4-Dichlorobenzene	3%	$5.9x10^{-4(C)}$	26%	$1.9x10^{-4}$(C)	ND	-
1,2-Dichlorobenzene	5.5%	$1x10^{-5(N)}$	33%	$1.5x10^{-4}$(N)	ND	-
1,2,4-Trichlorobenzene	ND	-	27%	$2.52x10^{-3}$(N)	ND	-
Nitrobenzene	ND	-	16%	$1.38x10^{-3}$(N)	22%	$4.1x10^{-4}$(N)
Phenol	ND	-	2.7%	$1x10^{-5}$(N)	12.4%	$1.2x10^{-4}$(N)
4-Methylphenol	ND	-	4%	$1x10^{-6}$(N)	22.1%	$3.3x10^{-4}$(N)
Bis(2-ethylhexyl) phthalate	8.3%	$2x10^{-2}$(C)	34%	$1.3x10^{-4}$(N)	11.2%	$2.3x10^{-3}$(C)
Carcinogenic PAHs	ND	-	(2)	(2)	(3)	(3)
Noncarcinogenic PAHs	ND	-	(2)	(2)	(3)	(3)

N = Noncarcinogenic relative risk value.
C = Carcinogenic relative risk value.
ERi = Relative Risk Value.
(1) Number of positive detections/number of samples collected, expressed as a percent.
(2) See Table 6-3, for relative risk values.
(3) See Table 6-5 for relative risk values.

As detailed on Tables 6-2 and 6-4, the following PAHs were selected as COCs:

- Naphthalene
- Acenaphthylene
- Phenanthrene
- Fluoranthene
- Pyrene
- Benzo(a)anthracene
- Chrysene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

PAHs were prevalent only in sediments. Six were detected in background sediment samples at maximum concentrations 5- to 10-fold less than those detected in Study Area samples. As discussed in Section 4.0, PAHs may have entered the Sudbury River system from numerous contaminant sources. PAHs are produced by the combustion process and, consequently, are frequently found along roadways traversed by motor vehicles. Unlike phenol, nitrobenzene, and the chlorinated benzene compounds listed in the preceding table, most PAHs have not been identified by EPA as site-specific contaminants for the Nyanza Site. Naphthalene is the only PAH designated as a Nyanza site-specific contaminant. Toxicity criteria do not exist currently for 2-methyl naphthalene. This chemical will be discussed qualitatively in the risk assessment.

1,3-Dichlorobenzene is selected as a COC because it was designated a site-specific compound for Nyanza.

Based on the selection criteria presented in the introduction to this section, the following semi-volatile organic compounds were not selected as COCs:

- 2-Chlorophenol
- Benzoic acid
- Dibenzofuran
- Diethylphthalate
- Fluorene
- Anthracene
- Di-n-butyl phthalate
- N-Nitrosodiphenylamine
- Butyl benzyl phthalate
- Di-n-octyl phthalate
- Bis(2-chloroethyl)ether
- Benzyl alcohol
- 2-Methylphenol
- Diethyl phthalate
- Acenaphthene

Tables 6-2, 6-3, and 6-4 present the occurrence and distribution statistics and toxicity screen results that support the decision not to select these chemicals as COCs. None of these compounds are Nyanza site-specific contaminants.

6.2.1.3 Pesticide/PCB Chemicals of Concern

Several pesticides/polychlorinated biphenyl compounds (PCBs) were detected in sediments and fish tissue samples collected from the Study Area. The following pesticides/PCBs were selected as COCs because they were detected in at least five percent of environmental samples and demonstrated a relative risk factor greater than 0.0001:

Chemical	Surface Water Statistics[1]	ERi	Sediment Statistics[1]	ERi	Fish Statistics[1]	ERi
4,4-DDD	ND	-	11%	$4.4x10^{-4}$(C)	33%	$3.3x10^{-4}$(C)
4,4-DDE	ND	-	5.4%	$5x10^{-6}$(C)	71.3%	$1.6x10^{-3}$(C)
4,4-DDT	ND	-	5.3%	$2.98x10^{-3}$(N)	15.4%	$5x10^{-6}$(C)
PCBs	ND	-	4.1%	$1.18x10^{2}$(C)	33.3%[2]	$7.1x10^{1}$(C)[2]
Dieldrin	ND	-	ND	-	6.6%	$5.5x10^{-4}$(C)
Chlordane	ND	-	1.4%	$3.2x10^{-4}$	12.8%	$7.2x10^{3}$(N)

N = Noncarcinogenic-relative risk value
C = Carcinogenic-relative risk value
ERi = Relative Risk.
(1) Number of positive detections/number of samples collected, expressed as a percent.
(2) See Table 6-5, relative risk factor presented for total PCBs.

Although heptaclor, aldrin, and endosulfan (and its metabolite, endosulfan sulfate) were detected in less than five percent of the fish tissue samples analyzed, they were included as COCs because the relative risk factors for these contaminants are greater than 0.001 (see Table 6-4).

The following pesticides did not meet the frequency of detection criteria and/or the toxicity screen criteria and were not selected as COCs:

- Heptachlor epoxide
- Endrin
- Endrin ketone
- Gamma BHC (Lindane)

Dieldrin, 4,4-DDE, endrin, 4,4-DDD, endosulfan sulfate, 4,4-DDT, and chlordane and Aroclor-1260 were all detected in background samples as well as Study Area samples. The maximum concentration detected in Study Area samples was no greater than 10-times the maximum background sample concentrations. As discussed in Section 4, pesticides/PCBs may have entered the Study Area waterways from various contaminant sources. These chemicals have not been designated by EPA as site-specific contaminants for the Nyanza Site.

6.2.1.4 Inorganic Chemicals of Concern

Mercury, chromium, lead, cadmium, antimony, and arsenic were identified in Section 4 as predominant Nyanza site contaminants. As shown on Tables 6-2, 6-3, and 6-4, these five metals meet the established COC selection criteria. Additionally, the maximum and/or average concentration of these metals in Study Area sediment and surface water samples are greater than two times the concentrations detected at background sample locations. All are selected as COCs for the Study Area risk assessment.

Barium, beryllium, manganese, nickel, selenium, silver, thallium, vanadium, and zinc meet one or more COC selection criteria for surface waters, sediments, or fish and are included as COCs. However, for several of these metals, particularly barium, copper, vanadium, and zinc, the concentrations detected in Study Area samples are similar to concentrations detected in background (less than two times background) sediment, surface water, and fish tissue samples. Others (e.g. thallium) were detected very infrequently. Toxicity criteria do not exist currently for copper. This metal will be discussed quantitatively in the risk assessment.

The following inorganic chemicals were not selected as COCs for the Study Area risk assessment:

- Aluminum
- Calcium
- Cobalt
- Iron
- Magnesium
- Potassium
- Sodium

Several are macronutrients (potassium) which are necessary for health maintenance and all are known to be relatively nontoxic when compared to the heavy metals previously selected as COCs. Aluminum and cobalt do not fall into this category. Toxicity criteria are not currently available for these metals. Neither is a Nyanza site-specific chemical. Because of the large number of COCs already selected for the Study Area risk assessment, it is unlikely that the exclusion of these metals as COCs will significantly affect the results of the risk assessment. However, both metals will be discussed in the uncertainty analyses presented in Section 6.6.

The COCs selected for the Sudbury River Study Area are summarized in Table 6-5.

6.2.2 Toxicity Profiles

The purpose of this section is to identify the potential health hazards associated with exposure to the chemicals of concern identified in Section 6.2.1. A toxicological evaluation of each indicator chemical was conducted to characterize its inherent toxicity. The evaluation consisted of the review of scientific data to determine the nature and extent of the human health hazards associated with exposure to the various chemicals. Based on the scientific data review, a toxicity profile for each indicator chemical was developed.

Toxic effects considered in these profiles include noncarcinogenic (toxic) and carcinogenic health effects. Noncarcinogenic health effects are generally assumed to occur only at doses exceeding a certain "threshold dose." Toxicological endpoints, routes of

TABLE 6-5
CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Volatile Organic Chemicals

Vinyl chloride
1,2-Dichloroethene
Trichloroethene
Benzene
Chlorobenzene
Methylene chloride
Acetone
1,1-Dichloroethene

Semi-Volatile Organic Chemicals

1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
Nitrobenzene
1,2,4-Trichlorobenzene
Bis(2-ethylhexyl)phthalate
Phenol
3-Methylphenol
4-Methylphenol
Napthalene
2-Methyl napthalene
Acenapthylene
Phenanthrene
Fluoranthene
Pyrene
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno-(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

Pesticides/PCBs

4,4-DDD, DDE, and DDT
Polychlorinated biphenyl compounds
Chlordane
Endosulfan I, II
(and endosulfan sulfate)
Dieldrin
Aldrin
Heptachlor

Metals/Alkylated Metals

Monomethyl mercury
Dimethyl mercury
Mercury
Arsenic
Antimony
Barium
Beryllium
Cadmium
Chromium
Copper
Lead
Manganese
Nickel
Silver
Selenium
Thallium
Vanadium
Zinc

exposure, and doses in human and/or animal studies are discussed in the profiles.

Carcinogenic health effects are associated with exposure to a chemical capable of promoting, initiating, or causing a malignant neoplasm. Routes of exposure and doses in human and/or animal studies are discussed. Also presented is the EPA's weight-of-evidence for a compound's carcinogenicity (Group A, known human carcinogens; Group B, probable carcinogens, Group C, possible carcinogens, Group D, not classifiable as to its carcinogenicity).

The available toxicological information indicates that many of the indicator chemicals have both noncarcinogenic and carcinogenic health effects in humans and/or in experimental animals. Although the indicator chemicals may cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

All toxicity profiles are presented in Appendix K. A brief summary of the toxicological properties of each chemical of concern is also provided in the following paragraphs. The toxicity profiles provide the qualitative weight-of-evidence that Study Area contaminants pose actual or potential hazards to human health and the environment.

6.2.2.1 Acetone

Adverse noncarcinogenic health effects (human receptors) reported for acetone exposure through inhalation include: nausea, vomiting, muscle weakness, and difficulty breathing. At high concentrations of exposure through inhalation, the compound can have a narcotic effect. Prolonged repeated exposure by inhalation will produce headaches (human receptors). Acetone is a kidney toxin (test animals (rats) and humans (oral route of exposure)). Dermal exposure to high concentrations of acetone or pure product may cause excessive drying of the skin (human receptors).

6.2.2.2 Aldrin

Aldrin, one of the cyclodiene insecticides, is a neurotoxicant and has been classified as a B-2 carcinogen (test animal=mice; oral route of exposure). Studies have demonstrated that it produces liver tumors in test animals (mice). The effect of concern listed in the HEAST FY 1991 tables for the RfD is liver lesions (oral route of exposure test animal=rat).

6.2.2.3 Antimony

Long-term repeated exposure to antimony, by the ingestion route of exposure, can reduce life span, alter blood makeup, and cause heart damage (test animals (rat)). Exposure to antimony by inhalation may cause difficulty in breathing (human receptors). Skin rashes are often produced as a result of direct dermal contact with the chemical (human receptor).

6.2.2.4 Arsenic

Arsenic has been implicated in the production of skin cancer in humans. There is also extensive evidence that inhalation of arsenic compounds causes lung cancer in workers; elevated incidence of chromosome aberrations have been reported in humans exposed to arsenic compounds. Arsenic compounds have been reported to be teratogenic, fetotoxic, and embryotoxic in several animal species, and an increased incidence of multiple malformations among children born to women occupationally exposed to arsenic has been reported. Arsenic compounds also cause noncancerous, possibly precancerous, skin changes in exposed individuals.

The current chronic Reference Dose (RfD) for Arsenic is 3×10^{-4} mg/kg/day, based on the results of an epidemiological study conducted in Taiwan (Tseng, 1977). The noncarcinogenic end point of concern was keratosis (formation of horny growths on the skin) and hyperpigmentation (human receptor; oral route of exposure). The RfD is currently under review by the EPA RfD group.

Inorganic arsenic is classified as a Class A human carcinogen (a known human carcinogen). The cancer slope factor (CSF) for the inhalation route of exposure is 50 $(mg/kg/day)^{-1}$ and is based on epidemiological studies of smelter workers. A unit risk of 5×10^{-5} $(ug/L)^{-1}$ (oral route of exposure) proposed by the Risk Assessment Forum, is currently under review.

6.2.2.5 Barium

Increased blood pressure has been observed in experimental animals (rats) routinely exposed to barium in drinking water. Barium is also toxic to the nervous system, the muscular system, and gastrointestinal system when ingested at high concentrations. The soluble barium salts are more toxic than the insoluble barium salts (Clements, 1985). This is probably due to the fact the soluble barium salts are more likely to be absorbed than insoluble barium salts.

6.2.2.6 Benzene

Benzene is classified as a known human carcinogen (Class A), based on the incidence of leukemia in individuals exposed in the work place. Numerous epidemiologic and case studies have reported an increased incidence or casual relationship between leukemia and benzene exposure. An increased incidence of neoplasia has also been reported in rats and mice exposed by inhalation and gavage. The current Health Advisory available for benzene is based on animal studies which demonstrated noncarcinogenic liver effects in animals exposed through inhalation. Both oral and inhalation Reference Doses are under review by the U.S. EPA. The carcinogenic slope factor (oral) is 2.9 x 10^{-2} (U.S. EPA, IRIS, December 1991).

6.2.2.7 Beryllium

Short-term exposure to beryllium by inhalation can cause formation of scar tissue in the lungs, breathing difficulty, and weight loss (human receptors). Skin exposure to beryllium can cause a skin rash at the point of contact. Beryllium is currently classified as a probable human carcinogen based on the results of occupational studies and animal studies (rats) demonstrating a possible relationship between beryllium exposure and lung cancer. Other cancers were also noted.

6.2.2.8 Bis(2-ethylhexyl)phthalate

The RfD and CSF available for bis(2-ethylhexyl)phthalate are based on animal studies detecting adverse noncarcinogenic liver effects and liver tumors in test animals (guinea pigs) exposed through the oral route of exposure.

6.2.2.9 Cadmium

There is suggestive evidence linking cadmium with cancer of the prostate in humans (U.S. EPA, 1980). An increased incidence of tumors has not been seen in animals exposed to cadmium orally, but four of the five available studies were inadequate by current standards (Clement, 1983).

The evidence from a large number of studies on the mutagenicity of cadmium is equivocal; it has been hypothesized that cadmium is not directly mutagenic but impedes repair (Clement, 1983). Cadmium is a known animal teratogen and reproductive toxin. It has been shown to cause renal dysfunction in both humans and animals. Other toxic effects attributed to cadmium include immunosuppression (in animals), anemia (in humans), pulmonary disease (in humans), a possible effect on the endocrine system, defects in sensory function, and bone damage.

The current oral RfD (chronic) for cadmium is 5 x 10^{-4}. A toxicokinetic model was used to establish this value. The noncarcinogenic end point of concern is renal damage (proteinuria). An uncertainty factor of ten is associated with this RfD. Cadmium is classified as a probable human carcinogen (B-1) for the inhalation route of exposure.

6.2.2.10 Chlordane

Chlordane, a cyclodiene insecticide, is a pesticide which degrades very slowly in the environment. Clinical effects observed as the result of human exposure include muscle tremors, anemia, and leukemia. Reproductive effects have been reported in animal studies (Lappenbusch, 1988). The RfD and CSF available for chlordane are based on animal studies demonstrating liver necrosis and liver tumors in test animals (rats, oral route of exposure). Chlordane has been designated a Class B-2 carcinogen by the EPA. As noted for many other pesticides/PCBs, chlordane bioconcentrates significantly in fish tissue.

6.2.2.11 Chlorobenzene

A carcinogenicity study showed that chlorobenzene caused neoplastic nodules in the liver of male rats but was not carcinogenic in female rats or in mice. Occupational studies suggest that chronic exposure to monochlorobenzene vapor may cause blood dyscrasia, hyperlipidemia, and cardiac dysfunction in humans. Like many organic solvents, monochlorobenzene is a central nervous system depressant in overexposed humans, but no chronic neurotoxic effects have been reported.

The oral Reference Dose for chlorobenzene is 2 x 10^{-2} mg/kg/day. The uncertainty assigned this Reference Dose is 1,000. There is a medium level of confidence for this Reference Dose because of a low assessment of toxicity possible in the study. Carcinogenicity of chlorobenzene is under review by a U.S. EPA work group (U.S. EPA, IRIS, September 1990).

6.2.2.12 Chromium

Skin rashes (human receptor) may occur as a result of dermal contact with certain chromium compounds (chromium III). Exposure by inhalation of chromium (VI) can cause irritation, inflammation, ulceration, and perforations of the nasal cavity. Exposure to chromium (VI) compounds can cause kidney damage. Occupational health studies demonstrate a cause-effect relationship between chromium exposure in workers and lung cancer.

6.2.2.13 Copper

A deficiency of copper, an essential element, may result in anemia, loss of pigment, reduced growth, and loss of arterial elasticity. However, persons who are overexposed may exhibit Wilson's Disease (disorder of Cu metabolism) or liver cirrhosis (Lappenbusch, 1988).

6.2.2.14 4,4-DDT; 4,4-DDE; and 4,4-DDD

Dichlorodiphenyl trichloroethane was a widely used insecticide. The central nervous system and liver are primary target organs for this compound and its degradation products. Tremors have been observed in the chronically exposed (Lappenbusch, 1988). The RfD and CSF available for DDT and its degradation byproducts are based on liver effects and liver tumors observed in test animals (oral route of exposure rats, mice, hamsters). 4,4-DDT; 4,4-DDE; and 4,4-DDD have been designated as Class B-2 carcinogens by the EPA.

6.2.2.15 1,2-Dichlorobenzene; 1,3-Dichlorobenzene; and 1,4-Dichlorobenzene

The liver is a target organ for all three dichlorobenzenes. "Liver effects" and/or "liver and kidney effects" are listed as the "effect of concern" for the available RfDs (inhalation and oral routes of exposure; test animal=rats). Additional bioeffects may include anemia and skin lesions (Lappenbusch, 1988). The CSF available for 1,4-dichlorobenzene is based on animal studies that detected liver tumors in test animals (mice) exposed through the oral route of exposure.

6.2.2.16 1,1-Dichloroethene (1,1-DCE)

The liver and kidney are primary target organs for 1,1-DCE. The compound is currently classified as a possible human carcinogen (Class C). Inhalation exposure has an anesthetic effect.

6.2.2.17 1,2-Dichloroethene (1,2-DCE)

1,2-DCE is a central nervous system and liver toxin. The current Reference Dose for the oral route of exposure is based on animal studies (test animal=rats) reporting an adverse effect on the blood system. Inhalation exposure to elevated concentrations of 1,2-DCE can cause nausea, vomiting, muscle weakness, tremors, and cramps. Repeated exposure by this route can effect proper functioning of the liver. Short-term, high-concentration exposures can effect the central nervous system.

6.2.2.18 Dieldrin

Dieldrin, one of the cyclodiene insecticides, is a neurotoxicant and has been classified a B-2 carcinogen. CSFs are available for the inhalation and oral routes of exposure. Studies have demonstrated that it produces liver tumors in test animals (mice). The effect of concern listed in the HEAST FY 1991 tables for the RfD, is liver lesions (oral route of exposure, test animal=rats). The BCF for dieldrin exceeds 4,500; the chemical bioconcentrates significantly in fish tissues (Lappenbusch, 1988). The use of this chemical has been discontinued in the U.S. because of its carcinogenicity (Hodgson et al., 1988).

6.2.2.19 Endosulfan

Mild kidney lesions have been observed in rats exposed to endosulfan in their diet. The uncertainty factor assigned to the RfD currently available for this compound is 3000. Endosulfan is described in Sax as a highly toxic organochlorine pesticide which does not accumulate significantly in human tissue. It is a central nervous stimulant producing convulsions (receptor not specified - Sax, 1991).

6.2.2.20 Heptachlor/Heptachlor Epoxide

Heptachlor, a cyclodiene insecticide, is a moderately persistent insecticide. In the body, heptachlor is metabolized to heptachlor epoxide. Adverse bioeffects resulting from exposure to heptachlor/heptachlor epoxide include neurological effects like irritability as well as blood disorders (anemia, leukemia) (Lappenbusch, 1988). The RfD for heptachlor was derived based on studies demonstrating increased liver weight in test animals exposed through the oral route of exposure. Heptachlor has also produced liver tumors in mice.

6.2.2.21 Lead

There is evidence that several lead salts are carcinogenic in mice or rats, causing tumors of the kidneys after either oral or dermal administration. Data concerning the carcinogenicity of lead in humans are inconclusive. There is equivocal evidence that exposure to lead causes genotoxicity in humans and animals. The available evidence indicates that lead presents a hazard to reproduction and exerts a toxic effect on conception, pregnancy, and the fetus in humans and experimental animals.

Many lead compounds are sufficiently soluble in body fluids to be toxic. Lead poisoning may cause peripheral neuropathy in adults and children; permanent learning disabilities that are clinically undetectable in children may be caused by exposure to relatively low levels. Short-term exposure to lead can cause reversible kidney damage, but prolonged exposure at high concentrations may result in progressive kidney damage and possibly kidney failure. Anemia is an early manifestation of lead poisoning. Lead is classified as a probable human carcinogen. A CSF has not been published to date by the EPA. (U.S. EPA, IRIS, September 1990).

A RfD for lead is not currently available for either the oral or inhalation route of exposure. However, lead is considered a highly toxic metal. Recently, the EPA presented a strategy to address health and environmental problems caused/suspected to occur as a result of public exposure to this multi-media contaminant (EPA, February 1991). An Action Level of 15 ug/L for lead in drinking water supplies was established in June 1991.

6.2.2.22 Manganese

The central nervous system is a primary target organ for manganese. Inhalation of manganese dusts may result in lung disease. Long-term manganese inhalation exposure can affect the central nervous system and the liver. An iron-deficient diet may magnify these effects.

6.2.2.23 Mercury and Mercury Compounds

Elemental mercury is not highly toxic as an acute poison. Soluble mercuric salts are highly poisonous on ingestion, with oral LD_{50} values of 20 to 60 mg/kg reported. Mercurous compounds are less toxic when administered orally. Acute exposure to mercury compounds at high concentrations causes a variety of gastrointestinal symptoms and severe anuria with uremia. Signs and symptoms associated with chronic exposure involve the central nervous system and include behavioral and neurological disturbances.

In general, organic mercury compounds (methyl mercury) are more toxic than inorganic compounds. Neurotoxicity is a toxic endpoint for methylmercury compounds. Although brain damage due to prenatal exposure to methyl mercury has occurred in human populations, no conclusive evidence is available to suggest that mercury causes anatomical defects in humans.

The current oral RfD (chronic) for inorganic mercury and methyl mercury is 3 x 10^{-4} mg/kg/day. The end points of concern are neurotoxicity and kidney effects. The RfD is based on epidemiological studies and rat studies which evaluated the ingestion and parenteral routes of exposure. An uncertainty factor of 1,000 and 10 have been assigned to the RfDs for inorganic mercury and methyl mercury, respectively.

6.2.2.24 Methyl Napthalene

2-Methyl Napthalene is described as moderately toxic via the ingestion and intraperitoneal routes of exposure (receptor not specified). If the compound is heated, acrid smoke and irritating fumes are emitted. The LD-50 for rats is 1630 mg/kg (oral route of exposure) (Sax, 1991).

6.2.2.25 Methylene Chloride

Methylene chloride is currently categorized as a probable human carcinogen through the ingestion and inhalation routes of exposure. The results of animal studies (rats-oral route of exposure) indicate that it is a liver toxin. At high concentrations, the compound is a severe skin and eye irritant (human receptor).

6.2.2.26 3-Methylphenol/4-Methylphenol

The current RfD for 3-/4-methylphenol was derived based on the results of animal studies demonstrating reduced body weight gain and neurotoxicity in chronically exposed (oral route of exposure) test animals (rats).

6.2.2.27 Nickel

Short-term inhalation exposure to nickel can cause pneumonia-like symptoms. Long-term inhalation exposures can produce nasal injury, cancer of the nasal cavity, and lung cancer (human receptor). Skin contact may produce a skin rash at the point of contact (human receptor). The current Reference Dose for nickel is based on animal studies (rat) demonstrating reduced body weight as a result of nickel exposures (oral route of exposure).

6.2.2.28 Nitrobenzene

Headaches, vertigo, and methemoglobinemia have been observed in workers exposed to nitrobenzene. The current oral RfD for nitrobenzene is 5 x 10^{-4} mg/kg/day. The end points of concern are hematological, adrenal, renal, and hepatic lesions observed in test animals (mice) exposed through the oral route of exposure. The oral RfD for nitrobenzene may change in the near future pending the outcome of a review currently underway by the Oral RfD Work Group.

The current Ambient Water Quality Criteria (AWQC) for the protection of human health is 30 ug/L (assuming water and fish consumption) and is based on organoleptic end points. The AWQC lowest effects concentration (LEC) for the protection of freshwater aquatic life is 27,000 ug/L (acute limit).

6.2.2.29 Phenol

The current RfD for phenol is based on the chemical's adverse health effects on the fetus. Other target organs for this compound are the liver, kidney, lung, and heart (Lappenbusch, 1988). Phenol has been shown to be a promoter of carcinogenesis in experimental animals (Hodgson et al., 1988).

6.2.2.30 Polychlorinated Biphenyl Compounds (PCBs)

Acneform eruptions, abnormal liver function, increased abortions and premature deliveries, and immuno-suppression have been observed in humans exposed to PCBs through the oral route of exposure. PCBs have been designated Class B-2 carcinogens by the EPA. Liver tumors have been detected in mice exposed through the oral route of exposure (Lappenbusch, 1988). PCBs are known to bioconcentrate significantly in fish tissue.

6.2.2.31 Polynuclear Aromatic Hydrocarbons (PAHs)

Polynuclear aromatic hydrocarbons are a large, diverse class of chemicals found in the environment as complex mixtures. Proliferating tissues (the intestinal epithelium) are particularly susceptible target organs for the PAHs (Lappenbusch, 1988). The RfDs which are available for naphthalene, acenaphthylene, phenanthrene, fluoranthene, and pyrene specify the liver, kidney, skin, and/or decreased body weight gain as target organs or effects of concern (test animal=rats). Several PAHs have been designated as Class B-2 carcinogens and it is the carcinogenic potential of these chemicals that is usually of prime concern in public health risk assessment (several test species-oral and inhalation route of exposure). The CSFs available for benzo(a)pyrene are derived based on animal studies demonstrating tumors of the respiratory tract and stomach in test animals exposed through the inhalation and oral routes of exposure, respectively. Many PAHs cause tumors in the skin and epithelial tissues of test animals. An excess mortality from lung cancer has been observed among workers exposed to large amounts of PAH-containing materials such as coal gas, tars, and coke oven emissions (Lappenbusch, 1988).

6.2.2.32 Selenium

Acute (high-dose) exposure to selenium can adversely affect the liver, kidney, myocardia, and nervous system. Chronic selenium toxicity is manifest by depression, nervousness, dermatitis, and gastrointestinal disturbances. Selenium is an essential element in animals and probably in humans (Sax, 1991).

6.2.2.33 Silver

Argyria (a bluish discoloration) has been observed in patients exposed therapeutically to silver. Acute (high-dose) exposures (oral route) can result in lesions of the liver, kidney, bone marrow, and lung as well as severe gastrointestinal distress (convulsions and vomiting). Chronic exposure may adversely affect numerous organ systems and impair immunological resistance (Sax, 1991).

6.2.2.34 Thallium

As noted in Table 6-1, thallium (RfD = 7×10^{-5}; oral route of exposure, chronic) has one of the lowest RfDs available for metals currently listed in IRIS or in the HEAST tables. The effect of concern specified is increased SGOT (serum glutamic oxalacetic transaminase) and serum LDH (lactic dehydrogenase) levels and alopecia (absence or loss of hair) in test animals (rats) exposed through the oral route of exposure. Chronic toxicity includes reddening of the skin, polyneuritis, alopecia, and cataracts. Hepatic and renal damage has been observed after chronic exposure (Hodgson et al., 1988).

6.2.2.35 Zinc

Anemia has been observed in patients exposed therapeutically to zinc. However, zinc is an essential trace element. Excess amounts may adversely affect the gastrointestinal system (i.e. cause vomiting) and alter the distribution of other trace elements in the human body (Sax, 1991).

6.2.2.36 1,2,4-Trichlorobenzene

The current RfD for trichlorobenzene is derived from the results of animal studies demonstrating porphyria in test animals (rats, oral route of exposure). Porphyria is a disorder in which there is increased formation and excretion of porphyrins or their precursors. Porphyrins are a group of pigments found in living cells that act as the prosthetic group for respiratory pigments.

6.2.2.37 Trichloroethene (TCE)

TCE is a skin and eye irritant. Inhalation of high concentrations can produce a numbing effect and heart failure. Repeated exposure can cause headaches, drowsiness, and damage internal organs. TCE is a liver toxin and is currently classified as a probable human carcinogen.

6.2.2.38 Vanadium

The primary health effect from airborne exposure to vanadium is irritation of the skin, eyes, and respiratory tract. Prolonged inhalation exposure can cause coughing, bronchitis, chest spasms, and chest pain.

6.2.2.39 Vinyl Chloride

Vinyl chloride has been designated a Class A (known human carcinogen) by the EPA. Studies have demonstrated that it produces liver tumors in animals exposed through various routes of exposure. The principal toxicological concern is that chronic poisoning with vinyl chloride leads to angiosarcoma of the liver in humans. Vinyl chloride is a mutagen and it adversely affects reproduction in male and female test animals (Hodgson et al., 1988).

6.3 Dose-Response Assessment

An important component of the risk assessment process is the relationship between the dose of a compound (amount to which an individual or population is exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. This section discusses the toxicity criteria that will be used to characterize the public health risk associated with exposure to Study Area COCs and identifies standards/criteria available for Study Area COCs.

Tables 6-6 presents regulatory standards or guidelines available for the chemicals of concern selected in Section 6.2. Target organs are listed in Table 6-7. These values and the toxicity criteria (Reference Doses and Carcinogenic Slope Factors) presented in Table 6-1 are used in the risk characterization process which will be described in Section 6.5.

As discussed in succeeding sections, the risk assessment for the Study Area will be conducted inpart, by a comparison of contaminant levels to existing standards and criteria. Additionally, anticipated human exposure dosages resulting from potential human contact with contaminated environmental media will be evaluated using the Reference Doses and Carcinogenic Slope Factors in Table 6-1. The methodology for estimating exposure dosages is presented in Section 6.4.

6.3.1 Toxicity Criteria (Dose-Response Parameters)

6.3.1.1 Reference Dose (RfD)

As defined in IRIS (the EPA Integrated Risk Information System), an RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are developed for chronic and/or subchronic human exposure to hazardous chemicals and are based on the assumption that thresholds exist for certain toxic effects. The RfD is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). The RfD is derived by dividing the no-observed-adverse-effect-level (NOAEL) or the lowest-observed-adverse-effect-level (LOAEL) by an uncertainty factor (UF) times a modifying factor. The use of uncertainty factors and modifying factors is discussed in the EPA, Office of Research and Development (ORD) Health Effects Assessment Summary Tables, FY 1991.

The uncertainty factor used in calculating the RfD reflects scientific judgement regarding the various types of data used to estimated RfD values. An uncertainty factor of 10 is usually used to account for variation in human sensitivity when extrapolating from valid human studies involving subchronic (for subchronic RfDs) or long-term (for chronic RfD) exposure of average, healthy subjects. An additional 10-fold factor is usually used for each of the following extrapolations: from long-term animal studies to the case of humans, from a LOAEL to a NOAEL, and from subchronic studies to a chronic RfD. An additional uncertainty or modifying factor, ranging from >0 to 10, is applied to reflect professional assessment of the uncertainties of the study and database not explicitly addressed by the above uncertainty factors (such as completeness of the overall data base). The default value for this modifying factor is 1.

TABLE 6-6
REGULATORY REQUIREMENTS FOR CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Chemical Of Concern	EPA SDWA Standards (ug/L)		EPA Drinking Water	Federal Ambient Water Quality Criteria for Human Health		Commonwealth of Massachusetts	FDA Action Levels Consumption of Fish (ppm) (5)
	MCL (Status) (ug/L) (1)	MCLG (Status) (ug/L) (1)	(ug/L) (1)	Ingestion of Water Plus Consumption of Aquatic Life (ug/L) (2)	Ingestion of Aquatic Life Only (ug/L) (2)	Drinking Water Standards/Guidelines (4)	
Volatile Organic							
Vinyl Chloride	2 (F)	0 (F)	10 (L.T. - child)	2 (3)	525 (3)	2	
Methylene Chloride	5 (P)	0 (P)	500 (L.T. - child)	0.19	15.7	5	
Acetone						700	
1,1-Dichloroethene	7 (F)	7 (F)	7 (Lifetime)	0.033	1.85	7	
1,2-Dichloroethene(cis)	70 (F)	70 (F)	70 (Lifetime)	700(3)	140,000(3)	70	
Trichloroethene	5 (F)	0 (F)		2.7	80.7	5	
Benzene	5 (F)	0 (F)	235 (10 day-child)	0.66	40	5	
Chlorobenzene	100 (F)	100 (F)	100 (Lifetime)	660(3)	21000(3)	100	
Semivolatile Organic							
1,4-Dichlorobenzene	75 (F)	75 (F)	75 (Lifetime)	400(3)	2600(3)	5	
1,2-Dichlorobenzene	600 (F)	600 (F)	600 (Lifetime)	2700(3)	17000(3)	600	
Nitrobenzene				30			
1,2,4-Trichlorobenzene	9 (P)	9 (P)	9(Lifetime)				
Bis(2-ethylhexyl) phthalate	4(P)		9(Lifetime)	15000 (1.8(3))	50000 (5.9 (3))	10	
Phenol			4000 (Lifetime)	21000(3)	4600000(3)		
4-Methylphenol							

TABLE 6-6
REGULATORY REQUIREMENTS FOR CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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Chemical Of Concern	EPA SDWA Standards (ug/L)		EPA Drinking Water	Federal Ambient Water Quality Criteria for Human Health		Commonwealth of Massachusetts	FDA Action Levels
	MCL (Status) (ug/L) (1)	MCLG (Status) (ug/L) (1)	(ug/L) (1)	Ingestion of Water Plus Consumption of Aquatic Life (ug/L) (2)	Ingestion of Aquatic Life Only (ug/L) (2)	Drinking Water Standards/Guidelines (4)	Consumption of Fish (ppm) (5)
Polyaromatic Hydrocarbons							
Naphthalene			20 (Lifetime)				
2-Methylnaphthalene							
Acenaphthylene				0.0028(3)	0.031 (3)		
Phenanthrene				0.0028(3)	0.031 (3)		
Fluoranthene				3000(3)	370(3)		
Pyrene				960(3)	11000(3)		
Benzo(a)anthracene	0.1 (P)	0 (P)		0.0028(3)	0.031 (3)		
Chrysene	0 2 (P)	0 (P)		0.0028(3)	0.031 (3)		
Benzo(b)fluoranthene	0 2 (P)	0 (P)		0.0028(3)	0.031 (3)		
Benzo(k)fluoranthene	0 2 (P)	0 (P)		0.0028(3)	0.031 (3)		
Benzo(a)pyrene	0 2 (P)	0 (P)		0.0028(3)	0.031 (3)		
Indeno(1,2,3-cd)pyrene	0 2 (P)	0 (P)		0.0028(3)	0.031 (3)		
Dibenz(a,h)anthracene	0.3 (P)	0 (P)		0.0028(3)	0.031 (3)		
Benzo(g,h,i)perylene	0 2 (P)	0 (P)					
Pesticides							
Aldrin			0.3 (L.T. - child)	0.00013(3)	0.00014(3)		0.3
4,4'-DDD				0.00083(3)	0.00084(3)		
4,4'-DDE				0.00059(3)	0.00059(3)		5
4,4,'-DDT				0.000024(3)	0.000024		5
Dieldrin			0.5 (L.T. - child)	0.033			
Heptachlor	0 4 (F)	0 (F)	5 (L.T. - child)	0.00021 (3)	0.00021 (3)	0.2	0.3
Chlordane (Total)	2 (F)	0 (F)	0.5 ug/L (L.T. - child)	0.00057(3)	0.00059(3)	0.5	0.3
Endosulfan I							
Endosulfan II							
Endosulfan Sulfate							

TABLE 6-6
REGULATORY REQUIREMENTS FOR CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 3

Chemical Of Concern	EPA SDWA Standards (ug/L)		EPA Drinking Water	Federal Ambient Water Quality Criteria for Human Health		Commonwealth of Massachusetts	FDA Action Levels Consumption of Fish (ppm) (5)
	MCL (Status) (ug/L) (1)	MCLG (Status) (ug/L) (1)	(ug/L) (1)	Ingestion of Water Plus Consumption of Aquatic Life (ug/L) (2)	Ingestion of Aquatic Life Only (ug/L) (2)	Drinking Water Standards/Guidelines (4)	
PCBs							
Aroclor 1248	0 5 (F)	0 (F)		0 000044(3)	0.000045(3)	0 5	
Aroclor 1254	0 5 (F)	0 (F)		0 000044(3)	0 000045(3)	0.5	
Aroclor 1260	0 5 (F)	0 (F)		0 000044(3)	0 000045(3)	0.5	
Metals/Alkylated Metals							
Monomethyl Mercury							
Dimethyl Mercury							
Mercury	2 (F)	2 (F)	2 (Lifetime)	0 14(3)	0.15(3)	2	1
Antimony	5 (P)	3 (P)	3 (Lifetime)	14(3)	4300(3)		
Arsenic	0 05 mg/L (I)			0 0022	0.0175	50	
Barium	2000 (P)	2000 (P)	5000 (Lifetime)			1000	
Beryllium	1 (P)	0 (P)	4000 (L T - child)	0 0077(3)	0.13(3)		
Cadmium	5 (F)	5 (F)	5 (Lifetime)	10	170(3)	10	
Chromium (Total)	100 (F)	100 (F)	100 (Lifetime)	50	3400(3)	50	
Copper	1300 (P)	1300 (P)		1300 (3)		1300	
Lead	15 (Action Level)			50 (3)		50	
Manganese	50 (F) Secondary						
Nickel	100 (P)	100 (P)	100 (Lifetime)	610(3)	4600(3)		
Selenium	50 (F)	50 (F)		100(3)	6800(3)	10	
Silver	100 (F)		100 (Lifetime)	105(3)	65000(3)	50	
Thallium	1 (P)	0 5 (P)	0 4 (Lifetime)	1 7(3)	6 3(3)		
Vanadium			20 (Lifetime)				
Zinc	5000 (F) Secondary						

* – Unless otherwise noted

KEY: I – Interim * – Underreview
P – Proposed
F – Final
LT – Long Term

FOOTNOTES:

(1) EPA Drinking Water Regulations and Health Advisory Memorandum – Office of Drinking Water – April 1991.
(2) AWQC values presented in IRIS (12-3-91)
(3) AWQC values presented in EPA Headquaters Office of Water Summary Tables
(see Appendix K) are presented in those cases when values were not available on IRIS (The 10-6 risk value is presented for carcinogens)
(4) Commonwealth of Massachusetts Drinking Water and Standards and Guidelines Memorandum (see Appendix K)
(5) ASTDR – Health Assessment Guidance Manual (ASTDR – July, 1990) (see Appendix K)

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TABLE 6-7
CHEMICALS OF CONCERN AND TARGET ORGANS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Chemical	Target Organ: Oral / Inhalation
Volatile Organic	
Vinyl Chloride	
Methylene Chloride	Liver/Liver
Acetone	Liver, Kidney/
1,1-Dichloroethene	Liv,Kid/Liv,Kid
1,2-Dichloroethene	
Trichloroethene	
Benzene	
Chlorobenzene	Liver, Kidney/
Semivolatile Organic	
1,4-Dichlorobenzene	
1,2-Dichlorobenzene	Liver/
Nitrobenzene	Liver, Kidney/
1,2,4-Trichlorobenzene	Epidermis/
Bis(2-ethylhexyl) phthalate	Liver/
Phenol	Fetus/
3/4-Methylphenol	None/
(Polyaromatic Hydrocarbons)	
Naphthalene	Body Weight/
2-Methylnaphthalene	Body Weight/
Acenaphthylene	Epidermis/
Phenanthrene	Body Weight/
Fluoranthene	Liver, Kidney/
Pyrene	Kidney/
Benzo(a)anthracene	--
Chrysene	--
Benzo(b)fluoranthene	--
Benzo(k)fluoranthene	--
Benzo(a)pyrene	--
Indeno(1,2,3-cd)pyrene	--
Dibenz(a,h)anthracene	--
Benzo(g,h,i)perylene	
Pesticides	
4,4,'-DDD	--
4,4,'-DDE	--
4,4,'-DDT	Liver/
Dieldrin	Liver/
Chlordane (Total)	Liver (Females)/
Endosulfan I	Kidney/
Endosulfan II	Kidney/
Endosulfan Sulfate	
Aldrin	Liver/
Heptachlor	Liver/
PCBs	
Aroclor 1248	--
Aroclor 1254	--
Aroclor 1260	--
Metals/Alkylated Metals	
Monomethyl Mercury	CNS/
Dimethyl Mercury	CNS/
Mercury	Brain, Kidney/
Antimony	Longevity, Blood/
Arsenic	Skin/
Barium	Blood/
Beryllium	
Cadmium	Kidney/
Chromium (VI)/III	Liver/
Copper	
Lead	
Manganese	CNS/CNS
Nickel	Body Weight/Lung
Selenium	Selenosis/
Silver	Argyria/
Thallium	
Vanadium	
Zinc	Anemia/

6.3.1.2 Carcinogenic Slope Factor (CSF)

CSFs are applicable for estimating the lifetime probability (assumed 70-year lifespan) of human receptors contracting cancer as a result of exposure to known or suspected carcinogens. This factor is generally reported in units of $(mg/kg/day)^{-1}$ and is derived through assumed low-dosage responses determined from human or animal studies. Cancer risk and CSFs are most commonly estimated through the use of a linearized, multistage, mathematical extrapolation model applied to animal bioassay results. The value used in reporting the slope factor is the upper 95 percent confidence limit.

The available toxicity criteria presented in Table 6-1 are summarized from IRIS (EPA, December 1991). Toxicity criteria available from EPA Region I, the EPA Health Effects Assessment Summary Tables (HEAST) - FY 1991, and the EPA Drinking Water Health Advisory Memorandum (EPA, April 1991), are presented when toxicity criteria are not available from IRIS.

6.3.2 Criteria/Standards

Table 6-6 presents available regulatory standards or guidelines for the Study Area chemicals of concern. These values will be used in the risk characterization presented in Section 6.5.

6.3.2.1 Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act (SDWA) and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to all public water systems. A public water system is defined as a system which provides water to the public for human consumption and which has at least 15 service connections or regularly serves an average of at least 25 individuals daily for a minimum of 60 days per year. MCLs are designed for prevention of human health effects associated with lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming two liters of water per day, but also reflect the technical feasibility of removing the contaminant. These enforceable standards also reflect the fraction of the toxicant expected to be absorbed by the gastrointestinal tract.

The federal SDWA standards undergo periodic review by the Environmental Protection Agency and are subject to change as new toxicological information becomes available. Recent proposed standards and criteria are included in Table 6-6 for the chemicals of concern.

Surface waters within the Study Area are listed by the State of Massachusetts as Class B waters, suitable for recreational use and propagation of wildlife. The use of Study Area surface waters as a drinking water supply source is not considered within this assessment. MCLs have been presented on Table 6-6 for reference purposes only.

6.3.2.2 Maximum Contaminant Level Goals (MCLGs)

MCLGs are specified as zero for carcinogenic substances, based on the assumption of nonthreshold toxicity, and do not consider the technical or economic feasibility of achieving these goals. MCLGs are non-enforceable guidelines based entirely on health effects. The MCLs have been set as close to the MCLGs as is considered technically and economically feasible.

6.3.2.3 Ambient Water Quality Criteria (AWQC)

AWQC are not enforceable regulatory guidelines. They may be used for identifying human health risks and acute and chronic toxic effects in aquatic organisms. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and adverse carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), from ingestion of water alone (2 liters/day) and from ingestion of aquatic organisms alone (6.5 grams/day). The AWQCs for protection of human health for carcinogenic substances are based on the EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (the 10^{-7} to 10^{-5} range).

6.3.2.4 Health Advisories (HAs)

HAs are guidelines developed by the EPA Office of Drinking Water for non-regulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day or for adults (assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (long-term) exposure scenarios. Health advisory guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of known or probable human carcinogens.

Table 6-6 presents available U.S. Food and Drug Administration (FDA) Action Levels for chemicals in fish tissue and Commonwealth of Massachusetts Drinking Water standards and guidelines, when available.

6.4 Exposure Assessment

The purpose of this section is to evaluate the potential for human exposure to the chemicals of concern identified in the surface water, sediment, and fish tissue samples collected in the Sudbury River Study Area. This section identifies actual or potential routes of exposure, characterizes the exposed populations, and presents the methodology used to estimate the degree or magnitude of exposure.

To determine whether there is an actual exposure or a potential for exposure in the future, the most likely pathways of chemical release and transport as well as the human and environmental activity patterns within the Study Area must be considered. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment; (2) a route of contaminant transport through an environmental medium; and (3) an exposure or contact point for a human receptor. These components are addressed in the following subsections. In the final subsection, exposure scenarios will be developed based on indicator chemical concentrations, chemical fate and mobility, and relevant demographic information. The exposure scenarios will allow quantitative estimation of human intakes as a result of contact with Study Area contaminants.

6.4.1 Sources of Contamination

As detailed in Section 1, several contaminant sources exist within the Sudbury River Study Area:

- The Nyanza Superfund Site
- Twelve active or inactive landfill sites)
- Potential oil/hazardous materials release sites
- Wastewater discharge sites

Additionally, non-point sources such as road runoff are suspected to have contributed to contaminant concentrations detected in the surface water, sediment, and fish tissue samples taken from the Study Area.

6.4.1.1 The Nyanza Site Contaminant Source Area

The Nyanza Superfund Site is a 35-acre site located on Megunko Road in Ashland, Massachusetts, approximately 22 miles west of Boston. The site was occupied from 1917 through 1978 by several companies involved in manufacturing textile dyes and dye intermediates. During that period, the following wastes were disposed into vaults, tanks, lagoons, and surface drainage systems at various onsite locations:

- o Partially treated process wastewater
- o Chemical sludge from the wastewater treatment process
- o Solid process wastes (chemical precipitate and filtercake
- o Solvent recovery distillation residue
- o Off-specification products

Based on historical monitoring, the EPA has identified the following metals as Nyanza site-specific contaminants:

- o Antimony
- o Arsenic
- o Cadmium
- o Chromium
- o Lead
- o Mercury

Previous Nyanza site investigations indicate that onsite soils, sludges, and sediments were contaminated with heavy metals such as mercury, chromium, lead, and cadmium. Cadmium, chromium, arsenic, mercury, and lead were also repeatedly detected in groundwater at the Site. As discussed in Section 4 and summarized in Tables 6-2, 6-3 and 6-4, all of these metals were detected in surface waters, sediments, and fish tissues samples collected in the Study Area.

The EPA has identified the following organics as Nyanza site-specific contaminants:

- o Trichloroethene
- o Chlorobenzene
- o Dichlorobenzenes
- o Aniline
- o Phenolic compounds
- o 1,2-Dichloroethene
- o Nitrobenzene
- o 1,2,4-Trichlorobenzene
- o Naphthalene
- o Benzidine

Based on past Nyanza site investigations, trichloroethene and chlorobenzene were detected in onsite soils and sediments at concentrations exceeding 100 μg/kg and 1,000 μg/kg, respectively. Nitrobenzene; the dichlorobenzenes; 1,2,4-trichlorobenzene; aniline; and naphthalene were detected in the 100 to 1,000 μg/kg concentration range. As reported in this RI report, chlorobenzene; the dichlorobenzenes; trichloroethene; and 1,2-dichloroethene were detected in the sediments/soils of the Eastern Wetlands which border the Nyanza Site. Aniline, the dichlorobenzenes, trichloroethene, and nitrobenzene have been detected in the unconsolidated overburden and bedrock aquifers underlying and downgradient of the Nyanza site (Ebasco, 1991). With the exception of aniline and benzidine, all of these organic contaminants were detected in surface water, sediments, and/or fish tissue samples collected during the Sudbury River study.

6.4.1.2 Offsite Contaminant Sources

Section 4.2.2 described the landfills, oil/hazardous materials release sites, wastewater discharges, and nonpoint sources which may contribute to contaminant concentrations detected in environmental samples collected from the Sudbury River. Several of the landfills are currently undergoing environmental assessment by the Massachusetts Department of Environmental Protection. These offsite sources may act as sources of the nonsite-specific contaminants detected in the River. For example, the landfills may contribute to the phthalate, PAH, and pesticide/PCB contamination detected in environmental samples. Nonpoint contaminant sources such surface drainage and stormwater runoff from light industrial areas, highways, and railways may contribute to the petroleum related contaminants (benzene and PAHs) and pesticide/PCB contamination detected in the Study Area.

6.4.2 Contaminant Transport and Migration

The fate and migration of Study Area contaminants was discussed in Section 5.0. Summarizing from Section 5.0, the principal mechanisms by which contaminants appear to be migrating from source areas (and potentially resulting in exposure to human and ecological receptors) are as follows:

- Surface drainage/stormwater runoff from contaminated sites/soils areas (the Nyanza Site) may transport contaminants to surface waters/sediments of the Sudbury River.

- Chemicals introduced to the Sudbury River may be transported through the surface water in the dissolved phase or adsorbed to entrained sediments.

- Chemicals in surface waters/sediments may be exchanged between these media through adsorption/desorption processes.

- Chemical transport to and from surface waters/sediments and the groundwater may occur as the groundwater (possibly) discharges to and is recharged by surface waters.

As described in Sections 4.0 and 5.0 of this report, surface water drainage from the Nyanza site is considered the primary contaminant flow path to the river. Site surficial runoff drains to the Eastern Wetlands to the east of the site and to Chemical Brook to the north. Surface waters from the Eastern Wetlands drain into Trolley Brook which converges with Chemical Brook to form a confluence at the upstream end of the Chemical Brook Culvert. The culvert carries surface waters through Ashland. Outfall Creek is formed by the discharge of surface waters from the culvert. Outfall Creek flows north for a short distance and then discharges to the lower end of the Raceway which in turn discharges to the Sudbury River.

6.4.3 Receptor Identification and Exposure Routes

This section identifies the human receptors potentially exposed to contaminated environmental media and provides the methodology used to estimate the degree or magnitude of exposure.

6.4.3.1 Site Characterization and Receptor Identification Site Characterization

For this report, the Sudbury River Study Area is defined as 33 miles of the Sudbury River drainage basin from the head waters at Cedar Pond in Westborough to the confluence of the Sudbury and Assabet Rivers which form the Concord River in Concord, Massachusetts. As described in Section 3.0, the Study Area is composed of various types of open water bodies (the River, tributaries to the river, several reservoirs and ponds) and associated wetlands which are generally accessible to the public.

Land use along the Sudbury River Study Area varies, as described in Section 3.2.2. Although the land in the vicinity of Cedar Swamp is largely undeveloped, residential, commercial, and industrial properties as well as wetlands and meadows abut the river. The Sudbury River and its tributaries in the Study Area flow through several communities that range in size from 4,000 to 65,000 residents. The area is classified as rural to urban suburban. From the Framingham/Wayland town line northward approximately 9 miles to Route 117, the River is bordered by the Great Meadows National Refuge.

The Sudbury River in Ashland is classified as a Class B surface water, which is protected for the propagation of fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. As described in Section 3.2.1, water use in certain areas of the Study Area is restricted. However, much of the river (and the river front) is used for recreation (boating, hiking, fishing).

While it is understood that some surface water bodies within the Study Area are used more extensively for recreational purposes than others, for the purposes of this risk assessment, it is assumed that all areas of open water are similar, in that persons are likely to swim, fish, or wade in any area. Although the reservoirs are somewhat restricted areas, a certain amount of trespass is expected. Therefore, legal and physical restrictions of the reservoirs are not considered. It is assumed that residents who own property abutting the reservoir areas will use them as recreational resources.

The following tributaries and wetlands are included in the Study Area:

- The Raceway
- Trolley Brook
- The Eastern Wetlands
- Cold Spring Brook
- Chemical Brook
- Chemical Brook Culvert
- Outfall Creek

The following paragraphs briefly describe these surface water bodies/wetlands and characterize each in terms of the potential for human exposure to surface water/sediments/fish.

Eastern Wetlands

The Eastern Wetlands includes the two small ponds and their outlet to the north, as described in Section 3. This is an area which has unrestricted access and can be used by the public without restriction. The area is wooded, with substantial marsh areas on the eastern sides of the ponds. This characteristic may dissuade public use of the area. However, the outlet to the wetlands, Trolley Brook, passes under a public roadway, flows to Chemical Brook and then into a large culvert to the north of the site.

Public exposure and contact with the surface waters and sediments is more likely in these areas.

Chemical Brook Culvert

The Chemical Brook Culvert, referred to as the "culvert", is an underground pipeline constructed of corrugated pipe, concrete pipe, and stone blocks. This culvert passes through several concrete catch basins and receives water from various sources as it passes in a northeasterly direction under the town center of Ashland. The culvert is completely isolated from the general public because of its construction and location. Therefore, the public is unlikely to be exposed to the waters and sediments in the Chemical Brook Culvert.

Outfall Creek

The outfall for the Chemical Brook Culvert is an open creek which runs northeast to the Raceway upstream from its confluence with the Sudbury River. This creek is a moderately flowing stream, varying in depth from 6 to 18 inches. Access to the outfall creek is unrestricted and adjacent woodlands abut several residential properties.

Raceway

The Raceway flows out of Mill Pond separate from the Sudbury River and flows under a large factory building before becoming an open watercourse. The Raceway is a fast moving waterway with a gravel and sand bottom. The Raceway parallels the River, receiving the Chemical Brook outfall creek waters and then rejoining the Sudbury River. Access to the Raceway is also unrestricted and adjacent woodlands abut public and private properties.

Sudbury River

The reaches of the Sudbury River, described in Section 1.2.1, are considered alike in that each reach is subject to unrestricted access by the residential population in the adjoining towns. In the case of some reaches, the potential for interaction increases, especially in the areas of the Wildlife Refuge and areas of the River which are more heavily fished. The characteristics of the Sudbury River range from slow moving and meandering river conditions (including shallow lakes and ponds) to quickly moving riffle/run areas of limited extent. The River is expected to be used for various recreational purposes including fishing, boating, swimming and wading, as well as numerous play activities by children.

Cold Spring Brook

Cold Spring Brook is a tributary to the Sudbury River flowing from the south and connecting to the River at the junction of Reaches 2 and 3. Since this is an upstream location not influenced by the Sudbury River, this stream is considered a separate reach.

Heard Pond

Heard Pond is a moderate-sized eutrophic pond located to the west of the Sudbury River at Reach 7. This pond is nearly surrounded by wetlands. There is no information confirming or disproving the possibility of a hydraulic connection between the River and Heard Pond although a source reported that the pond is affected by the River during flood conditions. Heard Pond is therefore considered a separate reach from the River but not a background location.

Bordering Wetlands

Bordering wetlands within the Study Area are grouped as a separate section. These wetlands include the woodlands and floodplains adjacent to the river and its tributaries which are only inundated during flood-stage river conditions. The bordering wetlands are generally unrestricted from public access and include some private properties which abut the river and reservoirs. The activities which are expected to occur in these areas include hiking, bird watching, and numerous play activities by children, the same as those expected to occur in yards of private homes.

Recreational Facilities

Much of the study area is utilized for recreational purpose although there are no formally regulated recreational zones such as municipal playgrounds or swimming beaches. The only formal recreational area is the Great Meadows National Wildlife Refuge, located at reaches 7 and 8. This area is frequented by numerous visitors, who are restricted to non-intrusive activities such as hiking and bird watching.

There are small boat launching areas in many reaches, including Mill Pond (Reach 2), Heard Pond (Reach 7) and both upstream and downstream of Fairhaven Bay (Reach 9) these areas in particular could be used for swimming or other recreational activities, but it is important to note that except for the MDC Reservoirs No. 1 and 2, the entire study area is available for public access. Children will access water bodies wherever it is convenient, and light boat access can be obtained at nearly any street crossing.

6.4.3.2 Receptors of Concern

Based on the contaminant occurrence and distribution, contaminant fate and transport, and water/land use information presented in previous sections of this report, there are two contaminated environmental media which human receptors are likely to contact in the Study Area: surface waters and sediments. Human receptors that could be potentially exposed to Study Area contaminants include:

- Individuals using the surface water bodies and river front of the Study Area for recreational purposes. These receptors may contact contaminated surface waters/ sediments while wading, boating, hiking, or swimming. Recreational facilities do exist within the Study Area. Additionally, although the use of some of the Study Area surface bodies is restricted, trespass is a possibility.

- Sports or subsistence fishermen who fish the open surface water bodies of the Study Area (Discussions with local town people indicate that local ethnic groups heavily fish certain areas of the Sudbury River Study Area).

- Individuals residing along the river front or any of the wetlands investigated during the RI.

6.4.3.3 Exposure Routes

This subsection presents the methodology that will be used to estimate potential exposure doses incurred by a human receptor who may contact contaminated surface waters/sediments in the Study Area or who may consume fish taken from the Study Area.

The exposure scenarios developed in this section are based on estimated parameters such as exposure rates, durations, and frequency. Exposure doses are calculated using mathematical models which account for these estimated parameters as well as for the contaminant concentrations detected. While most of the exposure scenarios presented consider the recreational use of surface water bodies within the Sudbury River Study Area, the sediment exposure scenarios also consider exposures incurred by individuals <u>residing</u> close to river front areas or wetlands occasionally inundated with surface waters. The fish ingestion scenarios consider both subsistence and sports fishermen as receptors of concern. Table 6-8 summarizes the input parameters for the exposure scenarios. Exposure dose calculations and results are presented in Appendix K.

TABLE 6-8(1)

SUMMARY OF INPUT PARAMETERS FOR EXPOSURE SCENARIOS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

Environmental Media	Land/Surface Water Use Scenario	Route of Exposure	Receptor of Concern	Contact Rate	Skin Surface Area (cm^2)	Exposure Time (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Exhibit Number
Surface Water	Recreational	Accidental Ingestion	Child	0.05 L/hr	NA	2.0 hrs/day	50	6	6-1
			Teen				150	12	
			Adult				50	12	
		Dermal Absorption	Child	NA	3,490	2.0 hrs/day	50	6	6-2
			Teen		6,207		150	12	
			Adult		19,400		50	12	
Sediments	Recreational	Accidental Ingestion	Child	200 mg/day	NA	NA	50	6	6-1
			Teen	100 mg/day			150	12	
			Adult	50 mg/day			50	12	
		Dermal Absorption	Child	500 mg/day	2,000 cm^2	NA	50	6	6-3
			Teen				150	12	
			Adult				50	12	
	Residential	Accidental Ingestion	Child	200 mg/day	NA	NA	270	6	6-1
			Teen	100 mg/day				12	
			Adult	50 mg/day				12	
		Dermal Absorption	Child	500 mg/day	2,000 cm^2	NA	270	6	6-3
			Teen					12	
			Adult					12	
Fish	Subsistence Fishing	Ingestion	Adult	0.132 kg/day	NA	NA	350	30	6-4
	Sport Fishing	Ingestion	Adult	0.054 kg/day	NA	NA	350	30	

NA Not applicable

(1) The reader is referred to Appendix K for a detailed explanation and listing of references supporting the use of the input parameters presented.

Several types of open water bodies exist within the Study Area: stream flow zones of the Sudbury River; tributaries, such as the Raceway, to the River; and the Eastern Wetlands. Assuming the recreational use of these surface water bodies, the following human exposure scenarios are possible:

- o Accidental ingestion/dermal absorption of contaminants during swimming or wading in surface waters of the Study Area
- o Accidental ingestional/dermal absorption of contaminants in sediments
- o Ingestion of finfish taken from surface water bodies within the Study Area

Recreational Exposure Scenarios: Surface Waters

The exposure dose equation presented in Exhibit 6-1 will be used to estimate an exposure dose resulting from the accidental ingestion of chemicals in surface water during swimming. The receptors of concern for the exposure scenario are a 70-kg adult, a 37-kg adolescent (teenager), and a 15-kg child. The exposure rate, exposure frequency, and exposure duration estimates are NUS estimates based primarily on climatic conditions in the Study Area and the assumption that the adolescent is the receptor most likely to be using the Study Area surface water bodies for recreational purposes. The water ingestion rate (50 mL/hour) is an EPA estimate (EPA, December 1989).

The exposure dose equation for dermal contact with surface water is presented in Exhibit 6-2. The receptor body weight, exposure rate, exposure frequency, and exposure duration assumptions are the same as those assumed for the accidental-ingestion-of-surface-water exposure scenario. It is assumed that the total skin surface area of the adult receptor (19,400 cm^2) is exposed to surface water contaminants while swimming. The skin surface area for the adolescent receptor is calculated assuming that the total body surface area (13,300 cm^2) is exposed while swimming and the feet and lower legs (20 percent body surface area = 2,660 cm^2) are exposed while wading. The skin surface area for the adolescent receptors presented in Table 6-8 is a time-weighted value assuming that the adolescent receptor swims 50 days/year and wades 100 days/year, respectively. It is assumed that 50 percent of the child's total body surface area (6,980 cm^2) is exposed to surface water contaminants while swimming/wading. Contaminant-specific

EXHIBIT 6-1
INCIDENTAL INGESTION OF CHEMICALS IN SURFACE WATER AND SEDIMENTS
NYANZA OPERABLE UNIT 3

$$\text{Exposure Dose (mg/kg-day)} = \frac{C \times CR \times ER \times EF \times ED \times ABS \times 10\text{-}6\ \text{kg/mg}^{*}}{BW \times AVG \times 365\ \text{days/year}}$$

C = Measured/Estimated Media Concentration (mg/L, water; mg/kg, sediment)

CR = Contact Rate or Ingestion Rate (IR) (L/hr (0.05L/hr) for surface waters; mg/day for sediments (e.g. 200 mg/day-child). See Table 6-8.

ER = Exposure Rate or Time (hrs/day) (applicable to surface water only) (2 hrs/day)

EF = Exposure Frequency (days per year) (Adults - 50 days/yr; Teens - 150 days/yr; Child - 50 days/yr)

ED = Exposure Duration (years/lifetime) (Adults + 12 yrs; Teen -12 yrs; Child - 6 yrs)

BW = Receptor Body Weight (Kg) (Adult - 70kg; Teen - 37.2 kg; Child 14.5 kg)

AVG = Number of years over which the exposure is averaged (70 years for carcinogenic effects, ED for noncarcinogenic effects)

ABS = Absorption through the gut (unitless)

Volatile organic compounds - 100%
Semivolatile organic compounds - 100%
(Sediments - PCBs - 30%)
Pesticides - 100%
(Sediments - high absorption to soils - 30%)
Inorganics - 100%
(Sediments - Lead - Adults 30%, Children 50%)

Notes:

* The conversion factor of 10^{-6} kg/mg is used for the ingestion of sediments only. Ingestion of water scenario requires no such conversion factor.

o Example calculations are presented in Appendix K.

o Input parameters for the exposure scenarios are presented in Table 6-8. See Appendix K for contaminant-specific absorption factors.

References:

EPA, March 1991
EPA, June 1989
EPA, December 1989
EPA, May 1989

EXHIBIT 6-2
DERMAL CONTACT WITH CHEMICALS IN SURFACE WATER NYANZA OPERABLE UNIT 3

$$\text{Absorbed Dose (mg/kg/day)} = \frac{C \times PC \times SSA \times ER \times EF \times ED}{BW \times AVG \times 365 \text{ days/year} \times CF}$$

C = Measured/Estimated Surface Water Concentration (mg/L)

PC = Permeability Constant (cm/hour). See Appendix K for contaminant specific PC values. The default value is 8 x 10^{-4} cm/hr. (EPA, December 1989)

SSA = Contact Rate (Skin Surface Area Available for Contact - cm^2). Adults - 19,400 cm^2; Teens - 6,207 cm^2; Children - 3490 cm^2)

ER = Exposure Rate (hours per day) (2 hrs/day)

EF = Exposure Frequency (days/year) (Adults - 50 days/yr; Teen - 150 days/yr; Children - 50 days/yr)

ED = Exposure Duration (years/lifetime) (Adults - 12 yrs; Teens - 12 yrs; Child - 6 yrs)

BW = Receptor Body Weight: Kg (Adult - 70 kg; Teen - 13.71 g; Child - 14.51 g)

AVG = Number of years over which the exposure is averaged (70 years for carcinogenic effects; ED for noncarcinogenic effects)

CF = Volumetric Conversion Factor for Water (1,000 cm^3/L)

Notes:

- In the absence of contaminant-specific permeability constants, the permeability constant for water (0.0008 cm/hr) may be used. (See Appendix K for contaminant-specific permeability constants used in risk assessment.)
- Example calculations are presented in Appendix K.
- Input parameters for the exposure scenario are presented in Table 6-8.

References:

EPA, March 1991
EPA, December 1989
EPA, May 1989

permeability constants are used if available. (In accord with EPA Region I guidance, permeability constants, available in the recently published Interim Guidance for Dermal Exposure Assessment ((EPA, March 1991) were used whenever possible.)) In the absence of contaminant-specific permeability constants, the permeability constant for water (0.0008 cm/hr) will be used for organic contaminants. The reader is referred to Exhibit 6-2 and Appendix K for the references supporting the exposure parameter assumptions and permeability constants used to evaluate the dermal-contact-with-surface-water exposure scenario.

Recreational Exposure Scenarios: Sediments

Exhibit 6-1 presents the exposure dose equation for the accidental-ingestion-of-sediments exposure scenario. The receptor body weight, exposure frequency, and exposure duration assumptions are the same as those assumed for the surface water exposure scenarios. The sediment ingestion rates are those presented in the EPA Risk Assessment Guidance for Superfund, Volume I (EPA, December 1989) and available supplemental guidance (EPA, March 1991). The contaminant absorption rates are those presented in the Region I Supplemental Risk Assessment Guidance of the Superfund Program (EPA, June 1989).

The exposure dose equation for dermal-contact-with-sediment exposure scenario is presented in Exhibit 6-3. The receptor body weight, exposure frequency, and exposure duration assumptions are the same as those stated for the surface water exposure scenarios. The soil contact rate and contaminant absorption rates are those presented in the Region I risk assessment guidance document. The dermal absorption rate assumed for semi volatile organics other than PAHs and PCBs (10%) is more conservative than the absorption rate assumed for PAHs and PCBs (5%). If the true absorption rate for all semi volatiles is 5%, the absorbed dose for semi volatiles other than PAHs and PCBs may be overestimated. Given the fact that the risks associated with the accidental-ingestion-of-sediment exposure scenario predominate, the use of a 5% or 10% absorption rate for semivolatiles will not significantly alter results of the risk assessment). The dermal absorption factors assumed for mercury (0.01) and methyl mercury (0.77) were provided by the Massachusetts Department of Environmental Protection. The current EPA Region I guidance for the dermal adsorption factor for mercury is 0.05. The assumed rate of 0.01 therefore is more conservative than current EPA Region I guidelines and the risks associated with sediment contact scenarios may be over estimated, but will not significantly alter results of the risk assessment.

EXHIBIT 6-3
DERMAL CONTACT WITH CHEMICALS IN SEDIMENTS
NYANZA OPERABLE UNIT 3

$$\text{Absorbed Dose (mg/kg/day)} = \frac{C \times SCR \times RAF \times EF \times ED \times 10\text{-}6 \text{ kg/mg}}{BW \times AVG \times 365 \text{ days/year}}$$

C = Measured/Estimated Contaminant Concentration in Sediment (mg/kg)

SCR = Soil/Sediment Contact Rate (mg soil/day of exposure) (500 mg/day)

RAF = Absorption Factor for Soils/Sediments (unitless)
Volatile Organic compounds - 50%
Semivolile organic compounds - 10%
Polyaromatic hydrocarbons - 5%
Polychlorinated biphenyl compounds - 5%
Pesticides - high sorption to soils - 5%
- low sorption to soils - 50%
Inorganics (except mercury) - negligible
Mercury - 1%
Methylmercury - 77%

EF = Exposure Frequency (days/year) (Adult - 50 days/yr; Teen -150 days/yr; Child - 50 days/yr)

ED = Exposure Duration (years/lifetime) (Adult - 12 yrs; Teen - 12 yrs.; Child - 6 yrs)

BW = Receptor Body Weight: Kg (Adult - 70 kg; Teen - 37 kg; Child 14.5 kg)

AVG = Number of years over which the exposure is averaged (70 years for carcinogenic effects; ED for noncarcinogenic effects).

Notes:

- Example calculations are presented in Appendix K.
- Input parameters for the exposure scenarios are presented in Table 6-8.
- See Appendix K for contaminant-specific absorption factors.

References:

EPA, March 1991
EPA, December 1989
EPA, June 1989

Fish Ingestion Exposure Scenario

The ingestion-of-fish exposure scenario (Exhibit 6-4) considers consumption of fish taken from the Study Area by sports and subsistence fishermen. The receptor of concern is an adult receptor (70 kg) who consumes the fish 350 days/year over a 30-year lifetime. Based on EPA guidance, the sports fisherman and subsistence fisherman consume 0.054 kg/day and 0.132 kg/day, respectively. (EPA, March 1991) the fraction of fish taken from the Sudbury River is assumed to be 0.25 and 0.75 for sports and subsistence fishermen, respectively.

Residential Exposure Scenario: Sediments

Bordering wetlands within the Study Area include vegetated wetlands, swamps, and marshes adjacent to the open water area. Unlike the Eastern Wetlands, most of these wetlands are contain no surface water during dry periods.

Because residential areas adjoin or are located in the vicinity of the bordering wetlands, residents of these areas may be in frequent contact with contaminated soils/sediments. Consequently, Table 6-8 includes exposure assumptions for residents exposed to the soil/sediment through the accidental-ingestion and dermal-contact exposure scenarios. All exposure assumptions for the residential exposure scenario are the same as those presented for the recreational exposure scenarios except that the exposure frequency (days/year exposed) increases to 270 days/year.

6.5 Risk Characterization

Risk characterization evaluates the potential for adverse health effects from site media by integrating information developed during the exposure and toxicity assessments. EPA guidelines (EPA, September 1986) for the use of dose-additive models were used to combine the risks for individual chemicals to estimate the cumulative risks for mixtures found in the Study Area, assuming that the toxicological endpoints are the same. An average and reasonable maximum-case scenario are presented based on the evaluation of maximum and average contaminant concentrations.

6.5.1 Methodology for Estimation of Carcinogenic Risks

Carcinogenic risks can be estimated by combining information on the strength or potency of a known or suspected carcinogen (Carcinogenic Slope Factor, Table 6-6) with an estimate of the individual exposure doses of a chemical.

EXHIBIT 6-4
INGESTION OF FINFISH
NYANZA OPERABLE UNIT 3

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times FI \times EF \times ED}{BW \times AVG \times 365 \text{ days/year}}$$

C = Measured/Estimated Contaminant Concentration in Fish Flesh (mg/kg).

IR = Ingestion Rate
0.054 kg/day for sport fishing
0.132 kg/day for subsistence fishing

FI = Fraction of consumed fish taken from Sudbury River
Sportsmen 0.25
Subsistence fishermen 0.75

EF = Exposure Frequency (days/year) (350 days/year)

ED = Exposure Duration (years/lifetime) (30 years)

BW = Receptor Body Weight (70 kg)

AVG = Number of years over which the exposure is averaged

- 70 years for carcinogenic effects
- ED for noncarcinogenic effects

Notes:

- Example calculations are presented in Appendix K.
- Input parameters for exposure scenarios are presented in Table 6-8.

References:

EPA, December 1989
EPA, 1986
EPA, March, 1991

Carcinogenic risk may be estimated as follows:

$\text{Risk}^{(1)} = (\text{CSF})\ (\text{Dose})$

Where:

CSF = Carcinogenic Slope Factor (slope of the dose-response curve in $(\text{mg/kg-day})^{-1}$ from Table 6-2).

Dose = Amount of a contaminant absorbed by a receptor in mg/kg-day.

(1) The carcinogenic risk formula presented is applicable to situations where the carcinogenic risk is not expected to exceed 10^{-2}.

The resultant risk value (1×10^{-6} or a 1-in-1,000,000 chance) can also be applied to a given population to determine the number of excess cases of cancer that could be expected to result from exposure (1×10^{-6} is one additional case of cancer in 1,000,000 exposed persons).

The total risk for exposure to multiple compounds is presented as the summation of the risk for the individual contaminants. Risks can be calculated in this manner under the following assumptions:

- o There are no antagonist/synergistic effects between chemicals.
- o All chemicals produce the same result (cancer).
- o Cancer risks from various exposure routes are additive, if the exposed populations are the same (EPA, 1986).

6.5.2 Methodology for Estimation of Noncarcinogenic Risks

Potential health risks resulting from exposure to noncarcinogenic compounds are estimated by comparing the maximum daily dose calculated for an exposure to an acceptable intake dose, such as a chronic or subchronic reference dose. If the ratio between an exposure dose and the RfD exceeds unity, there is a potential health risk associated with exposure to that chemical (EPA, September 1986). The Dose/RfD ratio is not a mathematical prediction of the severity or probability of toxic effects; it is simply a numerical indicator of the potential for adverse effects. The ratio of the exposure dose to the Reference Dose is sometimes referred to as the Hazard Quotient (HQ). The summation of HQs for several compounds is frequently referred to as the Hazard Index (HI).

Conservatively, a total HI for any exposure route is calculated by summing the Dose/RfD rations (HQs) for the individual chemicals of concern (EPA, September 1986). To provide a better indication of risks, Dose/RfD ratios should be summed according to the target organ affected, for example, the Dose/RfD ratios for those chemicals affecting the liver should be summed separately from those chemicals affecting the nervous system.

The target organ or toxicity endpoint of concern identified on the tables in this section are those that were specified on IRIS or the Health Effects Assessment Summary Tables (EPA, January 1991) as the endpoint of concern for the Reference Dose. Appendix K summarizes the toxicological effects and target organs reported in the literature for the Study Area indicator compounds. The Hazard Index and RfDs are subject to the uncertainties described in this section.

6.5.3 Risk Assessment Results

This section presents the results of the risk assessment conducted for the Sudbury River Study Area. As discussed previously, mercury and methyl mercury are the principal contaminants of concern. Mercury and methyl mercury have been detected above background concentrations in sediments and fish of the Sudbury River and other surface water bodies downstream of the Nyanza Site. Mercury has also been detected in fish tissue samples above FDA Action Levels.

The following subsections present the carcinogenic and noncarcinogenic risk assessment results, assuming the recreational and residential exposure scenarios presented in Section 6.4. Each Sudbury River reach and several surface water bodies are discussed individually.

The reader should note that the hazard quotients for the organic mercury compounds were not considered (i.e. added) during the calculation of hazard indicies presented in the risk results tables. Hazard quotients developed for total mercury were considered in the development of hazard indices.

6.5.3.1 Risk Assessment Results for Background Surface Water and Sediment Exposure Scenarios - River Reach 1 and the Sudbury Reservoir - Recreational

Reach 1 and the Sudbury Reservoir are upstream/upgradient of the Nyanza Site, its surficial drainage, and groundwater contaminant plume. Analyses of samples collected from Reach 1 and the Sudbury Reservoir provide background COC concentrations for the Study Area.

Tables 6-9 and 6-10 present risk assessment results for COC concentrations detected in background sediments and surface waters, respectively. The accidental-ingestion and dermal contact routs of exposure (surface water and sediments) were evaluated assuming recreational land/water use scenarios. Hazard indices calculated for the accidental-ingestion exposure route exceed those calculated for the dermal-contact exposure route. Noncarcinogenic risks estimated for the sediment exposure scenarios exceed those estimated for the surface-water exposure scenarios. Only the hazard quotient for arsenic exceeds 0.1 (accidental ingestion of sediments by a child receptor, reasonable maximum case). The hazard quotients and hazard indices calculated for surface water and sediment exposure scenarios do not exceed unity when maximum or average COC concentrations are evaluated. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes for each media and then combined for surface waters and sediment exposures, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

The cancer risks (CR) estimated for the sediment exposures (combined accidental-ingestion and dermal-contact exposure routes) are 1.8×10^{-5} and 8.2×10^{-6} when the reasonable maximum and average-case scenarios are evaluated for all COCs detected. Arsenic, beryllium, and the carcinogenic PAHs are the COCs contributing to the estimated excess lifetime cancer risk. Cancer risks estimated for the surface water exposure scenarios (combined accidental-ingestion and dermal-contact exposure routes) are 1.7×10^{-6} and 1.5×10^{-6} when the reasonable maximum- and average-case scenarios are evaluated. 1,1-Dichloroethene is the only COC contributing to the risk. As a point of reference, the 1×10^{-4} to 1×10^{-6} cancer risk range is often evaluated in the development of health-based standards/criteria and in the determination of cleanup goals at hazardous waste sites.

TABLE 6-9A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
BACKGROUND - REACH 1 AND SUDBURY RESERVOIR
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	21 1	8 74	1 11E-06	0 00E+00	3 00E-04	1 3E-01	5 3E-02	0 0E+00	0 0E+00	7 8E-02	3 2E-02	0.0E+00	0.0E+00	6.9E-03	2.9E-03	0.0E+00	0.0E+00	SKIN
ANTIMONY*	6 9	6 05	1 11E-06	0 00E+00	4 00E-04	3 2E-02	2 8E-02	0 0E+00	0 0E+00	1 9E-02	1 7E-02	0.0E+00	0.0E+00	1.7E-03	1.5E-03	0 0E+00	0.0E+00	BLOOD
CHROMIUM*	55 2	22 4	1 11E-06	0 00E+00	1.00E+00	1 0E-04	4 1E-05	0 0E+00	0 0E+00	6 1E-05	2.5E-05	0.0E+00	0.0E+00	5.4E-06	2.2E-06	0.0E+00	0.0E+00	LIVER
LEAD*	248	85 09	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	1 59	0 27	1 11E-06	5 55E-08	3 00E-04	9 7E-03	1 6E-03	2 4E-04	4 1E-05	5 9E-03	1 0E-03	2.9E-04	5.0E-05	5.2E-04	8.8E-05	5.2E-05	8.8E-06	CNS
ACETONE	0 01	0 01	1 11E-06	2 78E-06	1 00E-01	1 8E-07	1 8E-07	2 3E-07	2 3E-07	1 1E-07	1.1E-07	2 8E-07	2.8E-07	9.8E-09	9 8E-09	4.9E-08	4.9E-08	L/K
PHENANTHRENE	0 16	0 15	1 11E-06	2 78E-07	4 00E-03	7 3E-05	7 0E-05	9 1E-06	8 6E-06	4 4E-05	4 2E-05	1.1E-05	1.0E-05	3.9E-06	3.7E-06	2.0E-06	1.8E-06	NS
FLUORANTHENE	0 32	0 219	1 11E-06	2 78E-07	4 00E-02	1 5E-05	1 0E-05	1 8E-06	1 3E-06	8 9E-06	6 1E-06	2.2E-06	1.5E-06	7.8E-07	5.4E-07	3.9E-07	2.7E-07	L/K
PYRENE	0 27	0 1807	1 11E-06	2 78E-07	3 00E-02	1 6E-05	1 1E-05	2 1E-06	1.4E-06	1 0E-05	6.7E-06	2.5E-06	1.7E-06	8.8E-07	5.9E-07	4.4E-07	2.9E-07	KIDNEY
CHRYSENE	0 18	0 18	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	0 2	0 185	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
BENZO(A)PYRENE	0 081	0 081	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BARIUM	178	66 66	1 11E-06	0 00E+00	5 00E-02	6 5E-03	2 4E-03	0 0E+00	0 0E+00	4.0E-03	1.5E-03	0.0E+00	0.0E+00	3.5E-04	1.3E-04	0 0E+00	0.0E+00	BLOOD
BERYLLIUM	1 8	0 85	1 11E-06	0 00E+00	5 00E-03	6 6E-04	3 1E-04	0 0E+00	0 0E+00	4.0E-04	1.9E-04	0.0E+00	0.0E+00	3.5E-05	1.7E-05	0 0E+00	0 0E+00	NS
COPPER	340 4	73 02	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
MANGANESE	1640	434 51	1 11E-06	0 00E+00	1 00E-01	3 0E-02	7 9E-03	0 0E+00	0 0E+00	1.8E-02	4.8E-03	0.0E+00	0.0E+00	1.6E-03	4.3E-04	0 0E+00	0.0E+00	CNS
NICKEL	51	11 39	1 11E-06	0 00E+00	2 00E-02	4 7E-03	1 0E-03	0 0E+00	0 0E+00	2.8E-03	6 3E-04	0.0E+00	0.0E+00	2.5E-04	5.6E-05	0.0E+00	0.0E+00	BW
SELENIUM	3 1	1 04	1 11E-06	0 00E+00	5 00E-03	1 1E-03	3 8E-04	0 0E+00	0 0E+00	6 9E-04	2 3E-04	0.0E+00	0.0E+00	6.1E-05	2.0E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	48 45	20 18	1 11E-06	0 00E+00	7 00E-03	1 3E-02	5 3E-03	0 0E+00	0 0E+00	7 7E-03	3 2E-03	0.0E+00	0.0E+00	6.8E-04	2.8E-04	0.0E+00	0.0E+00	NS
ZINC	629	133 6	1 11E-06	0 00E+00	2 00E-01	5 7E-03	1 2E-03	0 0E+00	0 0E+00	3.5E-03	7.4E-04	0.0E+00	0.0E+00	3.1E-04	6.5E-05	0 0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	1 7E-01	8 3E-02	2 4E-04	4 1E-05	1.0E-01	5 0E-02	2.9E-04	5.0E-05	9.1E-03	4.4E-03	5.2E-05	8.8E-06
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	6 1E-02	1 9E-02	1 3E-05	1 1E-05	3 7E-02	1 1E-02	1.6E-05	1.4E-05	3.3E-03	1.0E-03	2.8E-06	2.4E-06
ALL CHEMICALS OF CONCERN	HAZARD INDEX	2 3E-01	1 0E-01	2 6E-04	5 3E-05	1 4E-01	6 2E-02	3.1E-04	6.4E-05	1.2E-02	5.4E-03	5.5E-05	1.1E-05

TOXICITY ENDPOINTS ABBREVIATIONS NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-9B
RISK RESULTS FOR SEDIMENT EXPOSURE
BACKGROUND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
ARSENIC*	21 1	8 74	3 64E-07	0.00E+00	1.4E-05	5.7E-06	0.0E+00	0.0E+00	1.80E+00 A
ANTIMONY*	6 9	8 05	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	55 2	22 4	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	248	85 09	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	1.59	0 27	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ACETONE	0.01	0.01	3.64E-07	7.56E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PHENANTHRENE	0.16	0.15	3.64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
FLUORANTHENE	0.32	0 219	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PYRENE	0.27	0.1807	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHRYSENE	0.18	0.18	3.64E-07	7.56E-08	3.8E-07	3.4E-07	7.9E-08	7.0E-08	5.80E+00 B2
BENZO(B)FLUORANTHENE	0.2	0.185	3.84E-07	7.56E-08	4.2E-07	3.9E-07	8.8E-08	8.1E-08	5.80E+00 B2
BENZO(A)PYRENE	0.091	0 091	3.64E-07	7.56E-08	1.9E-07	1.9E-07	4.0E-08	4.0E-08	5.80E+00 B2
BARIUM	178	66.68	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	1.8	0 85	3 64E-07	0.00E+00	2.8E-06	1.3E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	340.4	73.02	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	1640	434 51	3 64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	51	11.35	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	3.1	1.04	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	48.45	20.19	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	629	133.5	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	1.4E-05	5.7E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	3.8E-06	2.2E-06	2.1E-07	1.9E-07
ALL CHEMICALS OF CONCERN	CANCER RISK	1.8E-05	8.0E-06	2.1E-07	1.9E-07

TABLE 6-10A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
BACKGROUND - REACH 1 AND SUDBURY RESERVOIR
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		TOXICITY END-POINT
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT					
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT			
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG		
LEAD*	0 0211	0 004	1 11E-03	1 36E-04		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
1,1-DICHLOROETHENE	0 003	0 0026	1 11E-03	2 19E-03	9 00E-03	3 0E-04	2 6E-04	3 4E-04	2 9E-04	3.7E-04	3.2E-04	7.3E-04	6.3E-04	6.5E-05	5.7E-05	4.0E-04	3.5E-04	L/K
BARIUM	0 0231	0 0157	1 11E-03	1 36E-04	5 00E-02	4 2E-04	2 9E-04	2 9E-05	2 0E-05	5.1E-04	3.5E-04	6.4E-05	4.3E-05	9.0E-05	6.1E-05	3.5E-05	2.4E-05	BLOOD
COPPER	0 0031	0 0031	1 11E-03	1 36E-04		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	0 111	0 0808	1 11E-03	1 36E-04	1 00E-01	1 0E-03	7 4E-04	7 1E-05	5.1E-05	1.2E-03	9.0E-04	1.5E-04	1.1E-04	2.2E-04	1.6E-04	8.4E-05	6.1E-05	CNS
NICKEL	0 0177	0 0051	1 11E-03	1 36E-04	2 00E-02	8 1E-04	2 3E-04	5 6E-05	1 6E-05	9.8E-04	2.8E-04	1.2E-04	3.5E-05	1.7E-04	5.0E-05	6.7E-05	1.9E-05	BODY WT
SILVER	0 0169	0 0047	1 11E-03	1 36E-04	3 00E-03	5 1E-03	1 4E-03	3 6E-04	1 0E-04	6.3E-03	1.8E-03	7.6E-04	2.2E-04	1.1E-03	3.1E-04	4.3E-04	1.2E-04	ARGYRIA
ZINC	0 0062	0 0062	1 11E-03	1 36E-04	2 00E-01	2 8E-05	2 8E-05	2 0E-06	2 0E-06	3.4E-05	3.4E-05	4.3E-06	4.3E-06	6.1E-06	6.1E-06	2.4E-06	2.4E-06	BLOOD

NYANZA SITE CONTAMINANTS*				HAZARD INDEX		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0 0E+00
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		7 7E-03	3 0E-03	8 6E-04	4 8E-04	9 4E-03	3.6E-03	1.9E-03	1.0E-03	1.7E-03	6.4E-04	1.0E-03	5.8E-04
ALL CHEMICALS OF CONCERN				HAZARD INDEX		7.7E-03	3.0E-03	8.6E-04	4.8E-04	9.4E-03	3.6E-03	1.9E-03	1.0E-03	1.7E-03	6.4E-04	1.0E-03	5.8E-04

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-10B
RISK RESULTS FOR SURFACE WATER
BACKGROUND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
LEAD*	0.0211	0.004	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
1,1-DICHLOROETHENE	0.003	0.0026	3.02E-04	6.70E-04	5.4E-07	4.7E-07	1.2E-06	1.0E-06	6.00E-01 C
BARIUM	0.0231	0.0157	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	0.0031	0.0031	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.111	0.0808	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	0.0177	0.0051	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.0169	0.0047	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	0.0062	0.0062	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	5.4E-07	4.7E-07	1.2E-06	1.0E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	5.4E-07	4.7E-07	1.2E-06	1.0E-06

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

6.5.3.2 Risk Assessment Results for Background Fish Ingestion Scenarios - Sudbury Reservoir, Southville Pond, and Cedar Swamp Pond

The Sudbury Reservoir, Southville Pond, and Cedar Swamp Pond are located upstream of the Nyanza Site. Tables 6-11, 6-12, and 6-13 present risk assessment results assuming that sports fishermen and subsistence fishermen consume fish taken from these surface water bodies.

The Sudbury Reservoir

Hazard indices calculated for the subsistence fishermen consuming fish taken from the Sudbury Reservoir (Table 6-11) exceed unity when the reasonable maximum case is evaluated. (Mercury (Max#HQ=5.3) and methyl mercury (Max#HQ=2.9) are the principal COCs contributing to the risk. The hazard index calculated for subsistence fishermen also exceeds unity when average contaminant concentrations are evaluated. The hazard index calculated for COCs affecting the central nervous system and the kidney (mercury, methyl mercury, manganese) exceeds unity when the subsistence fisherman is the receptor of concern. Hazard indices calculated for other toxic endpoints (or target organs) do not exceed unity. These results indicate that adverse health effects are possible for subsistence fishermen (reasonable maximum- and average-case) routinely ingesting fish taken from the Sudbury Reservoir. Hazard indices calculated assuming that a sports fisherman is the receptor of concern do not exceed unity. However, the maximum and average mercury concentrations detected in fish tissue samples exceed the current FDA Action Level for mercury (1 mg/kg) by less than a factor of 2. The maximum concentration of methyl mercury (C_{max} = 0.652 mg/kg) is approximately one-half the Action Level.

The excess lifetime cancer risks estimated for sports fishermen and subsistence fishermen exceed 1×10^{-5} and 1×10^{-4}, respectively, when average or maximum COC concentrations are evaluated. The principal contaminants contributing to the risk are the pesticides and PCBs which have not been identified as predominant Nyanza Site contaminants. One Nyanza Site contaminant, arsenic, does contribute to the estimated cancer risk.

The Southville Pond

Hazard indices calculated for COC concentrations in the Southville Pond fish tissue samples (Table 6-12) exceed unity only when the subsistence fisherman is evaluated as the receptor of concern.

TABLE [illegible]
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
SUDBURY RESERVOIR
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN		SPORTSFISHERMEN		SUBSISTENCE FISHERMEN			SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
						MAXIMUM	AVERAGE	MAXIMUM	AVERAGE				MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
PHENOL*	0.056	0.056	1.85E-04	1.36E-03	6.00E-01	1.7E-05	1.7E-05	1.3E-04	1.3E-04	FETUS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ARSENIC*	0.06	0.06	1.85E-04	1.36E-03	3.00E-04	3.7E-02	3.7E-02	2.7E-01	2.7E-01	SKIN	7.93E-05	5.81E-04	8.6E-06	8.6E-06	6.3E-05	6.3E-05	1.80E+00 A
CHROMIUM*	2.84	1.114	1.85E-04	1.36E-03	1.00E+00	5.3E-04	2.1E-04	3.9E-03	1.5E-03	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	1.18	0.89	1.85E-04	1.36E-03	3.00E-04	7.3E-01	5.5E-01	5.3E+00	4.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYL MERCURY*	0.652	0.486	1.85E-04	1.36E-03	3.00E-04	4.0E-01	3.0E-01	2.9E+00	2.2E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ENDOSULFAN SULFATE	0.0045	0.00275	1.85E-04	1.36E-03	5.00E-05	1.7E-02	1.0E-02	1.2E-01	7.5E-02	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
DIELDRIN	0.0005	0.0005	1.85E-04	1.36E-03	5.00E-05	1.8E-03	1.8E-03	1.4E-02	1.4E-02	LIVER	7.93E-05	5.81E-04	6.3E-07	6.3E-07	4.6E-06	4.6E-06	1.60E+01 B2
4,4-DDD	0.007	0.00375	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	1.3E-07	7.1E-08	9.8E-07	5.2E-07	2.40E-01 B2
4,4-DDE	0.041	0.01956	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	1.1E-06	5.3E-07	8.1E-06	3.9E-06	3.40E-01 B2
4,4-DDT	0.002	0.0009	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	5.4E-08	2.4E-08	4.0E-07	1.8E-07	3.40E-01 B2
ALPHA-CHLORDANE	0.001	0.001	1.85E-04	1.36E-03	6.00E-05	3.1E-03	3.1E-03	2.3E-02	2.3E-02	LIVER	7.93E-05	5.81E-04	1.0E-07	1.0E-07	7.6E-07	7.6E-07	1.30E+00 B2
AROCLOR-1260	0.095	0.06375	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	5.8E-05	3.9E-05	4.3E-04	2.9E-04	7.70E+00 B2
MANGANESE	2.43	1.082	1.85E-04	1.36E-03	1.00E-01	4.5E-03	2.0E-03	3.3E-02	1.4E-02	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	1.8	0.46	1.85E-04	1.36E-03	5.00E-03	6.7E-02	1.7E-02	4.9E-01	1.2E-01	SELENOSIS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	0.76	0.325	1.85E-04	1.36E-03	7.00E-03	2.0E-02	8.6E-03	1.5E-01	6.3E-02	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	61.62	32.358	1.85E-04	1.36E-03	2.00E-01	5.7E-02	3.0E-02	4.2E-01	2.2E-01	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	7.6E-01	5.9E-01	5.6E+00	4.3E+00	CANCER RISKS:	8.6E-06	8.6E-06	6.3E-05	6.3E-05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1.7E-01	7.3E-02	1.2E+00	5.3E-01	CANCER RISKS:	6.0E-05	4.0E-05	4.4E-04	3.0E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	9.3E-01	6.6E-01	6.8E+00	4.8E+00	CANCER RISKS:	6.9E-05	4.9E-05	5.0E-04	3.6E-04

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS:
NS NOT SPECIFIED
BW. BODY WEIGHT
CNS: CENTRAL NERVOUS SYSTEM
L/K LIVER AND KIDNEY

TABLE 6-12
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
SOUTHVILLE POND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 . / WEIGHT OF EVIDENCE
						SPORTSFISHERMEN		SUBSISTENCE FISHERMEN					SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS--TENCE FISHER-MEN		MAXIMUM	AVERAGE	MAXIMUM	AVERAGE		SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
CHROMIUM*	0.7	0.254	1.85E-04	1.36E-03	1.00E+00	1.3E-04	4.7E-05	9.5E-04	3.4E-04	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.77	0.239	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	0.89	0.315	1.85E-04	1.36E-03	3.00E-04	5.5E-01	1.9E-01	4.0E+00	1.4E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	3.1	0.887	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.38	0.38	1.85E-04	1.36E-03	1.00E-01	7.0E-04	7.0E-04	5.2E-03	5.2E-03	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	0.15	0.097	1.85E-04	1.36E-03	5.00E-03	5.5E-03	3.6E-03	4.1E-02	2.6E-02	SELENOSIS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	21.4	9.307	1.85E-04	1.36E-03	2.00E-01	2.0E-02	8.6E-03	1.5E-01	6.3E-02	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	5.5E-01	1.9E-01	4.0E+00	1.4E+00	CANCER RISKS:	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	2.6E-02	1.3E-02	1.9E-01	9.5E-02	CANCER RISKS:	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	HAZARD INDEX	5.7E-01	2.1E-01	4.2E+00	1.5E+00	CANCER RISKS:	0.0E+00	0.0E+00	0.0E+00	0.0E+00

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS: NS: NOT SPECIFIED BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM
L/K: LIVER AND KIDNEY

TABLE 6

RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
CEDAR SWAMP POND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION		EXPOSURE FACTOR NON CANCER		RFD (MG-KG-DAY)	NONCARCINOGENIC RISK CHARACTERIZATION HAZARD QUOTIENTS RECEPTOR= SPORTSFISHERMEN		NONCARCINOGENIC RISK CHARACTERIZATION HAZARD QUOTIENTS RECEPTOR= SUBSISTENCE FISHERMEN		TOXICITY END-POINT	EXPOSURE FACTOR-		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX MG/KG	AVG MG/KG	- SPORTS FISHER-MEN	- SUBSIS-TENCE FISHER-MEN		MAXIMUM	AVERAGE	MAXIMUM	AVERAGE		SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	SPORT FISHERMEN MAXIMUM	SPORT FISHERMEN AVERAGE	SUBSISTENCE FISHERMEN MAXIMUM	SUBSISTENCE FISHERMEN AVERAGE	
ANTIMONY*	0.82	0.566	1.85E-04	1.36E-03	4.00E-04	3.8E-01	2.6E-01	2.8E+00	1.9E+00	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	0.64	0.211	1.85E-04	1.36E-03	1.00E+00	1.2E-04	3.9E-05	8.7E-04	2.9E-04	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	1.17	0.12	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	9.6	0.732	1.85E-04	1.36E-03	3.00E-04	5.9E+00	4.5E-01	4.3E+01	3.3E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	6	0.494	1.85E-04	1.36E-03	2.00E-02	5.5E-02	4.6E-03	4.1E-01	3.3E-02	BW	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	4	0.312	1.85E-04	1.36E-03	5.00E-03	1.5E-01	1.2E-02	1.1E+00	8.5E-02	SELENOSIS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	2.2	0.164	1.85E-04	1.36E-03	3.00E-03	1.4E-01	1.0E-02	9.9E-01	7.4E-02	ARGYRIA	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
THALLIUM	0.08	0.049	1.85E-04	1.36E-03	7.00E-05	2.1E-01	1.3E-01	1.5E+00	9.5E-01	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	56.8	9.965	1.85E-04	1.36E-03	2.00E-01	5.3E-02	9.2E-03	3.9E-01	6.8E-02	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS*	HAZARD INDEX					6.3E+00	7.1E-01	4.6E+01	5.2E+00		CANCER RISKS:		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX					6.0E-01	1.6E-01	4.4E+00	1.2E+00		CANCER RISKS:		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN	HAZARD INDEX					6.9E+00	8.8E-01	5.1E+01	6.4E+00		CANCER RISKS:		0.0E+00	0.0E+00	0.0E+00	0.0E+00	

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS
NS: NOT SPECIFIED
BW: BODY WEIGHT
CNS: CENTRAL NERVOUS SYSTEM
L/K: LIVER AND KIDNEY

Mercury is the principal contaminant contributing to the risk; the hazard quotient for this contaminant exceeds unity when maximum (HQ=4) or average (HQ=1.4) concentrations are evaluated. These results suggest that adverse noncarcinogenic health effects are possible for the subsistence fisherman routinely consuming fish taken from the Southville Pond. However, the hazard index calculated for the average-case scenario only slightly exceeds unity. Additionally, the maximum concentration of mercury detected in the fish tissue samples (0.89 mg/kg) approaches but does not exceed the FDA Action Level (1 mg/kg) for mercury in fish. Methyl mercury was not detected in the fish tissue samples.

Cancer risk estimates are not presented for the Southville Pond because Cancer Slope Factors (CSFs) are not available for any of the COCs detected. Of the chemicals listed on Table 6-12, only lead has been designated a carcinogen (Class B-2) by the EPA.

Cedar Swamp Pond

Hazard indices calculated for sports fishermen and subsistence fishermen consuming fish taken from Cedar Swamp Pond (Table 6-13) exceed unity when the reasonable maximum case is evaluated. The hazard index calculated for subsistence fishermen also exceeds unity when average contaminant concentrations are evaluated. Mercury is the principal contaminant contributing to the risk; the hazard quotient calculated for mercury exceeds unity in the aforementioned cases (HQs = 43, 3.3, 5.9). The hazard quotient presented for antimony also exceeds unity when the subsistence fisherman is considered the receptor of concern. However, it should be noted that antimony was detected very infrequently in the fish tissue samples collected from the Sudbury River Study Area. These results suggest that adverse noncarcinogenic health effects are possible for the subsistence fisherman routinely consuming fish taken from the Cedar Swamp Pond. The maximum concentration of mercury detected in the Cedar Swamp fish tissue samples (C_{max}=9.6 mg/kg) exceeds the FDA Action Level for mercury in fish. However, the average mercury concentration (C_{avg}=0.732 mg/kg) is below the FDA Action Level. Methyl mercury was not detected in fish tissue samples.

Cancer risk estimates are not presented for the Cedar Swamp Pond because CSFs are not available for any of the COCs detected. Of the COCs listed on Table 6-13, only lead has been designated a carcinogen (Class B-2) by the EPA.

6.5.3.3 Risk Assessment Results for River Reach 2 and Mill Pond

As described in Section 1.0, Reach 2 extends from the Pleasant Street impoundment to the Union Street (Route 135) bridge in Ashland. The Reach is directly impacted by Nyanza Site discharges downstream of Mill Pond and is geographically the most proximate of the Reaches to the Nyanza Site. In comparison to background, several Nyanza Site contaminants were detected in Reach 2 surface waters and sediments:

- 1,2-Dichloroethene
- 1,2-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Arsenic
- Lead
- Chlorobenzene
- 1,4-Dichlorobenzene
- Naphthalene
- Chromium
- Mercury
- Monomethyl mercury

The average concentration of mercury in Reach 2 sediments (C_{avg}=3.81 mg/kg) is 14 times the average concentration of mercury in background sediment samples (C_{avg}=0.27 mg/kg). The maximum concentration of monomethyl mercury for Study Area sediments was detected in a sample collected from Reach 2. The maximum concentration of cadmium (C_{max}=7.2 ug/L), lead (C_{max}=66.5 ug/L), and beryllium (C_{max}=7.5 ug/L) in surface waters exceeds proposed Federal SDWA standards or Action Levels. (Federal SDWA standards are mentioned as a point of reference only; surface waters of the Study Area are not used as a domestic water supply source.)

Tables 6-14 and 6-15 present risk assessment results for COC concentrations detected in sediments and surface waters of Reach 2. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediment) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices calculated for surface-water and sediment exposure scenarios approach 0.5 but do not exceed unity in any of the cases presented. Only the hazard quotient for mercury and manganese exceed 0.1 (accidental ingestion of sediments, surface waters, child receptor/teen receptor, reasonable maximum case). If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes for each medium and then combined for surface water

TABLE 6-14A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 2
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	TOXIC END-POINT
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT		MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
1,2-DICHLOROETHENE*	0.031	0.0087	1.11E-06	2.78E-06	1.00E-02	5.7E-06	1.6E-06	7.1E-06	2.0E-06	3.4E-06	9.7E-07	8.6E-06	2.4E-06	3.0E-07	8.5E-08	1.5E-06	4.3E-07	BLOOD
CHLOROBENZENE*	0.027	0.0094	1.11E-06	2.78E-06	2.00E-02	2.5E-06	8.6E-07	3.1E-06	1.1E-06	1.5E-06	5.2E-07	3.7E-06	1.3E-06	1.3E-07	4.6E-08	6.6E-07	2.3E-07	LIVER
1,2-DICHLOROBENZENE*	1.8	0.878	1.11E-06	5.55E-07	9.00E-02	3.7E-05	1.8E-05	9.1E-06	4.5E-06	2.2E-05	1.1E-05	1.1E-05	5.4E-06	2.0E-06	9.8E-07	2.0E-06	9.8E-07	LIVER
1,4-DICHLOROBENZENE*	1.1	0.641	1.11E-06	5.55E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER
124TRICHLOROBENZENE*	0.76	0.6389	1.11E-06	5.55E-07	1.30E-03	1.1E-03	9.0E-04	2.7E-04	2.2E-04	6.5E-04	5.5E-04	3.2E-04	2.7E-04	5.7E-05	4.8E-05	5.7E-05	4.8E-05	SKIN
NAPHTHALENE*	1.19	0.6094	1.11E-06	2.78E-07	4.00E-03	5.4E-04	2.7E-04	8.7E-05	3.4E-05	3.3E-04	1.7E-04	8.2E-05	4.2E-05	2.9E-05	1.5E-05	1.4E-05	7.3E-06	BW
ARSENIC*	14.9	6.95	1.11E-06	0.00E+00	3.00E-04	9.1E-02	4.2E-02	0.0E+00	0.0E+00	5.5E-02	2.6E-02	0.0E+00	0.0E+00	4.9E-03	2.3E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	218	34	1.11E-06	0.00E+00	1.00E+00	3.9E-04	6.2E-05	0.0E+00	0.0E+00	2.4E-04	3.8E-05	0.0E+00	0.0E+00	2.1E-05	3.3E-06	0.0E+00	0.0E+00	LIVER
LEAD*	295	66.07	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	30.8	3.81	1.11E-06	5.55E-08	3.00E-04	1.9E-01	2.3E-02	4.7E-03	5.8E-04	1.1E-01	1.4E-02	5.7E-03	7.1E-04	1.0E-02	1.2E-03	1.0E-03	1.2E-04	CNS
MONOMETHYLMERCURY*	0.312	0.109	1.11E-06	4.28E-06	3.00E-04	1.9E-03	6.6E-04	3.7E-03	1.3E-03	1.2E-03	4.0E-04	4.4E-03	1.6E-03	1.0E-04	3.6E-05	7.8E-04	2.7E-04	CNS
DICHLOROMETHANE	0.008	0.006	1.11E-06	2.78E-06	6.00E-02	2.4E-07	1.8E-07	3.0E-07	2.3E-07	1.5E-07	1.1E-07	3.7E-07	2.8E-07	1.3E-08	9.6E-09	6.5E-08	4.9E-08	LIVER
ACETONE	0.31	0.1205	1.11E-06	2.78E-06	1.00E-01	5.7E-06	2.2E-06	7.1E-06	2.8E-06	3.4E-06	1.3E-06	8.6E-06	3.3E-06	3.0E-07	1.2E-07	1.5E-06	5.9E-07	L/K
BEHP	2	0.6509	1.11E-06	5.55E-07	2.00E-02	1.8E-04	5.9E-05	4.6E-05	1.5E-05	1.1E-04	3.6E-05	5.6E-05	1.8E-05	9.8E-06	3.2E-06	9.8E-06	3.2E-06	LIVER
2-METHYLNAPHTHALENE	0.41	0.275	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	BW
ACENAPTHYLENE	0.5	0.4661	1.11E-06	2.78E-07	4.00E-03	2.3E-04	2.2E-04	2.9E-05	2.8E-05	1.4E-04	1.3E-04	3.5E-05	3.4E-05	1.2E-05	1.2E-05	6.1E-06	5.9E-06	NS
PHENANTHRENE	10.65	1.6345	1.11E-06	2.78E-07	4.00E-03	4.9E-03	7.5E-04	6.1E-04	9.3E-05	3.0E-03	4.5E-04	7.4E-04	1.1E-04	2.6E-04	4.0E-05	1.3E-04	2.0E-05	BW
FLUORANTHENE	9.25	2.014	1.11E-06	2.78E-07	4.00E-02	4.2E-04	9.2E-05	5.3E-05	1.1E-05	2.6E-04	5.6E-05	6.4E-05	1.4E-05	2.3E-05	4.9E-06	1.1E-05	2.5E-06	L/K
PYRENE	8.8	1.6691	1.11E-06	2.78E-07	3.00E-02	5.4E-04	1.0E-04	6.8E-05	1.3E-05	3.3E-04	6.2E-05	8.2E-05	1.5E-05	2.9E-05	5.4E-06	1.5E-05	2.7E-06	KIDNEY
BENZO(A)ANTHRACENE	4.4	1.1055	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	4.2	1.0623	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	3.55	1.0341	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	3.6	0.9695	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	3.75	1.0275	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0.9	0.6261	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
DIBENZ(AH)ANTHRACENE	0.093	0.0665	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0.65	0.5635	1.11E-06	2.78E-07	4.00E-03	3.0E-04	2.7E-04	3.7E-05	3.4E-05	1.8E-04	1.6E-04	4.5E-05	4.1E-05	1.6E-05	1.5E-05	8.0E-06	7.3E-06	NS
BARIUM	209	71.48	1.11E-06	0.00E+00	5.00E-02	7.6E-03	2.6E-03	0.0E+00	0.0E+00	4.6E-03	1.6E-03	0.0E+00	0.0E+00	4.1E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD
BERYLUUM	1.9	0.87	1.11E-06	0.00E+00	5.00E-03	6.9E-04	3.2E-04	0.0E+00	0.0E+00	4.2E-04	1.9E-04	0.0E+00	0.0E+00	3.7E-05	1.7E-05	0.0E+00	0.0E+00	NS
COPPER	184	40.19	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	4100	867.87	1.11E-06	0.00E+00	1.00E-01	7.5E-02	1.6E-02	0.0E+00	0.0E+00	4.6E-02	9.6E-03	0.0E+00	0.0E+00	4.0E-03	8.5E-04	0.0E+00	0.0E+00	CNS
NICKEL	19.1	7.47	1.11E-06	0.00E+00	2.00E-02	1.7E-03	6.6E-04	0.0E+00	0.0E+00	1.1E-03	4.1E-04	0.0E+00	0.0E+00	8.3E-05	3.7E-05	0.0E+00	0.0E+00	BW
VANADIUM	45.8	19.6	1.11E-06	0.00E+00	7.00E-03	1.2E-02	5.2E-03	0.0E+00	0.0E+00	7.3E-03	3.1E-03	0.0E+00	0.0E+00	6.4E-04	2.6E-04	0.0E+00	0.0E+00	NS
ZINC	330	126.44	1.11E-06	0.00E+00	2.00E-01	3.0E-03	1.2E-03	0.0E+00	0.0E+00	1.8E-03	7.0E-04	0.0E+00	0.0E+00	1.6E-04	6.2E-05	0.0E+00	0.0E+00	BLOOD
4,4-DDE	0.056	0.0169	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
4,4-DDD	0.0306	0.0306	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
4,4-DDT	1.4	0.1724	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS	HAZARD INDEX	2.6E-01	6.7E-02	6.7E-03	2.1E-03 *	1.7E-01	4.1E-02	1.1E-02	2.6E-03 *	1.5E-02	3.6E-03	1.9E-03	4.6E-04 *
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1.1E-01	2.7E-02	6.5E-04	2.0E-04	6.5E-02	1.7E-02	1.0E-03	2.4E-04	5.7E-03	1.5E-03	1.6E-04	4.2E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3.6E-01	9.5E-02	9.5E-03	2.3E-03	2.4E-01	5.8E-02	1.2E-02	2.8E-03	2.1E-02	5.1E-03	2.0E-03	5.0E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-14B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO. 2
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			EXPOSURE FACTOR		CANCER RISKS				
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
1,2-DICHLOROETHENE*	0 031	0 0087	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHLOROBENZENE*	0 027	0 0094	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,2-DICHLOROBENZENE	1 8	0 079	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,4-DICHLOROBENZENE	1 1	0 041	3 84E-07	1 51E-07	8 8E-09	5 8E-09	4 0E-09	2 3E-09	2.4E-02 B2
124TRICHLOROBENZENE	0 78	0 0388	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	1 18	0 5004	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ARSENIC*	14 8	8 05	3 84E-07	0 00E+00	9 8E-09	4 8E-08	0 0E+00	0 0E+00	1 8E+00 A
CHROMIUM*	218	34	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
LEAD*	295	58 07	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MERCURY*	30 8	3 81	3 84E-07	1 51E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MONOMETHYLMERCURY*	0 312	0 109	3 84E-07	1 18E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
DICHLOROMETHANE	0 008	0 008	3 84E-07	7 58E-07	2 2E-11	1 8E-11	4 5E-11	3 4E-11	7 5E-03 B2
ACETONE	0 31	0 1205	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BEHP	2	0 6500	3 84E-07	1 51E-07	1 0E-08	3 3E-09	4 2E-09	1 4E-09	1 4E-02 B2
2-METHYLNAPHTHALENE	0 41	0 275	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ACENAPTHYLENE	0 8	0 4881	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PHENANTHRENE	10 65	1 8348	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
FLUORANTHENE	9 25	2 014	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PYRENE	8 8	1 8891	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BENZO(A)ANTHRACENE	4 4	1 1055	3 84E-07	7 58E-08	8 3E-08	2 3E-08	1 9E-08	4 8E-07	5 8E+00 B2
CHRYSENE	4 2	1 0823	3 84E-07	7 58E-08	8 0E-08	2 3E-08	1 8E-08	4 8E-07	5 8E+00 B2
BENZO(B)FLUORANTHENE	3 55	1 0341	3 84E-07	7 58E-08	7 5E-08	2 2E-08	1 8E-08	4 5E-07	5 8E+00 B2
BENZO(K)FLUORANTHENE	3 8	0 8805	3 84E-07	7 58E-08	8 0E-08	2 1E-08	1 7E-08	4 3E-07	5 8E+00 B2
BENZO(A)PYRENE	3 75	1 0275	3 84E-07	7 58E-08	7 8E-08	2 2E-08	1 8E-08	4.5E-07	5 8E+00 B2
INDENO(123-CD)PYRENE	0 9	0 8201	3 84E-07	7 58E-08	1 8E-08	1 3E-08	3 9E-07	2.7E-07	5.8E+00 B2
DIBENZ(AH)ANTHRACENE	0 083	0 0805	3 84E-07	7 58E-08	2 0E-07	1 8E-07	4 1E-08	3 8E-08	5 8E+00 B2
BENZO(GHI)PERYLENE	0 85	0 5035	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BARIUM	208	71 48	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLUUM	1 8	0 87	3 84E-07	0 00E+00	3 0E-08	1 4E-08	0 0E+00	0 0E+00	4 3E+00 A
COPPER	184	40 18	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MANGANESE	4100	887 87	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NICKEL	18 1	7 47	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
VANADIUM	45 8	18 8	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ZINC	330	128 44	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
4,4-DDE	0 058	0 0188	1 00E-07	7 58E-08	2 2E-09	2 1E-09	1 5E-09	4 3E-10	3 4E-01 B2
4,4-DDD	0 0308	0 0308	1 00E-07	7 58E-08	8 0E-10	8 0E-10	5 5E-10	5 5E-10	2 4E-01 B2
4,4-DDT	1 4	0 1724	1 00E-07	7 58E-08	5 2E-09	8 4E-09	3 8E-09	4 4E-09	3.4E-01 B2

NYANZA SITE CONTAMINANTS	CANCER RISK	9 8E-09	4 6E-08	4 0E-09	2 3E-09 *
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	4 7E-06	1 4E-05	9 1E-06	2 6E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	5 6E-05	1 9E-05	9 1E-06	2 6E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-15A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO 2
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
1,2-DICHLOROETHENE*	0 001	0 001	1 11E-03	2 06E-03	1 00E-02	9 1E-05	9 1E-05	9 5E-05	9 5E-05	1.1E-04	1.1E-04	2.1E-04	2.1E-04	2.0E-05	2.0E-05	1.1E-04	1.1E-04	BLOOD
ARSENIC*	0 003	0 003	1 11E-03	1 36E-04	3 00E-04	9 1E-03	9 1E-03	6 4E-04	6 4E-04	1.1E-02	1.1E-02	1.4E-03	1.4E-03	2.0E-03	2.0E-03	7.6E-04	7.6E-04	SKIN
CADMIUM*	0 007	0 0028	1 11E-03	1 36E-04	5 00E-04	1 3E-02	5 2E-03	9 2E-04	3 6E-04	1.6E-02	6.3E-03	2.0E-03	7.8E-04	2.8E-03	1.1E-03	1.1E-03	4.3E-04	KIDNEY
CHROMIUM*	0 007	0 0053	1 11E-03	1 36E-04	1 00E+00	6 4E-06	4 8E-06	4 5E-07	3 4E-07	7.8E-06	5.9E-06	9.7E-07	7.3E-07	1.4E-06	1.0E-06	5.3E-07	4.0E-07	LIVER
LEAD*	0 067	0 0114	1 11E-03	1 36E-04		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
BARIUM	0 132	0 0336	1 11E-03	1 36E-04	5 00E-02	2 4E-03	6 2E-04	1.7E-04	4 3E-05	2.9E-03	7.5E-04	3.6E-04	9.3E-05	5.2E-04	1.3E-04	2.0E-04	5.1E-05	BLOOD
BERYLLIUM	0 008	0 0028	1 11E-03	1 36E-04	5 00E-03	1 4E-03	4.8E-04	9 6E-06	3 3E-05	1.7E-03	5.8E-04	2.1E-04	7.2E-05	2.9E-04	1.0E-04	1.1E-04	4.0E-05	NS
COPPER	0 026	0 0136	1 11E-03	1 36E-04		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
MANGANESE	9 64	1 5337	1 11E-03	1 36E-04	1 00E-01	9 0E-02	1 4E-02	6 3E-03	9 6E-04	1.1E-01	1.7E-02	1.4E-02	2.1E-03	1.9E-02	3.0E-03	/ 5E-03	1.2E-03	CNS
NICKEL	0 077	0 022	1 11E-03	1 36E-04	2 00E-02	3 6E-03	1 0E-03	2 5E-04	7 0E-05	4 3E-03	1.2E-03	5.3E-04	1.5E-04	7.6E-04	2.2E-04	2.9E-04	8.4E-05	BODY WT
SILVER	0 069	0 0096	1 11E-03	1 36E-04	3 00E-03	2 1E-02	2 9E-03	1 5E-03	2 0E-04	2 6E-02	3 5E-03	3.2E-03	4.4E-04	4.5E-03	6.2E-04	1.7E-03	2.4E-04	ARGYRIA
VANADIUM	0 016	0 0144	1 11E-03	1 36E-04	7 00E-03	2 1E-03	1 9E-03	1.5E-04	1.3E-04	2.6E-03	2.3E-03	3.2E-04	2.8E-04	4.5E-04	4.0E-04	1.7E-04	1.6E-04	NS
ZINC	0 125	0 0246	1 11E-03	1 36E-04	2 00E-01	5 7E-04	1.1E-04	4.0E-06	7.9E-06	6.9E-04	1.4E-04	8.6E-05	1.7E-05	1.2E-04	2.4E-05	4.7E-05	9.4E-06	BLOOD

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	2 2E-02	1 4E-02	1.7E-03	1 1E-03	2.7E-02	1.8E-02	3.6E-03	2.4E-03	4.8E-03	3.1E-03	2.0E-03	1.3E-03
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1 2E-01	2 1E-02	6 4E-03	1.5E-03	1.5E-01	2.6E-02	1.8E-02	3.2E-03	2.6E-02	4.5E-03	1.0E-02	1.7E-03
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1 4E-01	3.5E-02	1 0E-02	2.6E-03	1.7E-01	4.3E-02	2.2E-02	5.5E-03	3.1E-02	7.6E-03	1.2E-02	3.1E-03

TOXICITY ENDPOINTS ABBREVIATIONS:
NS NOT SPECIFIED
L/K: LIVER AND KIDNEY
CNS. CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

BLE 6-15B
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO. 2
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK RESULTS								
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)- / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
1,2-DICHLOROETHENE*	0.001	0.001	3.02E-04	6.28E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ARSENIC*	0.003	0.003	3.02E-04	4.21E-05	1.6E-06	1.6E-06	2.3E-07	2.3E-07	1.80E+00
CADMIUM*	0.007	0.0028	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	0.007	0.0053	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.067	0.0114	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	0.132	0.0338	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	0.008	0.0026	3.02E-04	4.21E-05	9.7E-06	3.4E-06	1.4E-06	4.7E-07	4.30E+00
COPPER	0.028	0.0135	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	9.84	1.5337	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	0.077	0.022	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.069	0.0096	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	0.016	0.0144	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	0.125	0.0248	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	1.6E-06	1.6E-06	2.3E-07	2.3E-07
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	9.7E-06	3.4E-06	1.4E-06	4.7E-07
ALL CHEMICALS OF CONCERN	CANCER RISK	1.1E-05	5.0E-06	1.6E-06	7.0E-07

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

and sediment exposures, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated for a receptor contacting Reach 2 surface waters and sediments under the conditions of the recreational exposure scenarios defined in Section 6.4.

The cancer risks estimated for sediment exposure scenarios exceed 6 x 10^{-5} and 2 x 10^{-5} (risks summed for the accidental-ingestion and dermal-contact exposure routes) when the reasonable maximum and average cases are evaluated, respectively. Cancer risks estimated for the accidental-ingestion exposure route exceed those estimated for the dermal exposure route. The principal COCs contributing to the estimated cancer risk are the carcinogenic PAHs. Two Nyanza site-specific contaminants, arsenic and 1,4-dichlorobenzene, contribute to the excess lifetime cancer risk. However, the risk estimated for Nyanza Site contaminants does not exceed 1 x 10^{-5} even when maximum contaminant concentrations are evaluated. As a point of reference, excess lifetime cancer risks estimated for COC concentrations in background sediment samples were 1.8 x 10^{-5} and 8.2 x 10^{-6} when the reasonable maximum- and average-case scenarios are evaluated, respectively.

The cancer risks estimated for the surface water exposure scenarios slightly exceed 1 x 10^{-5} and 5 x 10^{-6} (risks summed for accidental-ingestion and dermal-contact exposure routes) when the reasonable maximum- and average-cases are evaluated, respectively. Risks estimated for the accidental-ingestion exposure route predominate. Beryllium and arsenic, a Nyanza Site contaminant, are the only COCs contributing to the estimated risk. Both metals have been designated by the EPA as Class A human carcinogens. The risk levels estimated for the background surface waters were 1.7 x 10^{-6} and 1.5 x 10^{-6} when the reasonable maximum and average cases were evaluated, respectively.

Hazard indices calculated for COC concentrations detected in Mill Pond fish tissue samples (Table 6-16) exceed unity when the reasonable maximum case is evaluated. The hazard index also exceeds unity when average contaminant concentrations are evaluated and the subsistence fisherman is considered the receptor of concern. Mercury and methyl mercury are the principal COCs contributing to the risk; the hazard quotient calculated for mercury exceeds unity in the aforementioned cases. The maximum concentration of mercury detected in Mill Pond fish tissue samples exceeds the FDA Action Level for mercury in fish:

C_{max} (mercury) = 2 mg/kg
C_{max} (methyl mercury) = 0.7 mg/kg

TABLE [illegible]
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
MILL POND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS--TENCE FISHER-MEN		SPORTSFISHERMEN		SUBSISTENCE FISHERMEN			SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
						MAXIMUM	AVERAGE	MAXIMUM	AVERAGE				MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
MERCURY*	1.981	0.315	1.85E-04	1.36E-03	3.00E-04	1.2E+00	1.9E-01	9.0E+00	1.4E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYL MERCURY*	0.73	0.21568	1.85E-04	1.36E-03	3.00E-04	4.5E-01	1.3E-01	3.3E+00	9.7E-01	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
4,4-DDE	0.03	0.01068	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	8.1E-07	2.9E-07	5.9E-06	2.1E-06	3.40E-01 B2
AROCLOR-1248	0.5	0.0725	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	3.1E-04	4.4E-05	2.2E-03	3.2E-04	7.70E+00 B2
COPPER	0.404	0.081	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.313	0.125	1.85E-04	1.36E-03	1.00E-01	5.8E-04	2.3E-04	4.2E-03	1.7E-03	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.025	0.025	1.85E-04	1.36E-03	3.00E-03	1.5E-03	1.5E-03	1.1E-02	1.1E-02	ARGYRIA	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	0.046	0.035	1.85E-04	1.36E-03	7.00E-03	1.2E-03	9.2E-04	8.9E-03	6.8E-03	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	3.912	3.228	1.85E-04	1.36E-03	2.00E-01	3.6E-03	3.0E-03	2.7E-02	2.2E-02	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	1.2E+00	1.9E-01	9.0E+00	1.4E+00	CANCER RISKS:	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	7.0E-03	5.7E-03	5.1E-02	4.2E-02	CANCER RISKS:	3.1E-04	4.5E-05	2.2E-03	3.3E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1.2E+00	2.0E-01	9.0E+00	1.5E+00	CANCER RISKS:	3.1E-04	4.5E-05	2.2E-03	3.3E-04

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS:
NS: NOT SPECIFIED
BW: BODY WEIGHT
CNS: CENTRAL NERVOUS SYSTEM
L/K: LIVER AND KIDNEY

FINAL

These results indicate that adverse noncarcinogenic health effects are anticipated for the sports fisherman (reasonable maximum-case) and subsistence fishermen routinely consuming fish taken from Mill Pond.

Cancer risks estimated for Mill Pond fish tissue samples exceed 1 x 10^{-4} when the reasonable worst-case is evaluated. Estimated excess lifetime cancer risks also exceed 1 x 10^{-4} when the average case is evaluated and the subsistence fisherman is the receptor of concern. Aroclor-1248 and 4,4-DDE are the only COCs contributing to the estimated cancer risk. These risks are approximately 5 times those estimated for the Sudbury Reservoir fish tissue samples.

6.5.3.4 Risk Assessment Results for the Eastern Wetlands

The Eastern Wetlands receive surface water runoff directly from the Nyanza Site and constitute a headwaters area of a small tributary (Trolley Brook) of the Sudbury River. In contrast to most of the River Reaches, several organic and inorganic Nyanza Site contaminants were detected in the both sediment and surface water samples collected from the area:

- Trichloroethene
- Chlorobenzene
- 1,2-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Arsenic
- Lead
- 1,2-Dichloroethene
- Nitrobenzene
- 1,4-Dichlorobenzene
- Naphthalene
- Chromium
- Mercury
- Monomethyl mercury

Trichloroethene and mercury were detected at least once in surface water samples at concentrations in excess of Federal SDWA MCLs. The average mercury concentration detected in the Eastern Wetland sediments (C_{avg}=35.9 mg/kg) is more than 100 times the concentration detected in the background sediment samples (C_{avg}=0.27 mg/kg)

Risk assessment results for the Eastern Wetlands are presented on Tables 6-17, 6-18, and 6-19. Risk assessment results for the surficial samples (Table 6-17) are presented separately from those

TABLE 6-17A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
EASTERN WETLANDS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.17	0.0914	1.11E-06	2.78E-06		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0.13	0.0723	1.11E-06	2.78E-06	1.00E-02	2.4E-05	1.3E-05	3.0E-05	1.6E-05	1.4E-05	8.0E-06	3.6E-05	2.0E-05	1.3E-06	7.1E-07	6.4E-06	3.5E-06	BLOOD
CHLOROBENZENE*	1.6	0.8084	1.11E-06	2.78E-06	2.00E-02	1.5E-04	7.4E-05	1.8E-04	9.2E-05	8.9E-05	4.5E-05	2.2E-04	1.1E-04	7.8E-06	3.9E-06	3.9E-05	2.0E-05	LIVER
NITROBENZENE*	0.65	0.65	1.11E-06	5.55E-07	5.00E-04	2.4E-03	2.4E-03	5.9E-04	5.9E-04	1.4E-03	1.4E-03	7.2E-04	7.2E-04	1.3E-04	1.3E-04	1.3E-04	1.3E-04	L/K
1,2-DICHLOROBENZENE*	7.2	4.013	1.11E-06	5.55E-07	9.00E-02	1.5E-04	8.1E-05	3.7E-05	2.0E-05	8.9E-05	5.0E-05	4.4E-05	2.5E-05	7.8E-06	4.4E-06	7.8E-06	4.4E-06	LIVER
1,4-DICHLOROBENZENE*	1.6	1.2125	1.11E-06	5.55E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER
124TRICHLOROBENZENE*	3.1	1.9825	1.11E-06	5.55E-07	1.30E-03	4.4E-03	2.8E-03	1.1E-03	6.9E-04	2.6E-03	1.7E-03	1.3E-03	8.4E-04	2.3E-04	1.5E-04	2.3E-04	1.5E-04	SKIN
NAPHTHALENE*	2.3	1.5825	1.11E-06	2.78E-07	4.00E-03	1.1E-03	7.1E-04	1.3E-04	8.9E-05	6.4E-04	4.3E-04	1.6E-04	1.1E-04	5.6E-05	3.8E-05	2.8E-05	1.9E-05	BW
ARSENIC*	12.7	6.59	1.11E-06	0.00E+00	3.00E-04	7.7E-02	4.0E-02	0.0E+00	0.0E+00	4.7E-02	2.4E-02	0.0E+00	0.0E+00	4.1E-03	2.1E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	462	123.88	1.11E-06	0.00E+00	1.00E+00	8.4E-04	2.3E-04	0.0E+00	0.0E+00	5.1E-04	1.4E-04	0.0E+00	0.0E+00	4.5E-05	1.2E-05	0.0E+00	0.0E+00	LIVER
LEAD*	142	72.58	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	152	35.878	1.11E-06	5.55E-08	3.00E-04	9.3E-01	2.2E-01	2.3E-02	5.5E-03	5.6E-01	1.3E-01	2.8E-02	6.6E-03	5.0E-02	1.2E-02	5.0E-03	1.2E-03	CNS
MONOMETHYLMERCURY*	0.228	0.0678	1.11E-06	4.28E-06	3.00E-04	1.4E-03	4.1E-04	2.7E-03	7.9E-04	8.5E-04	2.5E-04	3.3E-03	9.6E-04	7.5E-05	2.2E-05	5.8E-04	1.7E-04	CNS
ACETONE	1.6	0.9	1.11E-06	2.78E-06	1.00E-01	2.9E-05	1.6E-05	3.7E-05	2.1E-05	1.8E-05	1.0E-05	4.4E-05	2.5E-05	1.6E-06	8.8E-07	7.8E-06	4.4E-06	L/K
3/4METHYLPHENOL	0.26	0.26	1.11E-06	5.55E-07	5.00E-02	9.5E-06	9.5E-06	2.4E-06	2.4E-06	5.8E-06	5.8E-06	2.9E-06	2.9E-06	5.1E-07	5.1E-07	5.1E-07	5.1E-07	BW,CNS
PHENANTHRENE	0.62	0.62	1.11E-06	2.78E-07	4.00E-03	2.8E-04	2.8E-04	3.5E-05	3.5E-05	1.7E-04	1.7E-04	4.3E-05	4.3E-05	1.5E-05	1.5E-05	7.6E-06	7.6E-06	BW
FLUORANTHENE	1.6	1.2125	1.11E-06	2.78E-07	4.00E-02	7.3E-05	5.5E-05	9.1E-06	6.9E-06	4.4E-05	3.4E-05	1.1E-05	8.4E-06	3.9E-06	3.0E-06	2.0E-06	1.5E-06	L/K
PYRENE	1.7	1.2825	1.11E-06	2.78E-07	3.00E-02	1.0E-04	7.7E-05	1.3E-05	9.8E-06	6.3E-05	4.7E-05	1.6E-05	1.2E-05	5.5E-06	4.1E-06	2.8E-06	2.1E-06	KIDNEY
CHRYSENE	1.2	1.0125	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	2.5	2.77	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0.88	0.8425	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BARIUM	57.7	33.815	1.11E-06	0.00E+00	5.00E-02	2.1E-03	1.2E-03	0.0E+00	0.0E+00	1.3E-03	7.5E-04	0.0E+00	0.0E+00	1.1E-04	6.6E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	4	2.21	1.11E-06	0.00E+00	5.00E-03	1.5E-03	8.1E-04	0.0E+00	0.0E+00	8.9E-04	4.9E-04	0.0E+00	0.0E+00	7.8E-05	4.3E-05	0.0E+00	0.0E+00	NS
COPPER	120	83.73	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1320	288.11	1.11E-06	0.00E+00	1.00E-01	2.4E-02	5.3E-03	0.0E+00	0.0E+00	1.5E-02	3.2E-03	0.0E+00	0.0E+00	1.3E-03	2.8E-04	0.0E+00	0.0E+00	CNS
NICKEL	40.4	10.143	1.11E-06	0.00E+00	2.00E-02	3.7E-03	9.3E-04	0.0E+00	0.0E+00	2.2E-03	5.6E-04	0.0E+00	0.0E+00	2.0E-04	5.0E-05	0.0E+00	0.0E+00	BW
SELENIUM	6.5	1.43	1.11E-06	0.00E+00	5.00E-03	2.4E-03	5.2E-04	0.0E+00	0.0E+00	1.4E-03	3.2E-04	0.0E+00	0.0E+00	1.3E-04	2.8E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM •	37.4	17.57	1.11E-06	0.00E+00	7.00E-03	9.8E-03	4.6E-03	0.0E+00	0.0E+00	5.9E-03	2.8E-03	0.0E+00	0.0E+00	5.2E-04	2.5E-04	0.0E+00	0.0E+00	NS
ZINC	164	65.303	1.11E-06	0.00E+00	2.00E-01	1.5E-03	6.0E-04	0.0E+00	0.0E+00	9.1E-04	3.6E-04	0.0E+00	0.0E+00	8.0E-05	3.2E-05	0.0E+00	0.0E+00	BLOOD
4,4-DDD	0.177	0.0755	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS	HAZARD INDEX	1.0E+00	2.6E-01	2.5E-02	7.0E-03 *	6.2E-01	1.6E-01	3.1E-02	8.5E-03 *	5.4E-02	1.4E-02	5.4E-03	1.5E-03
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	4.5E-02	1.4E-02	9.6E-05	7.5E-05 *	2.8E-02	8.7E-03	1.2E-04	9.1E-05 *	2.4E-03	7.7E-04	2.1E-05	1.6E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1.1E+00	2.6E-01	2.5E-02	7.0E-03	6.4E-01	1.7E-01	3.1E-02	8.6E-03	5.7E-02	1.5E-02	5.4E-03	1.5E-03

TOXICITY ENDPOINTS ABBREVIATIONS: NS NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEPH BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6 - 17B
RISK RESULTS FOR SEDIMENT EXPOSURE
EASTERN WETLANDS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 17	0 0914	3 64E-07	7 56E-07	6.8E-10	3.7E-10	1.4E-09	7.6E-10	1.10E-02 B2
1,2-DICHLOROETHENE*	0 13	0 0723	3 64E-07	7.56E-07	0.0E+00	0.0E+00	0 0E+00	0.0E+00	
CHLOROBENZENE*	1 6	0 8064	3 64E-07	7.56E-07	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
NITROBENZENE*	0 65	0 65	3 64E-07	1 51E-07	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
1,2-DICHLOROBENZENE	7 2	4 013	3 64E-07	1.51E-07	0 0E+00	0.0E+00	0.0E+00	0 0E+00	
1,4-DICHLOROBENZENE	1 6	1 2125	3 64E-07	1.51E-07	1.4E-08	1.1E-08	5.8E-09	4.4E-09	2.40E-02 B2
124TRICHLOROBENZENE	3 1	1 9625	3 64E-07	1.51E-07	0.0E+00	0.0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	2 3	1 5625	3 64E-07	7 56E-08	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
ARSENIC*	12 7	6 59	3 64E-07	0 00E+00	8 3E-06	4.3E-06	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	462	123 68	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	142	72 58	1 82E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	152	35 876	3 64E-07	1.51E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
MONOMETHYLMERCURY	0 229	0 0676	3 64E-07	1.16E-06	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
ACETONE	1 6	0 9	3 64E-07	7.56E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
3/4METHYLPHENOL	0 26	0 26	3 64E-07	1 51E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PHENANTHRENE	0 62	0 62	3 64E-07	7 56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
FLUORANTHENE	1 8	1 2125	3 64F-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
PYRENE	1 7	1 2625	3 64E-07	7 56E-08	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
CHRYSENE	1 2	1 0125	3 64E-07	7.56E-08	2.5E-08	2.1E-08	5.3E-07	4.4E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	2 5	2 77	3 64E-07	7.56E-08	5 3E-08	5 6E-08	1 1E-06	1.2E-06	5.80E+00 B2
BENZO(A)PYRENE	0 88	0 8425	3 64E-07	7 56E-08	1 8E-08	1.8E-08	3 8E-07	3 7E-07	5.80E+00 B2
BARIUM	57 7	33 615	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLUUM	4	2 21	3 64E-07	0 00E+00	6 3E-08	3 5E-08	0 0E+00	0.0E+00	4.30E+00 A
COPPER	120	63 73	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
MANGANESE	1320	288 11	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
NICKEL	40 4	10 143	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
SELENIUM	6 5	1 43	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
VANADIUM	37 4	17 57	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
ZINC	164	65 383	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
4,4-DDD	0 177	0 0755	1 09E-07	7.56E-08	4.6E-09	2.0E-09	3.2E-09	1.4E-09	2.40E-01 B2

NYANZA SITE CONTAMINANTS	CANCER RISK	8 3E-06	4.3E-06	7.2E-09	5 2E-09 *
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	* 1.6E-05	1.3E-05	2.0E-06	2.0E-06 *
ALL CHEMICALS OF CONCERN	CANCER RISK	2 4E-05	1.8E-05	2.0E-06	2.0E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-18A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
EASTERN WETLANDS DRILLING
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS FOR ADULT, TEEN, AND CHILD RECEPTORS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS RECEPTOR = CHILD				HAZARD QUOTIENTS RECEPTOR = TEEN				HAZARD QUOTIENTS RECEPTOR = ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	3.4	0.2184	1.11E-06	2.78E-06		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	5.5	0.2621	1.11E-06	2.78E-06	1.00E-02	1.0E-03	4.8E-05	1.3E-03	6.0E-05	6.1E-04	2.9E-05	1.5E-03	7.3E-05	5.4E-05	2.6E-06	2.7E-04	1.3E-05	BLOOD
CHLOROBENZENE*	34	2.6048	1.11E-06	2.78E-06	2.00E-02	3.1E-03	2.4E-04	3.9E-03	3.0E-04	1.9E-03	1.4E-04	4.7E-03	3.6E-04	1.7E-04	1.3E-05	8.3E-04	6.4E-05	LIVER
NITROBENZENE*	0.14	0.1013	1.11E-06	5.56E-07	5.00E-04	5.1E-04	3.7E-04	1.3E-04	9.3E-05	3.1E-04	2.3E-04	1.6E-04	1.1E-04	2.7E-05	2.0E-05	2.7E-05	2.0E-05	L/K
1,2-DICHLOROBENZENE*	13	1.8777	1.11E-06	5.56E-07	9.00E-02	2.6E-04	3.8E-05	6.6E-05	9.5E-06	1.6E-04	2.3E-05	8.0E-05	1.2E-05	1.4E-05	2.0E-06	1.4E-05	2.0E-06	LIVER
1,3-DICHLOROBENZENE*	0.29	0.2730	1.11E-06	5.55E-07	3.00E-02	1.8E-05	1.7E-05	4.4E-06	4.2E-06	1.1E-05	1.0E-05	5.4E-06	5.1E-06	9.5E-07	8.9E-07	9.5E-07	8.9E-07	NS
1,4-DICHLOROBENZENE*	3.1	0.5798	1.11E-06	5.56E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER
124TRICHLOROBENZENE*	0.32	0.3038	1.11E-06	5.55E-07	1.30E-03	4.5E-04	4.3E-04	1.1E-04	1.1E-04	2.7E-04	2.6E-04	1.4E-04	1.3E-04	2.4E-05	2.3E-05	2.4E-05	2.3E-05	SKIN
NAPHTHALENE*	0.082	0.082	1.11E-06	2.78E-07	4.00E-03	3.7E-05	3.7E-05	4.7E-06	4.7E-06	2.3E-05	2.3E-05	5.7E-06	5.7E-06	2.0E-06	2.0E-06	1.0E-06	1.0E-06	BW
ARSENIC*	7	1.71	1.11E-06	0.00E+00	3.00E-04	4.3E-02	1.0E-02	0.0E+00	0.0E+00	2.6E-02	6.3E-03	0.0E+00	0.0E+00	2.3E-03	5.6E-04	0.0E+00	0.0E+00	SKIN
CADMIUM*	3.4	0.65	1.11E-06	0.00E+00	5.00E-04	1.2E-02	2.4E-03	0.0E+00	0.0E+00	7.6E-03	1.4E-03	0.0E+00	0.0E+00	8.7E-04	1.3E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	424	41.82	1.11E-06	0.00E+00	1.00E+00	7.7E-04	7.6E-05	0.0E+00	0.0E+00	4.7E-04	4.6E-05	0.0E+00	0.0E+00	4.1E-05	4.1E-06	0.0E+00	0.0E+00	LIVER
LEAD*	5760	201.8	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	91.5	6.12	1.11E-06	5.55E-08	3.00E-04	5.6E-01	3.7E-02	1.4E-02	9.3E-04	3.4E-01	2.3E-02	1.7E-02	1.1E-03	3.0E-02	2.0E-03	3.0E-03	2.0E-04	CNS
BENZENE	0.004	0.004	1.11E-06	2.78E-06		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
DICHLOROMETHANE	1.6	0.1386	1.11E-06	2.78E-06	6.00E-02	4.9E-05	4.2E-06	6.1E-05	5.3E-06	3.0E-05	2.6E-06	7.4E-05	6.5E-06	2.6E-06	2.3E-07	1.3E-05	1.1E-06	LIVER
ACETONE	0.11	0.0342	1.11E-06	2.78E-06	1.00E-01	2.0E-06	6.2E-07	2.5E-06	7.8E-07	1.2E-06	3.8E-07	3.1E-06	9.5E-07	1.1E-07	3.3E-08	5.4E-07	1.7E-07	L/K
BEHP	0.036	0.0225	1.11E-06	5.55E-07	2.00E-02	3.3E-06	2.1E-06	8.2E-07	5.1E-07	2.0E-06	1.2E-06	1.0E-06	6.2E-07	1.6E-07	1.1E-07	1.6E-07	1.1E-07	LIVER
3/4METHYLPHENOL	0.074	0.074	1.11E-06	5.55E-07	5.00E-02	2.7E-06	2.7E-06	6.8E-07	6.8E-07	1.6E-06	1.6E-06	8.2E-07	8.2E-07	1.4E-07	1.4E-07	1.4E-07	1.4E-07	BW,CNS
2-METHYLNAPHTHALENE	0.06	0.06	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	BW
ACENAPTHYLENE	0.045	0.0313	1.11E-06	2.78E-07	4.00E-03	2.1E-05	1.4E-05	2.6E-06	1.8E-06	1.2E-05	8.7E-06	3.1E-06	2.2E-06	1.1E-06	7.7E-07	5.5E-07	3.8E-07	NS
PHENANTHRENE	0.27	0.0781	1.11E-06	2.78E-07	4.00E-03	1.2E-04	3.6E-05	1.5E-05	4.5E-06	7.5E-05	2.2E-05	1.9E-05	5.4E-06	6.6E-06	1.9E-06	3.3E-06	9.6E-07	BW
FLUORANTHENE	0.26	0.1686	1.11E-06	2.78E-07	4.00E-02	1.2E-05	7.7E-06	1.5E-06	9.7E-07	7.2E-06	4.7E-06	1.8E-06	1.2E-06	8.4E-07	4.1E-07	3.2E-07	2.1E-07	L/K
PYRENE	0.025	0.025	1.11E-06	2.78E-07	3.00E-02	1.5E-06	1.5E-06	1.9E-07	1.9E-07	9.3E-07	9.3E-07	2.3E-07	2.3E-07	6.2E-08	6.2E-08	4.1E-08	4.1E-08	KIDNEY
BENZO(A)ANTHRACENE	0.19	0.129	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	0.1	0.0783	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	0.66	0.28	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0.12	0.12	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
DIBENZ(AH)ANTHRACENE	0.12	0.12	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BARIUM	64.7	32.64	1.11E-06	0.00E+00	5.00E-02	2.4E-03	1.2E-03	0.0E+00	0.0E+00	1.4E-03	7.2E-04	0.0E+00	0.0E+00	1.3E-04	6.4E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	8.2	1.8	1.11E-06	0.00E+00	5.00E-03	3.0E-03	6.6E-04	0.0E+00	0.0E+00	1.8E-03	4.0E-04	0.0E+00	0.0E+00	1.6E-04	3.5E-05	0.0E+00	0.0E+00	NS
COPPER	316	31.6	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	478	86.31	1.11E-06	0.00E+00	1.00E-01	8.7E-03	1.6E-03	0.0E+00	0.0E+00	5.3E-03	9.6E-04	0.0E+00	0.0E+00	4.7E-04	8.4E-05	0.0E+00	0.0E+00	CNS
NICKEL	23.4	7.5	1.11E-06	0.00E+00	2.00E-02	2.1E-03	6.8E-04	0.0E+00	0.0E+00	1.3E-03	4.2E-04	0.0E+00	0.0E+00	1.1E-04	3.7E-05	0.0E+00	0.0E+00	BW
THALLIUM	1.4	0.46	1.11E-06	0.00E+00	7.00E-05	3.7E-02	1.2E-02	0.0E+00	0.0E+00	2.2E-02	7.3E-03	0.0E+00	0.0E+00	2.0E-03	6.4E-04	0.0E+00	0.0E+00	NS
VANADIUM	22.8	13.61	1.11E-06	0.00E+00	7.00E-03	5.9E-03	3.6E-03	0.0E+00	0.0E+00	3.6E-03	2.2E-03	0.0E+00	0.0E+00	3.2E-04	1.9E-04	0.0E+00	0.0E+00	NS
ZINC	280	42.66	1.11E-06	0.00E+00	2.00E-01	2.6E-03	3.9E-04	0.0E+00	0.0E+00	1.6E-03	2.4E-04	0.0E+00	0.0E+00	1.4E-04	2.1E-05	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	6.2E-01	5.1E-02	1.9E-02	1.5E-03	3.8E-01	3.1E-02	2.4E-02	1.8E-03	3.3E-02	2.7E-03	4.2E-03	3.2E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	6.1E-02	2.0E-02	6.5E-05	1.5E-05	3.7E-02	1.2E-02	1.0E-04	1.8E-05	3.3E-03	1.1E-03	1.8E-05	3.1E-06
ALL CHEMICALS OF CONCERN	HAZARD INDEX	6.8E-01	7.1E-02	1.9E-02	1.5E-03	4.1E-01	4.3E-02	2.4E-02	1.8E-03	3.6E-02	3.8E-03	4.2E-03	3.3E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6 - 168
RISK RESULTS FOR SEDIMENT EXPOSURE
WETLANDS DRILLING
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSUR FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D) - 1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTIO	DERMAL CONTACT	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	3 4	0 2184	3 84E-07	7 58E-07	1 4E-08	8 7E-10	2 8E-08	1 8E-09	1 10E-02 B2
1,2-DICHLOROETHENE*	5 5	0 2821	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHLOROBENZENE*	34	2 8048	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NITROBENZENE*	0 14	0 1013	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,2-DICHLOROBENZENE	13	1 8777	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,3-DICHLOROBENZENE	0 28	0 2738	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,4-DICHLOROBENZENE	3 1	0 5788	3 84E-07	1 51E-07	2 7E-08	5 1E-09	1 1E-08	2.1E-09	2 40E-02 B2
124TRICHLOROBENZENE	0 32	0 3038	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	0 082	0 082	3 84E-07	7 58E-08	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
ARSENIC*	7	1 71	3 84E-07	0 00E+00	4 8E-08	1.1E-08	0 0E+00	0 0E+00	1 80E+00 A
CADMIUM*	3 4	0 85	3 84E 07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHROMIUM*	424	41 82	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
LEAD*	5760	201 8	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MERCURY*	81 5	8 12	3 84E-07	1 51E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BENZENE	0 004	0 004	3 84E-07	7 58E-07	4 2E-11	4 2E-11	8 8E-11	8 8E-11	2 80E-02 A
DICHLOROMETHANE	1 8	0 1385	3 84E-07	7 58E-07	4 4E-09	3 8E-10	9 1E-09	7 9E-10	7 50E-03 B2
ACETONE	0 11	0 0342	3 84E-07	7 58E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BEHP	0 038	0 0225	3 84E-07	1 51E-07	1 8E-10	1 1E-10	7 8E-11	4 8E-11	1 40E-02 B2
3/4METHYLPHENOL	0 074	0 074	3 84E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
2-METHYLNAPHTHALENE	0 08	0 08	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ACENAPTHYLENE	0 045	0 0313	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PHENANTHRENE	0 27	0 0781	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
FLUORANTHENE	0 28	0 1885	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PYRENE	0 025	0 025	3 84E-07	7 58E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BENZO(A)ANTHRACENE	0 18	0 128	3 84E-07	7 58E-08	4 0E-07	2 7E-07	8 3E-08	5 5E-08	5 80E+00 B2
CHRYSENE	0 1	0 0783	3 84E-07	7 58E-08	2 1E-07	1 7E-07	4 4E-08	3 4E-08	5 80E+00 B2
BENZO(K)FLUORANTHENE	0 88	0 28	3 84E-07	7 58E-08	1 8E-06	5 8E-07	3 8E-07	1 2E-07	5 80E+00 B2
BENZO(A)PYRENE	0 12	0 12	3 84E-07	7 58E-08	2 5E-07	2 5E-07	5 3E-08	5 3E-08	5 80E+00 B2
DIBENZ(AH)ANTHRACENE	0 12	0 12	3 84E-07	7 58E-08	2 5E-07	2 5E-07	5 3E-08	5 3E-08	5 80E+00 B2
BARIUM	84 7	32 54	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLLIUM	8 2	1 8	3 84E-07	0 00E+00	1 3E-05	2 8E-06	0 0E+00	0 0E+00	4 30E+00 A
COPPER	318	31 8	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MANGANESE	478	88 31	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NICKEL	23 4	7 5	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
THALLIUM	1 4	0 48	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
VANADIUM	22 8	13 81	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ZINC	280	42 56	3 84E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	4 9E-08	1 1E-08	4 0E-08	3 9E-08
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	1 8E-05	4 3E-06	8 2E-07	3 2E-07
ALL CHEMICALS OF CONCERN	CANCER RISK	2 0E-05	5 5E-06	8 8E-07	3 2E-07

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-19A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
EASTERN WETLANDS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.0065	0.0045	1.11E-03	2.16E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0.008	0.0053	1.11E-03	2.06E-03	1.00E-02	7.3E-04	4.8E-04	7.6E-04	5.0E-04	6.9E-04	5.9E-04	1.6E-03	1.1E-03	1.6E-04	1.0E-04	9.1E-04	6.0E-04	BLOOD
1,2-DICHLOROBENZENE	0.003	0.003	1.11E-03	1.12E-02	9.00E-02	3.0E-05	3.0E-05	1.7E-04	1.7E-04	3.7E-05	3.7E-05	3.7E-04	3.7E-04	6.5E-06	6.5E-06	2.1E-04	2.1E-04	LIVER
CHROMIUM*	0.079	0.079	1.11E-03	1.38E-04	1.00E+00	7.2E-05	7.2E-05	5.0E-06	5.0E-06	6.8E-05	6.8E-05	1.1E-05	1.1E-05	1.5E-05	1.5E-05	6.0E-06	6.0E-06	LIVER
LEAD*	0.0053	0.004	1.11E-03	1.38E-04		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	0.0038	0.0021	1.11E-03	1.38E-04	3.00E-04	1.2E-02	6.4E-03	6.1E-04	4.5E-04	1.4E-02	7.8E-03	1.7E-03	9.7E-04	2.5E-03	1.4E-03	9.6E-04	5.3E-04	CNS
BARIUM	0.0094	0.0085	1.11E-03	1.38E-04	5.00E-02	1.7E-04	1.6E-04	1.2E-05	1.1E-05	2.1E-04	1.9E-04	2.6E-05	2.3E-05	3.7E-05	3.3E-05	1.4E-05	1.3E-05	BLOOD
COPPER	0.0146	0.0146	1.11E-03	1.38E-04		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	0.108	0.1007	1.11E-03	1.38E-04	1.00E-01	9.9E-04	9.2E-04	6.9E-05	6.4E-05	1.2E-03	1.1E-03	1.5E-04	1.4E-04	2.1E-04	2.0E-04	6.2E-05	7.6E-05	CNS

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	1.2E-02	7.0E-03	1.7E-03	1.1E-03	1.5E-02	8.5E-03	3.6E-03	2.4E-03	2.7E-03	1.5E-03	2.1E-03	1.3E-03
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1.2E-03	1.1E-03	6.1E-05	7.5E-05	1.4E-03	1.3E-03	1.7E-04	1.6E-04	2.5E-04	2.3E-04	9.6E-05	8.9E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1.4E-02	8.1E-03	1.8E-03	1.2E-03	1.6E-02	9.8E-03	4.0E-03	2.6E-03	2.9E-03	1.7E-03	2.2E-03	1.4E-03

TOXICITY ENDPOINTS ABBREVIATIONS NS: NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS: CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6-19B
RISK RESULTS FOR SURFACE WATER
EASTERN WETLANDS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.0065	0.0045	3.02E-04	6.61E-04	2.2E-08	1.5E-08	4.7E-08	3.3E-08	1.10E-02 B2
1,2-DICHLOROETHENE*	0.008	0.0053	3.02E-04	6.28E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
1,2-DICHLOROBENZENE*	0.003	0.003	3.02E-04	3.43E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	0.079	0.079	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.0053	0.004	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	0.0038	0.0021	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	0.0094	0.0085	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	0.0146	0.0146	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.108	0.1007	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	2.2E-08	1.5E-08	4.7E-08	3.3E-08
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	2.2E-08	1.5E-08	4.7E-08	3.3E-08

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

presented for the drilling samples (Table 6-18) because the average concentrations are significantly different. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios.

Table 6-17 presents risk assessment results for sediment exposure scenarios. Noncarcinogenic risks estimated for the accidental-ingestion exposure route predominate. Mercury is the principal contaminant of concern; the hazard quotient presented for mercury approaches unity (>0.9) when the maximum contaminant concentrations are evaluated and a small child is considered the receptor of concern for the accidental-ingestion exposure route. The hazard index calculation for chemicals targeting the kidney equals unity (= 0.95) when maximum contaminant concentrations are evaluated and a small child is the receptor of concern (risks summed for the accidental ingestion and dermal contact route). The hazard index equals unity and slightly exceeds unity (HI=1.1) when the reasonable maximum-case scenario is evaluated for Nyanza site contaminants and for all COCs respectively (accidental exposure route; a small child is the receptor of concern). As discussed previously, adverse noncarcinogenic health effects are possible when the HQ or HI exceeds unity.

In contrast to the risk assessment results presented for many of the Sudbury River reaches, the hazard index calculated for the Nyanza Site contaminants detected in the Eastern Wetlands clearly exceeds that calculated for other Sudbury River contaminants.

Hazard quotients and hazard indices presented for the surface water exposure scenarios (Table 6-19) do not exceed 0.1 even when the noncarcinogenic risks are summed for the accidental-ingestion and dermal-contact exposure routes.

The excess lifetime cancer risks estimated for the sediment and surface water exposure scenarios are 2.6 x 10^{-5} and 2.0 x 10^{-5} (risks summed for the accidental-ingestion and dermal-contact exposure routes) when the reasonable maximum- and average-case scenarios are evaluated, respectively. Risks estimated for the sediment exposure scenarios exceed those estimated for the surface water exposure scenarios. The principal contaminants contributing to the risk are the carcinogenic PAHs, beryllium and arsenic, a Nyanza Site contaminant. As a point of reference, the 1E-04 to 1E-06 risk range is often evaluated in the development of health-based standards/criteria and in the determination of cleanup goals at hazardous waste sites. Cancer risks estimated for background COC concentrations in surface waters and sediments were 2E-05 and

9.7E-06 (risks summed for the accidental-ingestion and dermal-contact exposure route) for the reasonable maximum and average case, respectively.

Risk Assessment Results for Eastern Wetlands Drilling Samples

Several organic and inorganic Nyanza Site contaminants were detected in samples (0- to 2-foot interval samples) collected during the drilling program conducted in the Eastern Wetlands:

- Trichloroethene
- Chlorobenzene
- 1,2-Dichlorobenzene
- 1,4-Dichlorobenzene
- Naphthalene
- Chromium
- Mercury
- 1,2-Dichloroethene
- Nitrobenzene
- 1,3-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Arsenic
- Lead

The average mercury concentration detected in the sediment samples (C_{avg}=6.12 mg/kg) was greater than 20 times the average concentration detected in background sediment samples (C_{avg}=0.27 mg/kg).

Table 6-18 presents the risk assessment results for COC concentrations detected in the 0- to 2-foot sediment samples collected during the Eastern Wetlands drilling program. Mercury is the principal contaminant contributing to the noncarcinogenic risk. The chemical-specific hazard quotient for mercury is greater than 0.5 when a small child is evaluated as the receptor of concern. However, chemical-specific hazard quotients and hazard indices calculated for each exposure route do not exceed unity even when the reasonable maximum case is evaluated. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Excess lifetime cancer risks estimated for maximum and average COC concentrations in the 0- to 2-foot samples slightly exceed 2E-05 and 5.5E-06 (risks summed for accidental-ingestion and dermal-contact exposure routes), respectively. As a point of reference, cancer risks estimated for background sediment concentrations were 1.8E-05 and 8.2E-06 for the reasonable maximum and average case scenarios, respectively. The carcinogenic PAHs, beryllium, and arsenic, a Nyanza Site contaminant, are the principal contaminants contributing to the estimated risk. It should be noted that cancer risks estimated for Nyanza Site contaminants are less than those estimated for "other Sudbury River contaminants."

6.5.3.5 Risk Assessment Results for Chemical Brook Culvert

Chemical Brook Culvert is fed by Chemical Brook and Trolley Brook. Water from the culvert discharges to Outfall Creek. Chemical and Trolley Brooks were primary surficial drainage routes from the Nyanza Site and the Eastern Wetlands. Several organic and inorganic Nyanza Site contaminants were detected in sediment samples collected from the culvert:

- Trichloroethene
- Chlorobenzene
- 1,2-Dichlorobenzene
- 1,4-Dichlorobenzene
- Naphthalene
- Chromium
- Mercury
- 1,2-Dichloroethene
- Nitrobenzene
- 1,3-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Arsenic
- Lead

The average mercury concentrations detected in the Brook Culvert sediments (C_{avg}=6.8) were greater than 25 times the average concentration detected in background sediments (C_{avg}=0.27 mg/kg).

Table 6-20 presents risk assessment results for COCs detected in sediment samples collected from the Culvert. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. Although mercury was detected in excess of background concentrations, the chemical-specific hazard quotients and hazard indices presented for each exposure route do not exceed unity. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects are not anticipated for a receptor contacting the sediments under the conditions of the recreational exposure scenarios defined in Section 6.4.

Arsenic, the carcinogenic PAHs, and beryllium are the principal contaminants contributing to the estimated excess lifetime cancer risks presented on Table 6-20. Cancer risks estimated for several carcinogenic PAHs exceed 1E-06. Arsenic is the only Nyanza Site contaminant demonstrating a cancer risk exceeding 1E-06. The cancer risks estimated for the sediment exposures are 1.6E-05 and 1.4E-05 (risk summed for the accidental-ingestion and dermal-contact routes) when the reasonable maximum- and average-case

TABLE 6-20A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
CHEMICAL BROOK CULVERT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENT CHILD				HAZARD QUOTIENT TEEN				HAZARD QUOTIENT ADULT				TOXIC END-POINT
	MAX MG/KG	AVG MG/KG	INGESTION	-DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 072	0 0377	1 11E-06	2 78E-06		0 0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0 043	0 025	1 11E-06	2 78E-06	1 00E-02	7 8E-06	4 6E-06	9 6E-06	5 7E-06	4.8E-06	2.8E-06	1.2E-05	6.9E-06	4.2E-07	2.4E-07	2.1E-06	1.2E-06	BLOOD
CHLOROBENZENE*	0 077	0 052	1 11E-06	2 78E-06	2 00E-02	7 0E-06	4 7E-06	8 8E-06	5 9E-06	4.3E-06	2.9E-06	1.1E-05	7.2E-06	3.8E-07	2.5E-07	1.9E-06	1.3E-06	LIVER
NITROBENZENE*	0 31	0 31	1 11E-06	5 55E-07	5 00E-04	1 1E-03	1 1E-03	2 6E-04	2 6E-04	6.9E-04	6.9E-04	3.4E-04	3.4E-04	6.1E-05	6.1E-05	6.1E-05	6.1E-05	L/K
1,2-DICHLOROBENZENE*	1 9	1 65	1 11E-06	5 55E-07	9 00E-02	3 8E-05	3 3E-05	9.6E-06	8.4E-06	2.3E-05	2.0E-05	1.2E-05	1.0E-05	2.1E-06	1.8E-06	2.1E-06	1.8E-06	LIVER
1,3-DICHLOROBENZENE*	0 1	0 1	1 11E-06	5 55E-07	3 00E-02	6 1E-06	6.1E-06	1.5E-06	1.5E-06	3.7E-06	3.7E-06	1.9E-06	1.9E-06	3 3E-07	3.3E-07	3.3E-07	3.3E-07	NS
1,4-DICHLOROBENZENE*	0 59	0 485	1 11E-06	5 55E-07		0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER
124TRICHLOROBENZENE*	0 87	0 835	1 11E-06	5 55E-07	1 30E-03	1 2E-03	1 2E-03	3.1E-04	2 9E-04	7.4E-04	7.1E-04	3.7E-04	3.6E-04	6.5E-05	6.3E-05	6.5E-05	6.3E-05	SKIN
NAPHTHALENE*	0 6	0 585	1 11E-06	2 78E-07	4 00E-03	2 7E-04	2 6E-04	3 4E-05	3 2E-05	1.7E-04	1.6E-04	4.2E-05	3.9E-05	1.5E-05	1.4E-05	7.3E-06	6.9E-06	BW
ARSENIC*	6 6	4 3	1 11E-06	0 00E+00	3 00E-04	4 0E-02	2 6E-02	0 0E+00	0.0E+00	2.4E-02	1.6E-02	0.0E+00	0.0E+00	2.2E-03	1.4E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	135	82 3	1 11E-06	0 00E+00	1 00E+00	2 5E-04	1 5E-04	0 0E+00	0 0E+00	1 5E-04	9.1E-05	0.0E+00	0.0E+00	1 3E-05	8.1E-06	0.0E+00	0.0E+00	LIVER
LEAD*	57 5	38 25	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	7 1	6 8	1 11E-06	5 55E-08	3 00E-04	4 3E-02	4 1E-02	1 1E-03	1 0E-03	2.6E-02	2.5E-02	1.3E-03	1.3E-03	2.3E-03	2.2E-03	2.3E-04	2.2E-04	CNS
BENZENE	0 002	0 002	1 11E-06	2 78E-06		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BEHP	0 2	0 15	1 11E-06	5 55E-07	2 00E-02	1 8E-05	1 4E-05	4 6E-06	3.4E-06	1.1E-05	8.3E-06	5.6E-06	4.2E-06	9.8E-07	7.3E-07	9.8E-07	7.3E-07	LIVER
2-METHYLNAPHTHALENE	0 18	0 18	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	BW
ACENAPTHYLENE	0 14	0 14	1 11E-06	2 78E-07	4 00E-03	6 4E-05	6 4E-05	8 0E-06	8 0E-06	3 9E-05	3.9E-05	9.7E-06	9.7E-06	3.4E-06	3.4E-06	1.7E-06	1.7E-06	NS
PHENANTHRENE	0 79	0 76	1 11E-06	2 78E-07	4 00E-03	3 6E-04	3 5E-04	4 5E-05	4 3E-05	2.2E-04	2.1E-04	5.5E-05	5.3E-05	1.9E-05	1.9E-05	9.7E-06	9.3E-06	BW
FLUORANTHENE	1 4	1 3	1 11E-06	2 78E-07	4 00E-02	6 4E-05	5 9E-05	8 0E-06	7.4E-06	3.9E-05	3.6E-05	9.7E-06	9.0E-06	3.4E-06	3.2E-06	1.7E-06	1.6E-06	L/K
PYRENE	1 2	1 2	1 11E-06	2 78E-07	3 00E-02	7 3E-05	7 3E-05	9.1E-06	9.1E-06	4 4E-05	4.4E-05	1.1E-05	1.1E-05	3.9E-06	3.9E-06	2.0E-06	2.0E-06	KIDNEY
BENZO(A)ANTHRACENE	0 81	0 71	1 11E-06	2 78E-07		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	0 78	0 748	1 11E-06	2 78E-07		0 0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	0 84	0 82	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	0 78	0 66	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0 77	0 72	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0 33	0 33	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0 27	0 27	1 11E-06	2 78E-07	4 00E-03	1 2E-04	1 2E-04	1 5E-05	1.5E-05	7.5E-05	7.5E-05	1.9E-05	1.9E-05	6.6E-06	6.6E-06	3.3E-06	3.3E-06	
BARIUM	25 9	18 65	1 11E-06	0 00E+00	5 00E-02	9 5E-04	6 6E-04	0 0E+00	0 0E+00	5 8E-04	4.1E-04	0.0E+00	0.0E+00	5.1E-05	3.6E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	0 56	0 45	1 11E-06	0 00E+00	5 00E-03	2 0E-04	1 6E-04	0 0E+00	0 0E+00	1 2E-04	1.0E-04	0.0E+00	0.0E+00	1.1E-05	8.8E-06	0.0E+00	0.0E+00	NS
COPPER	92 5	83 35	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	118	90 6	1 11E-06	0 00E+00	1 00E-01	2 2E-03	1 7E-03	0 0E+00	0 0E+00	1.3E-03	1.0E-03	0.0E+00	0.0E+00	1.2E-04	8.9E-05	0.0E+00	0.0E+00	CNS
VANADIUM	18	12	1 11E-06	0 00E+00	7 00E-03	4 7E-03	3.1E-03	0 0E+00	0 0E+00	2.9E-03	1.9E-03	0.0E+00	0.0E+00	2.5E-04	1.7E-04	0.0E+00	0.0E+00	NS
ZINC	103	92 65	1 11E-06	0 00E+00	2 00E-01	9 4E-04	8 5E-04	0 0E+00	0 0E+00	5.7E-04	5.2E-04	0.0E+00	0.0E+00	5.0E-05	4.5E-05	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	8 6E-02	7 0E-02	1 7E-03	1.7E-03	5 3E-02	4.3E-02	2.1E-03	2.0E-03	4.6E-03	3.8E-03	3.7E-04	3.6E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	9 7E-03	7 2E-03	9 0E-05	8 7E-05	5 9E-03	4.4E-03	1.1E-04	1.1E-04	5 2E-04	3.8E-04	1.9E-05	1.9E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	9 6E-02	7.8E-02	1 8E-03	1 8E-03	5 9E-02	4.7E-02	2.2E-03	2.1E-03	5.1E-03	4.2E-03	3.9E-04	3.8E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP: BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-20B
RISK RESULTS FOR SEDIMENT EXPOSURE
CHEMICAL BROOK CULVERT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION		CARCINOGENIC RISK ANALYSIS						SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			EXPOSURE FACTOR		CANCER RISKS				
	MAX MG/KG	AVG MG/KG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 072	0 0377	3 64E-07	7 56E-07	2.9E-10	1.5E-10	6.0E-10	3.1E-10	1.10E-02 B2
1,2-DICHLOROETHENE*	0 043	0 025	3 64E-07	7 56E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHLOROBENZENE*	0 077	0 052	3 64E-07	7 56E-07	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
NITROBENZENE*	0 31	0 31	3 64E-07	1 51E-07	0 0E+00	0.0E+00	0.0E+00	0 0E+00	
1,2-DICHLOROBENZENE	1 9	1 65	3 64E-07	1 51E-07	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
1,3-DICHLOROBENZENE	0 1	0 1	3 64E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
1,4-DICHLOROBENZENE	0 59	0 465	3 64E-07	1 51E-07	5.2E-09	4.1E-09	2.1E-09	1 7E-09	2.40E-02 B2
124TRICHLOROBENZENE	0 87	0 835	3 64E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	0 6	0 565	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ARSENIC*	6 6	4 3	3 64E-07	0 00E+00	4 3E-06	2 6E-06	0.0E+00	0 0E+00	1.80E+00 A
CHROMIUM*	135	82 3	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
LEAD*	57 5	38 25	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
MERCURY*	7 1	6 8	3 64E-07	1 51E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
BENZENE	0 002	0 002	3 64E-07	7 56E-07	2 1E-11	2 1E-11	4 4E-11	4 4E-11	2 90E-02 A
BEHP	0 2	0 15	3 64E-07	1 51E-07	1 0E-09	7.6E-10	4 2E-10	3 2E-10	1.40E-02 B2
2-METHYLNAPHTHALENE	0 18	0 18	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
ACENAPTHYLENE	0 14	0 14	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
PHENANTHRENE	0 79	0 76	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
FLUORANTHENE	1 4	1 3	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PYRENE	1 2	1 2	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
BENZO(A)ANTHRACENE	0 81	0 71	3 64E-07	7 56E-08	1 7E-08	1 5E-08	3 5E-07	3 1E- 07	5 80E+00 B2
CHRYSENE	0 76	0 745	3 64E-07	7 56E-08	1 6E-08	1 6E-08	3 3E-07	3 3E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	*0 64*	*0 62*	*3 64E-07*	*7 56E-08*	*1 8E-08*	*1 7E-08*	*3 7E-07*	*3 6E-07*	5.80E+00 B2
BENZO(K)FLUORANTHENE	0 78	0 68	3 64E-07	7 56E-08	1 6E-08	1 4E-08	3 4E-07	3 0E-07	5 80E+00 B2
BENZO(A)PYRENE	0 77	0 72	3 64E-07	7 56E-08	1 6E-08	1 5E-08	3.4E-07	3 2E-07	5.80E+00 B2
INDENO(123-CD)PYRENE	0 33	0 33	3 64E-07	7 56E-08	7.0E-07	7.0E-07	1.4E-07	1 4E-07	5.80E+00 B2
BENZO(GHI)PERYLENE	0 27	0 27	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BARIUM	25 9	18 65	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLLIUM	0 56	0 45	3 64E-07	0 00E+00	8 8E-07	7.0E-07	0.0E+00	0 0E+00	4.30E+00 A
COPPER	92 5	63 35	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
MANGANESE	119	90 6	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
VANADIUM	18	12	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
ZINC	103	92 95	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0 0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	4 3E-06	2 8E-06	2 7E-09	2 0E-09
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	9 9E-06	9.2E-06	1.9E-06	1 8E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	1 4E-05	1 2E-05	1.9E-06	1 8E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

scenarios are evaluated, respectively. As a point of reference, cancer risks estimated for background sediment concentrations were 1.8E-05 and 8.2E-06 for the reasonable maximum and average case, respectively. Thus, the cancer risks estimated for Chemical Brook Culvert sediments are similar to background levels.

6.5.3.6 Risk Assessment Results for Outfall Creek

Chemical Brook Culvert discharges to Outfall Creek. The following Nyanza Site contaminants were detected in surface waters and sediments of Outfall Creek:

- Trichloroethene
- Nitrobenzene
- 1,2,4-Trichlorobenzene
- 1,4-Dichlorobenzene
- Chromium
- Mercury
- 1,2-Dichloroethene
- 1,2-Dichlorobenzene
- Naphthalene
- Arsenic
- Lead

The average concentration of mercury in the creek sediments is greater than 100 times the concentration detected in background sediment samples. The maximum concentration of trichloroethene detected in creek surface waters (13 µg/L) exceeds the current Federal SDWA MCL (5 µg/L).

Risk assessment results for Outfall Creek are presented on Tables 6-21 and 6-22. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. Table 6-21 summarizes risk assessment results for sediment exposure scenarios. Although mercury was detected at concentrations 100 times background, the chemical-specific hazard quotients and hazard indices presented on Table 6-21 do not exceed unity. The HQ calculated for mercury does not exceed 0.6 in many of the cases presented. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. If the noncarcinogenic risks presented for the surface water exposure scenarios (Table 6-22) are also considered (the risks associated with the sediment-exposure scenarios are added to those associated with the surface water exposure scenarios), the total hazard index does not exceed unity. These results suggest that adverse noncarcinogenic health effects are not anticipated for a receptor

TABLE 6-21A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
OUTFALL CREEK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 004	2 83	1 11E-06	2 78E-06		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0 001	1	1 11E-06	2 78E-06	1 00E-02	1 8E-07	1 8E-04	2 3E-07	2.3E-04	1.1E-07	1.1E-04	2.8E-07	2.8E-04	9.8E-09	9.8E-06	4.9E-08	4.9E-05	BLOOD
NITROBENZENE*	0 5	0 35	1 11E-06	5 55E-07	5 00E-04	1 8E-03	1.3E-03	4 6E-04	3 2E-04	1.1E-03	7.8E-04	5.6E-04	3.9E-04	9.8E-05	6.8E-05	9 8E-05	6.8E-05	L/K
1,2-DICHLOROBENZENE	0 29	0 2475	1 11E-06	5 55E-07	9 00E-02	6 0E-06	5 0E-06	1 5E-06	1 3E-06	3.6E-06	3.1E-06	1 8E-06	1.5E-06	3.2E-07	2.7E-07	3 2E-07	2.7E-07	LIVER
124TRICHLOROBENZENE	1 3	0 8008	1 11E-06	5 55E-07	1 30E-03	1 8E-03	1 1E-03	4 6E-04	2 8E-04	1 1E-03	6.8E-04	5.6E-04	3.4E-04	9.8E-05	6.0E-05	9.8E-05	6.0E-05	SKIN
NAPHTHALENE*	0 34	0 2183	1 11E-06	2 78E-07	4 00E-03	1 6E-04	1 0E-04	1 9E-05	1 2E-05	9.4E-05	6.1E-05	2.4E-05	1.5E-05	8 3E-06	5.3E-06	4 2E-06	2.7E-06	BW
ARSENIC*	4 1	2 93	1 11E-06	0 00E+00	3 00E-04	2 5E-02	1 8E-02	0 0E+00	0 0E+00	1 5E-02	1.1E-02	0.0E+00	0.0E+00	1.3E-03	9.6E-04	0.0E+00	0.0E+00	SKIN
CHROMIUM*	988	341 8	1 11E-06	0 00E+00	1 00E+00	1 8E-03	6 2E-04	0 0E+00	0 0E+00	1.1E-03	3.8E-04	0 0E+00	0.0E+00	9.7E-05	3.3E-05	0.0E+00	0.0E+00	LIVER
LEAD*	233	105 85	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	99 2	35 33	1 11E-06	5 55E-08	3 00E-04	6 0E-01	2 2E-01	1 5E-02	5 4E-03	3 7E-01	1.3E-01	1.8E-02	6 5E-03	3 2E-02	1.2E-02	3.2E-03	1.2E-03	CNS
DICHLOROMETHANE	0 055	0 0222	1 11E-06	2 78E-06	6 00E-02	1 7E-06	6 7E-07	2 1E-06	8 4E-07	1.0E-06	4.1E-07	2.5E-06	1.0E-06	9.0E-08	3 6E-08	4 5E-07	1 8E-07	LIVER
ACETONE	0 034	0 0157	1 11E-06	2 78E-06	1 00E-01	6 2E-07	2 9E-07	7 8E-07	3 6E-07	3.8E-07	1.7E-07	9.4E-07	4.4E-07	3 3E-08	1.5E-08	1.7E-07	7.7E-08	L/K
BEHP	2	0 96	1 11E-06	5 55E-07	2 00E-02	1 8E-04	8 8E-05	4 6E-05	2 2E-05	1 1E-04	5.3E-05	5.6E-05	2.7E-05	9.8E-06	4.7E-06	9.8E-06	4.7E-06	LIVER
ACENAPTHYLENE	0 31	0 2633	1 11E-06	2 78E-07	4 00E-03	1 4E-04	1.2E-04	1 8E-05	1 5E-05	8 6E-05	7.3E-05	2.2E-05	1.8E-05	7.6E-06	6.4E-06	3.8E-06	3.2E-06	NS
PHENANTHRENE	0 93	0 63	1 11E-06	2 78E-07	4 00E-03	4 2E-04	2 9E-04	5 3E-05	3 6E-05	2 6E-04	1 7E-04	6.5E-05	4.4E-05	2.3E-05	1.5E-05	1.1E-05	7.7E-06	BW
FLUORANTHENE	1 6	1 3067	1 11E-06	2 78E-07	4 00E-02	7 3E-05	6 0E-05	9 1E-06	7 5E-06	4 4E-05	3 6E-05	1.1E-05	9.1E-06	3.9E-06	3.2E-06	2.0E-06	1.6E-06	L/K
PYRENE	2 5	1 8	1 11E-06	2 78E-07	3 00E-02	1 5E-04	1 1E-04	1 9E-05	1 4E-05	9 3E-05	6.7E-05	2.3E-05	1.7E-05	8 2E-06	5.9E-06	4.1E-06	2.9E-06	KIDNEY
BENZO(A)ANTHRACENE	1 05	0 8	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	1 4	1 0767	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	1 78	1 2333	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	1	0 4733	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	1 2	0 8	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0 835	0 4533	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0 73	0 4817	1 11E-06	2 78E-07	4 00E-03	3 3E-04	2 2E-04	4 2E-05	2 8E-05	2.0E-04	1 4E-04	5.1E-05	3.4E-05	1.8E-05	1.2E-05	8.9E-06	6.0E-06	NS
BARIUM	58 6	31 56	1 11E-06	0 00E+00	5 00E-02	2 1E-03	1 2E-03	0 0E+00	0 0E+00	1 3E-03	7.0E-04	0.0E+00	0.0E+00	1.1E-04	6.2E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	2 2	1 07	1 11E-06	0 00E+00	5 00E-03	8 0E-04	3 9E-04	0 0E+00	0 0E+00	4.9E-04	2.4E-04	0.0E+00	0.0E+00	4.3E-05	2.1E-05	0.0E+00	0.0E+00	NS
COPPER	358	137 83	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	308	164 57	1 11E-06	0 00E+00	1 00E-01	5 6E-03	3 0E-03	0 0E+00	0 0E+00	3.4E-03	1.8E-03	0.0E+00	0.0E+00	3.0E-04	1.6E-04	0.0E+00	0.0E+00	CNS
VANADIUM	36 1	17 26	1 11E-06	0 00E+00	7 00E-03	9 4E-03	4 5E-03	0 0E+00	0 0E+00	5.7E-03	2.7E-03	0.0E+00	0.0E+00	5.0E-04	2.4E-04	0.0E+00	0.0E+00	NS
ZINC	390	166 3	1 11E-06	0 00E+00	2 00E-01	3 6E-03	1.5E-03	0.0E+00	0 0E+00	2.2E-03	9.2E-04	0.0E+00	0.0E+00	1.9E-04	8.1E-05	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	6 3E-01	2.4E-01	1 6E-02	6 2E-03	3.9E-01	1.4E-01	1.9E-02	7.6E-03	3.4E-02	1.3E-02	3.4E-03	1.3E-03
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	2 3E-02	1 1E-02	1 9E-04	1 2E-04	1.4E-02	7.0E-03	2.3E-04	1.5E-04	1.2E-03	8.1E-04	4.1E-05	2.6E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	6 6E-01	2 5E-01	1 6E-02	6 3E-03	4.0E-01	1 5E-01	2 0E-02	7.7E-03	3.5E-02	1.3E-02	3.5E-03	1.4E-03

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP: BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-21B
RISK RESULTS FOR SEDIMENT EXPOSURE
OUTFALL CREEK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 004	2 63	3 64E-07	7 56E-07	1 6E-11	1.1E-08	3.3E-11	2 2E-08	1.10E-02 B2
1,2-DICHLOROETHENE*	0 001	1	3 64E-07	7.56E-07	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
NITROBENZENE*	0 5	0 35	3 64E-07	1.51E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
1,2-DICHLOROBENZENE*	0 29	0 2475	3 64E-07	1.51E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
124TRICHLOROBENZENE*	1 3	0 8008	3 64E-07	1 51E-07	0.0E+00	0.0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	0 34	0 2183	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0 0E+00	0 0E+00	
ARSENIC*	4 1	2 93	3 64E-07	0 00E+00	2 7E-06	1 9E-06	0 0E+00	0 0E+00	1.80E+00 A
CHROMIUM*	988	341 8	3 64E-07	0 00E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
LEAD*	233	105 95	1 82E-07	0 00E+00	0.0E+00	0 0E+00	0.0E+00	0 0E+00	
MERCURY*	99 2	35 33	3 64E-07	1.51E-08	0.0E+00	0 0E+00	0.0E+00	0 0E+00	
DICHLOROMETHANE	0 055	0 0222	3 64E-07	7 56E-07	1.5E-10	6 0E-11	3 1E-10	1 3E-10	7.50E-03 B2
ACETONE	0 034	0 0157	3 64E-07	7 56E-07	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
BEHP	2	0 96	3.64E-07	1.51E-07	1.0E-08	4.9E-09	4.2E-09	2.0E-09	1.40E-02 B2
ACENAPTHYLENE	0 31	0 2633	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
PHENANTHRENE	0 93	0 63	3 64E-07	7 56E-08	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
FLUORANTHENE	1 6	1 3067	3 64E-07	7.56E-08	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
PYRENE	2 5	1 6	3 64E-07	7 56E-08	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
BENZO(A)ANTHRACENE	1 05	0 8	3 64E-07	7 56E-08	2.2E-06	1.7E-06	4 6E-07	3 5E-07	5.80E+00 B2
CHRYSENE	1 4	1 0767	3 64E-07	7.56E-08	3 0E-06	2.3E-06	6.1E-07	4.7E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	1 75	1 2333	3 64E-07	7 56E-08	3 7E-06	2.6E-06	7.7E-07	5 4E-07	5.80E+00 B2
BENZO(K)FLUORANTHENE	1	0 4733	3 64E-07	7 56E-08	2.1E-06	1 0E-06	4.4E-07	2 1E-07	5.80E+00 B2
BENZO(A)PYRENE	1 2	0 8	3 64E-07	7.56E-08	2.5E-06	1.9E-06	5 3E-07	3 9E-07	5.80E+00 B2
INDENO(123-CD)PYRENE	0 635	0 4533	3 64E-07	7 56E-08	1.3E-06	9 6E-07	2.6E-07	2 0E-07	5.80E+00 B2
BENZO(GHI)PERYLENE	0 73	0 4917	3 64E-07	7.56E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
BARIUM	58 5	31 56	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	
BERYLUUM	2 2	1 07	3 64E-07	0 00E+00	3 4E-06	1 7E-06	0.0E+00	0 0E+00	4.30E+00 A
COPPER	359	137 83	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	309	164 57	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	36 1	17 28	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ZINC	390	166 3	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	2.7E-06	1.9E-06	3.3E-11	2 2E-06
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	1.8E-05	1.2E-05	3.1E-06	2.2E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	2.1E-05	1.4E-05	3.1E-06	2.2E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

(((

TA 6-22A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
OUTFALL CREEK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0 013	0 013	1 11E-03	2 16E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0 012	0 012	1 11E-03	2 05E-03	1 00E-02	1 1E-03	1 1E-03	1.1E-03	1 1E-03	1 3E-03	1.3E-03	2.5E-03	2.5E-03	2.3E-04	2.3E-04	1.4E-03	1.4E-03	BLOOD
1,4-DICHLOROBENZENE*	0 001	0 001	1 11E-03	1 12E-02		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	UVER
1,2-DICHLOROBENZENE*	0 004	0 004	1 11E-03	1 12E-02	9 00E-02	4 1E-05	4 1E-05	2 3E-04	2 3E-04	4 9E-05	4.9E-05	5.0E-04	5.0E-04	8.7E-08	8.7E-08	2.8E-04	2.8E-04	UVER
CHROMIUM*	0 0056	0 0056	1 11E-03	1 36E-04	1 00E+00	5 1E-08	5 1E-08	3 6E-07	3 6E-07	6.2E-08	6 2E-08	7.7E-07	7.7E-07	1.1E-08	1.1E-08	4.3E-07	4.3E-07	UVER
LEAD*	0 0087	0 0087	1 11E-03	1 36E-04		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	0 00046	0 0005	1 11E-03	1 36E-04	3 00E-04	1 5E-03	1 5E-03	1 0E-04	1.0E-04	1.8E-03	1.8E-03	2.2E-04	2.2E-04	3.1E-04	3.1E-04	1.2E-04	1.2E-04	CNS
BEHP	0 001	0 001	1 11E-03	1 10E-04	2 00E-02	4 6E-06	4 6E-06	2 5E-08	2 5E-08	5.6E-05	5 6E-05	5.5E-08	5.5E-08	9.8E-08	9.8E-08	3.0E-08	3.0E-08	UVER
BARIUM	0 0105	0 0105	1 11E-03	1 36E-04	5 00E-02	1 9E-04	1 9E-04	1 3E-05	1.3E-05	2 3E-04	2.3E-04	2.9E-05	2.9E-05	4.1E-05	4.1E-05	1.6E+05	1.6E-05	BLOOD
MANGANESE	0 14	0 14	1 11E-03	1 36E-04	1 00E-01	1 3E-03	1 3E-03	8 9E-05	8.9E-05	1.6E-03	1.6E-03	1.9E-04	1.9E-04	2.7E-04	2.7E-04	1.1E-04	1.1E-04	CNS
ZINC	0 0479	0 0479	1 11E-03	1 36E-04	2 00E-01	2 2E-04	2 2E-04	1.5E-05	1.5E-05	2.7E-04	2.7E-04	3.3E-05	3.3E-05	4.7E-05	4.7E-05	1.8E-05	1.8E-05	BLOOD
NYANZA SITE CONTAMINANTS*				HAZARD INDEX		2 6E-03	2 6E-03	1 5E-03	1 5E-03	3.2E-03	3.2E-03	3.2E-03	3.2E-03	5.6E-04	5.6E-04	1.6E-03	1.6E-03	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		1 7E-03	1 7E-03	1 2E-04	1.2E-04	2.1E-03	2.1E-03	2.6E-04	2.6E-04	3.7E-04	3.7E-04	1.4E-04	1.4E-04	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		4.3E-03	4 3E-03	1.6E-03	1.6E-03	5.3E-03	5.3E-03	3.4E-03	3.4E-03	9.3E-04	9.3E-04	1.9E-03	1.9E-03	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINTS ABBREVIATIONS

NS NOT SPECIFIED

L/K: LIVER AND KIDNEY

CNS CENTRAL NERVOUS SYSTEM

TABLE 6-22B
RISK RESULTS FOR SURFACE WATER
OUTFALL CREEK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/ KG		CARCINOGENIC RISK RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.013	0.013	3.02E-04	6.61E-04	4.3E-08	4.3E-08	9.5E-08	9.5E-08	1.10E-02 B2
1,2-DICHLOROETHENE*	0.012	0.012	3.02E-04	6.28E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
1,4-DICHLOROBENZENE*	0.001	0.001	3.02E-04	3.43E-03	7.3E-09	7.3E-09	8.2E-08	8.2E-08	2.40E-02 B2
1,2-DICHLOROBENZENE*	0.004	0.004	3.02E-04	3.43E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	0.0056	0.0056	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.0057	0.0057	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	0.00048	0.0005	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BEHP	0.001	0.001	3.02E-04	3.37E-05	4.2E-09	4.2E-09	4.7E-10	4.7E-10	1.40E-02 B2
BARIUM	0.0105	0.0105	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.14	0.14	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	0.0479	0.0479	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	5.0E-08	5.0E-08	1.8E-07	1.8E-07
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	4.2E-09	4.2E-09	4.7E-10	4.7E-10
ALL CHEMICALS OF CONCERN	CANCER RISK	5.5E-08	5.5E-08	1.8E-07	1.8E-07

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

contacting surface waters and sediments under the conditions of the exposure scenarios defined in Section 6.4.

Arsenic, beryllium, and the carcinogenic PAHs are the principal contaminants contributing to the excess lifetime cancer risks estimated for the sediment exposure scenarios. Cancer risks estimated for "other Sudbury River contaminants" not related to Site discharges exceed those estimated for the Nyanza Site contaminants. Estimated cancer risks range from 2.1×10^{-5} (accidental-ingestion, reasonable worst-case scenario) to 2.2×10^{-6} (dermal-contact, average-case scenario). As a point of reference, cancer risks estimated for background sediment concentrations were 1.8×10^{-5} and 8.2×10^{-6} for the reasonable maximum and average case, respectively. Cancer risks estimated for the surface water exposure scenarios do not exceed 1×10^{-6} in any case presented on Table 6-22. Cancer risks estimated for COC concentrations in Outfall Creek would not exceed 1×10^{-4} even if the risks associated with the surface water exposure scenarios were summed with those associated with the sediment exposure scenarios.

6.5.3.7 Risk Assessment Results for the Raceway

The Raceway is fed by Outfall Creek and, in turn, discharges to the Sudbury River. The following organic and inorganic Nyanza Site contaminants were detected in sediment and/or surface water samples collected from this tributary to the Sudbury River:

- Trichloroethene
- Chlorobenzene
- Naphthalene
- Cadmium
- Lead
- 1,2-Dichloroethene
- 1,2-Dichlorobenzene
- Arsenic
- Chromium
- Mercury

No COCs were detected in surface water samples at concentrations in excess of Federal SDWA Primary MCLs. The average mercury concentration detected in the sediments (C_{avg}=0.71 mg/kg) is approximately three times the concentration detected in background samples (C_{avg}=0.27 mg/kg).

Tables 6-23 and 6-24 present risk assessment results for COC concentrations detected in sediments and surface waters, respectively. The hazard quotients and hazard indices calculated do not exceed unity in any of the cases presented. Mercury is not the predominant contaminant contributing to the estimated noncarcinogenic risk. The hazard quotient calculated for one compound only, arsenic, exceeds 0.1 (accidental-ingestion scenario, child and teen receptors). If hazard indices are summed for the

TABLE 6-23A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
RACEWAY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	44	17.071	1.11E-06	2.78E-06		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	1.3	0.567	1.11E-06	2.78E-06	1.00E-02	2.4E-04	1.0E-04	3.0E-04	1.3E-04	1.4E-04	6.3E-05	3.6E-04	1.6E-04	1.3E-05	5.5E-06	6.4E-05	2.8E-05	BLOOD
CHLOROBENZENE*	19.5	5.9175	1.11E-06	2.78E-06	2.00E-02	1.8E-03	5.4E-04	2.2E-03	6.8E-04	1.1E-03	3.3E-04	2.7E-03	8.2E-04	9.5E-05	2.9E-05	4.8E-04	1.4E-04	LIVER
1,2-DICHLOROBENZENE*	7.1	4.3	1.11E-06	5.55E-07	9.00E-02	1.4E-04	8.7E-05	3.6E-05	2.2E-05	8.8E-05	5.3E-05	4.4E-05	2.7E-05	7.7E-06	4.7E-06	7.7E-06	4.7E-06	LIVER
NAPHTHALENE*	6.7	4.0613	1.11E-06	2.78E-07	4.00E-03	3.1E-03	1.9E-03	3.8E-04	2.3E-04	1.9E-03	1.1E-03	4.7E-04	2.8E-04	1.6E-04	1.0E-04	8.2E-05	5.0E-05	BW
ARSENIC*	37.2	24.86	1.11E-06	0.00E+00	3.00E-04	2.3E-01	1.5E-01	0.0E+00	0.0E+00	1.4E-01	9.2E-02	0.0E+00	0.0E+00	1.2E-02	8.1E-03	0.0E+00	0.0E+00	SKIN
CADMIUM*	5.6	2.28	1.11E-06	0.00E+00	5.00E-04	2.0E-02	8.3E-03	0.0E+00	0.0E+00	1.2E-02	5.1E-03	0.0E+00	0.0E+00	1.1E-03	4.5E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	208	155.5	1.11E-06	0.00E+00	1.00E+00	3.8E-04	2.8E-04	0.0E+00	0.0E+00	2.3E-04	1.7E-04	0.0E+00	0.0E+00	2.0E-05	1.5E-05	0.0E+00	0.0E+00	LIVER
LEAD*	758	435.75	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	0.97	0.71	1.11E-06	5.55E-08	3.00E-04	5.9E-03	4.3E-03	1.5E-04	1.1E-04	3.6E-03	2.6E-03	1.8E-04	1.3E-04	3.2E-04	2.3E-04	3.2E-05	2.3E-05	CNS
DICHLOROMETHANE	0.062	0.062	1.11E-06	2.78E-06	6.00E-02	1.9E-06	1.9E-06	2.4E-06	2.4E-06	1.1E-06	1.1E-06	2.9E-06	2.9E-06	1.0E-07	1.0E-07	5.1E-07	5.1E-07	LIVER
ACETONE	0.76	0.485	1.11E-06	2.78E-06	1.00E-01	1.4E-05	8.9E-06	1.7E-05	1.1E-05	8.4E-06	5.4E-06	2.1E-05	1.3E-05	7.4E-07	4.7E-07	3.7E-06	2.4E-06	L/K
BEHP	2.5	2.5	1.11E-06	5.55E-07	2.00E-02	2.3E-04	2.3E-04	5.7E-05	5.7E-05	1.4E-04	1.4E-04	6.9E-05	6.9E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	LIVER
PHENANTHRENE	16	12.113	1.11E-06	2.78E-07	4.00E-03	7.3E-03	5.5E-03	9.1E-04	6.9E-04	4.4E-03	3.4E-03	1.1E-03	8.4E-04	3.9E-04	3.0E-04	2.0E-04	1.5E-04	BW
FLUORANTHENE	20	14.263	1.11E-06	2.78E-07	4.00E-02	9.1E-04	6.5E-04	1.1E-04	8.1E-05	5.6E-04	4.0E-04	1.4E-04	9.9E-05	4.9E-05	3.5E-05	2.4E-05	1.7E-05	L/K
PYRENE	13	9.4	1.11E-06	2.78E-07	3.00E-02	7.9E-04	5.7E-04	9.9E-05	7.2E-05	4.8E-04	3.5E-04	1.2E-04	8.7E-05	4.2E-05	3.1E-05	2.1E-05	1.5E-05	KIDNEY
BENZO(A)ANTHRACENE	11	6.713	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	8.6	5.975	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	5.2	4.263	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	6.3	4.3	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	4.7	3.666	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BARIUM	72.1	44.1	1.11E-06	0.00E+00	5.00E-02	2.6E-03	1.6E-03	0.0E+00	0.0E+00	1.6E-03	9.8E-04	0.0E+00	0.0E+00	1.4E-04	8.6E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	10.15	7.06	1.11E-06	0.00E+00	5.00E-03	3.7E-03	2.6E-03	0.0E+00	0.0E+00	2.3E-03	1.6E-03	0.0E+00	0.0E+00	2.0E-04	1.4E-04	0.0E+00	0.0E+00	NS
COPPER	306	217.75	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	864	456.25	1.11E-06	0.00E+00	1.00E-01	1.6E-02	8.3E-03	0.0E+00	0.0E+00	9.6E-03	5.1E-03	0.0E+00	0.0E+00	8.5E-04	4.5E-04	0.0E+00	0.0E+00	CNS
NICKEL	180	89.89	1.11E-06	0.00E+00	2.00E-02	1.7E-02	8.2E-03	0.0E+00	0.0E+00	1.0E-02	5.0E-03	0.0E+00	0.0E+00	9.1E-04	4.4E-04	0.0E+00	0.0E+00	BW
VANADIUM	51.2	44.6	1.11E-06	0.00E+00	7.00E-03	1.3E-02	1.2E-02	0.0E+00	0.0E+00	8.1E-03	7.1E-03	0.0E+00	0.0E+00	7.2E-04	6.2E-04	0.0E+00	0.0E+00	NS
ZINC	542	365.66	1.11E-06	0.00E+00	2.00E-01	4.9E-03	3.3E-03	0.0E+00	0.0E+00	3.0E-03	2.0E-03	0.0E+00	0.0E+00	2.7E-04	1.8E-04	0.0E+00	0.0E+00	BLOOD
4,4-DDE	0.0212	0.0105	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
4,4-DDD	0.106	0.032	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
AROCLOR 1254	0.566	0.166	3.33E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	2.6E-01	1.7E-01	3.1E-03	1.2E-03	1.6E-01	1.0E-01	3.8E-03	1.4E-03	1.4E-02	9.0E-03	6.6E-04	2.5E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	6.7E-02	4.3E-02	1.2E-03	9.1E-04	4.1E-02	2.6E-02	1.5E-03	1.1E-03	3.6E-03	2.3E-03	2.6E-04	2.0E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3.3E-01	2.1E-01	4.3E-03	2.1E-03	2.0E-01	1.3E-01	5.2E-03	2.5E-03	1.7E-02	1.1E-02	9.2E-04	4.5E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-23B
RISK RESULTS FOR SEDIMENT EXPOSURE
RACEWAY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	44	17 071	3.64E-07	7.56E-07	1.8E-07	6.8E-08	3 7E-07	1.4E-07	1.10E-02 B2
1,2-DICHLOROETHENE*	1 3	0 567	3 64E-07	7.56E-07	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
CHLOROBENZENE*	19 5	5 9175	3 64E-07	7.56E-07	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
1,2-DICHLOROBENZENE*	7 1	4 3	3 64E-07	1.51E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NAPHTHALENE*	6 7	4 0613	3 64E-07	7.56E-08	0.0E+00	0 0E+00	0 0E+00	0.0E+00	
ARSENIC*	37 2	24 96	3 64E-07	0 00E+00	2 4E-05	1.6E-05	0.0E+00	0.0E+00	1.80E+00 A
CADMIUM*	5 6	2 28	3 64E-07	0.00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	208	155 5	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
LEAD*	758	435 75	1 62E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	0 97	0 71	3 64E-07	1.51E-08	0 0E+00	0.0E+00	0 0E+00	0 0E+00	
DICHLOROMETHANE	0 062	0 062	3 64E-07	7 56E-07	1 7E-10	1.7E-10	3 5E-10	3.5E-10	7.50E-03 B2
ACETONE	0 76	0 485	3 64E-07	7 56E-07	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
BEHP	2 5	2 5	3 64E-07	1.51E-07	1.3E-08	1.3E-08	5.3E-09	5.3E-09	1.40E-02 B2
PHENANTHRENE	18	12 113	3 64E-07	7.56E-08	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
FLUORANTHENE	20	14 263	3 64E-07	7 56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PYRENE	13	9 4	3 64E-07	7 56E-08	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
BENZO(A)ANTHRACENE	11	5 713	3 64E-07	7 56E-08	2 3E-05	1 2E-05	4.8E-06	2.5E-06	5.80E+00 B2
CHRYSENE	8 6	5 975	3 64E-07	7.56E-08	1.8E-05	1.3E-05	3 8E-06	2.6E-06	5.80E+00 B2
BENZO(B)FLUORANTHENE	5 2	4 263	3 64E-07	7 56E-08	1 1E-05	9 0E-06	2.3E-06	1.9E-06	5.60E+00 B2
BENZO(K)FLUORANTHENE	6 3	4 3	3 64E-07	7 56E-08	1 3E-05	9.1E-06	2 6E-06	1.9E-06	5.80E+00 B2
BENZO(A)PYRENE	4 7	3 888	3 64E-07	7 56E-08	9 9E-06	8 2E-06	2.1E-06	1.7E-06	5.80E+00 B2
BARIUM	72 1	44 1	3 84E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
BERYLLIUM	10 15	7 06	3 64E-07	0 00E+00	1 6E-05	1.1E-05	0.0E+00	0 0E+00	4.30E+00 A
COPPER	306	217 75	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	864	456 25	3 64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	186	89 89	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
VANADIUM	51 2	44 5	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
ZINC	542	365 88	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	
4,4-DDE	0 0212	0 0105	1 09E-07	7.56E-08	7 9E-10	1.3E-09	5.4E-10	2.7E-10	3.40E-01 B2
4,4-DDD	0 106	0 032	1 09E-07	7 56E-08	2 8E-09	6.4E-10	2.0E-09	5.8E-10	2.40E-01 B2
AROCLOR 1254	0 589	0.199	1.09E-07	0.00E+00	4.9E-07	1.7E-07	0.0E+00	1.2E-07	7.70E+00 B2

NYANZA SITE CONTAMINANTS*		2.5E-05	1.6E-05	3 7E-07	1.4E-07
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	9 2E-05	6 2E-05	1 6E-05	1.1E-05
ALL CHEMICALS OF CONCERN	CANCER RISK	1.2E-04	7.9E-05	1.6E-05	1.1E-05

BEHP: BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-24A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
RACEWAY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.002	0.002	1.11E-03	2.16E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
1,2-DICHLOROETHENE*	0.002	0.002	1.11E-03	2.05E-03	1.00E-02	1.8E-04	1.8E-04	1.9E-04	1.9E-04	2.2E-04	2.2E-04	4.1E-04	4.1E-04	3.9E-05	3.9E-05	2.3E-04	2.3E-04	BLOOD
BARIUM	0.0164	0.0164	1.11E-03	1.38E-04	5.00E-02	3.0E-04	3.0E-04	2.1E-05	2.1E-05	3.6E-04	3.6E-04	4.5E-05	4.5E-05	6.4E-05	6.4E-05	2.5E-05	2.5E-05	BLOOD
MANGANESE	0.2636	0.2636	1.11E-03	1.38E-04	1.00E-01	2.4E-03	2.4E-03	1.7E-04	1.7E-04	2.9E-03	2.9E-03	3.6E-04	3.6E-04	5.2E-04	5.2E-04	2.0E-04	2.0E-04	CNS

NYANZA SITE CONTAMINANTS*				HAZARD INDEX		1.8E-04	1.8E-04	1.9E-04	1.9E-04	2.2E-04	2.2E-04	4.1E-04	4.1E-04	3.9E-05	3.9E-05	2.3E-04	2.3E-04
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		2.7E-03	2.7E-03	1.9E-04	1.9E-04	3.3E-03	3.3E-03	4.1E-04	4.1E-04	5.8E-04	5.8E-04	2.2E-04	2.2E-04
ALL CHEMICALS OF CONCERN				HAZARD INDEX		2.9E-03	2.9E-03	3.8E-04	3.8E-04	3.5E-03	3.5E-03	8.2E-04	8.2E-04	6.2E-04	6.2E-04	4.5E-04	4.5E-04

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINTS ABBREVIATIONS

NS: NOT SPECIFIED

L/K: LIVER AND KIDNEY

CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-24B
RISK RESULTS FOR SURFACE WATER
RACEWAY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/ KG		CARCINOGENIC RISK RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)−1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
TRICHLOROETHENE*	0.002	0.002	3.02E−04	6.61E−04	6.6E−09	6.6E−09	1.5E−08	1.5E−08	1.10E−02 B2
1,2−DICHLOROETHENE*	0.002	0.002	3.02E−04	6.28E−04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	0.0164	0.0164	3.02E−04	4.21E−05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.2635	0.2635	3.02E−04	4.21E−05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	6.6E−09	6.6E−09	1.5E−08	1.5E−08
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	6.6E−09	6.6E−09	1.5E−08	1.5E−08

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

accidental-ingestion and dermal-contact exposure routes for each medium and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. Based on these results, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

The excess lifetime cancer risk estimated for the surface water and sediment exposures slightly exceed the 1E-04 and 9E-05 cancer risk levels (risks summed for the accidental-ingestion and dermal-contact exposure routes) when maximum and average contaminant concentrations are evaluated, respectively. Cancer risk levels associated with surface water exposures do not exceed 1 x 10^{-6}. As a point of reference, cancer risks estimated for COC concentrations detected in background surface waters and sediments were 2E-05 and 9.7E-06 for the reasonable maximum and average case, respectively. Thus, risks summed for Raceway surface waters and sediments exposures are an order of magnitude higher than background risks. The principal COCs contributing to estimated risk are the carcinogenic PAHs, the PCB Aroclor-1254, arsenic, beryllium and trichloroethene. Although arsenic and trichloroethene are Nyanza Site contaminants, the total cancer risk estimated for "other Sudbury River COCs" exceeds that estimated for all Nyanza Site contaminants. The total cancer risk estimated for Nyanza Site contaminants alone was approximately 2.5E-05 and 1.6E-07 when maximum and average contaminant concentrations were evaluated, respectively. Cancer risks estimated for the surface water exposure scenarios are minimal when compared to those estimated for sediments.

6.5.3.8 Risk Assessment Results for Cold Spring Brook

Cold Spring Brook is a tributary of the Sudbury River which is fed by discharges from the Cold Spring Culvert. Neither surface water body receives surface runoff from the Nyanza Site. Contaminant concentrations in surface water and sediment samples collected from the Brook are minimal compared to concentrations detected in areas that are obviously impacted by Nyanza Site contamination such as the Eastern Wetlands. No Nyanza Site contaminants were detected in surface water samples collected from the Brook. Arsenic, chromium, and lead were the only Nyanza Site contaminants detected in sediment samples. Mercury was not detected in environmental samples collected from the Brook.

Tables 6-25 and 6-26 present risk assessment results for COC concentrations detected in sediments and surface waters, respectively. The accidental-ingestion and dermal-contact routes

TABLE 6-25A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
COLD SPRING BROOK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	4 3	3 5	1 11E-06	0 00E+00	3 00E-04	2 6E-02	2 1E-02	0 0E+00	0 0E+00	1 6E-02	1.3E-02	0.0E+00	0.0E+00	1.4E-03	1.1E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	16 7	15 15	1 11E-06	0 00E+00	1 00E+00	3 1E-05	2 8E-05	0 0E+00	0.0E+00	1.9E-05	1.7E-05	0.0E+00	0.0E+00	1.6E-06	1.5E-06	0.0E+00	0.0E+00	LIVER
LEAD*	326	234	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
BARIUM	65 5	60	1 11E-06	0 00E+00	5 00E-02	2 4E-03	2 2E-03	0 0E+00	0 0E+00	1.5E-03	1 3E-03	0.0E+00	0.0E+00	1.3E-04	1.2E-04	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	1 9	1	1 11E-06	0 00E+00	5 00E-03	6 8E-04	3.7E-04	0 0E+00	0 0E+00	4 2E-04	2.2E-04	0.0E+00	0.0E+00	3.7E-05	2.0E-05	0.0E+00	0.0E+00	NS
COPPER	32 9	31 5	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	854	650	1 11E-06	0 00E+00	1 00E-01	1 6E-02	1 2E-02	0.0E+00	0.0E+00	9.5E-03	7.3E-03	0.0E+00	0.0E+00	8.4E-04	6.4E-04	0.0E+00	0.0E+00	CNS
VANADIUM	41 4	30 9	1 11E-06	0 00E+00	7 00E-03	1 1E-02	8.1E-03	0.0E+00	0 0E+00	6 6E-03	4.9E-03	0.0E+00	0.0E+00	5.8E-04	4.3E-04	0.0E+00	0.0E+00	NS
ZINC	166	146	1 11E-06	0 00E+00	2 00E-01	1 5E-03	1.4E-03	0 0E+00	0 0E+00	9 2E-04	8.2E-04	0.0E+00	0.0E+00	6.1E-05	7.2E-05	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	2 6E-02	2 1E-02	0 0E+00	0 0E+00 *	1.6E-02	1.3E-02	0.0E+00	0.0E+00 *	1.4E-03	1.1E-03	0 0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	3 1E-02	2 4E-02	0.0E+00	0 0E+00 *	1.9E-02	1.5E-02	0.0E+00	0.0E+00 *	1.7E-03	1.3E-03	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	HAZARD INDEX	5 7E-02	4 5E-02	0.0E+00	0 0E+00	3.5E-02	2.8E-02	0.0E+00	0.0E+00	3.1E-03	2.4E-03	0.0E+00	0.0E+00

TOXICITY ENDPOINTS ABBREVIATIONS NS NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-25B
RISK RESULTS FOR SEDIMENT EXPOSURE
COLD SPRING BROOK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	4.3	3.5	3.64E-07	0.00E+00	2.8E-06	2.3E-06	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	16.7	15.15	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	328	234	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	65.5	59	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	1.9	1	3.64E-07	0.00E+00	3.0E-06	1.6E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	32.9	31.5	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	854	658	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	41.4	30.9	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	166	148	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	2.8E-06	2.3E-06	0.0E+00	0.0E+00 *
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	3.0E-06	1.6E-06	0.0E+00	0.0E+00 *
ALL CHEMICALS OF CONCERN	CANCER RISK	5.8E-06	3.9E-06	0.0E+00	0.0E+00

FINAL

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TABLE 6-26A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
COLD SPRING BROOK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT		MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
BEHP	0.058	0.058	1.11E-03	1.10E-04	2.00E-02	2.6E-03	2.6E-03	1.5E-04	1.5E-04	3.2E-03	3.2E-03	3.2E-04	3.2E-04	5.7E-04	5.7E-04	1.8E-04	1.8E-04	LIVER
MANGANESE	0.108	0.108	1.11E-03	1.36E-04	1.00E-01	9.9E-04	9.9E-04	6.9E-05	6.9E-05	1.2E-03	1.2E-03	1.5E-04	1.5E-04	2.1E-04	2.1E-04	8.2E-05	8.2E-05	CNS
SILVER	0.0139	0.0139	1.11E-03	1.36E-04	3.00E-03	4.2E-03	4.2E-03	3.0E-04	3.0E-04	5.1E-03	5.1E-03	6.4E-04	6.4E-04	9.1E-04	9.1E-04	3.5E-04	3.5E-04	ARGYRIA
NYANZA SITE CONTAMINANTS*			HAZARD INDEX			0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			HAZARD INDEX			7.9E-03	7.9E-03	5.1E-04	5.1E-04	9.6E-03	9.6E-03	1.1E-03	1.1E-03	1.7E-03	1.7E-03	6.1E-04	6.1E-04	
ALL CHEMICALS OF CONCERN			*HAZARD INDEX*			*7.9E-03*	*7.9E-03*	*5.1E-04*	*5.1E-04*	*9.6E-03*	*9.6E-03*	*1.1E-03*	*1.1E-03*	*1.7E-03*	*1.7E-03*	*6.1E-04*	*6.1E-04*	

TOXICITY ENDPOINTS ABBREVIATIONS: NS. NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6−26B
RISK RESULTS FOR SURFACE WATER
COLD SPRING BROOK
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)−1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
BEHP	0.058	0.058	3.02E−04	3.37E−05	2.5E−07	2.5E−07	2.7E−08	2.7E−08	1.40E−02 B2
MANGANESE	0.108	0.108	3.02E−04	4.21E−05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.0139	0.0139	3.02E−04	4.21E−05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS*			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		2.5E−07	2.5E−07	2.7E−08	2.7E−08	
ALL CHEMICALS OF CONCERN			CANCER RISK		2.5E−07	2.5E−07	2.7E−08	2.7E−08	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices calculated for COC concentrations in surface waters and sediments do not exceed unity in any of the cases presented. None of the hazard quotients presented exceed 0.1. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes for each medium and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated for a receptor contacting surface waters and sediments under the conditions of recreational exposure scenarios defined in Section 6.4.

The excess lifetime cancer risks estimated for the surface water and sediment exposures are approximately 6E-06 and 4E-06 (risks summed for the accidental-ingestion and dermal-contact exposure routes) when the reasonable maximum-case and average-case scenarios are evaluated, respectively. These cancer risks are less than those estimated for background sample concentrations. Arsenic, beryllium, and bis(2-ethylhexyl)phthalate are the COCs contributing to the estimated excess lifetime cancer risk.

6.5.3.9 Risk Assessment Results for Reach 3

Sudbury River Reach 3 is a primary sedimentation area directly downstream of Reach 2. The Reach ends at Dam No. 2 which divides Reservoirs No. 2 and No. 1. Several Nyanza Site contaminants were detected in Reach 3 surface waters and sediments:

- Mercury
- Methyl mercury
- Arsenic
- Antimony
- Cadmium
- Chromium
- Lead
- 1,4-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Naphthalene

The average concentration of mercury (C_{avg}=15.98 mg/kg) in Reach 3 sediment samples was 60 times the average mercury concentration in background sediment samples. Monomethyl mercury and dimethyl mercury were detected in Reach 3 sediments.

Table 6-27 and 6-28 present risk assessment results for COC concentrations detected in sediments and surface water of Reach 3. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The majority of the noncarcinogenic risk is attributable to Nyanza site-specific COCs. The hazard quotients presented for arsenic and mercury exceed 0.1 in one or more cases

TABLE 6-27A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 3
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT		MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
1,4-DICHLOROBENZENE*	0 1256	0 1256	1 11E-06	5 55E-07		0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER
124TRICHLOROBENZENE*	0 18	0 1253	1 11E-06	5 55E-07	1 30E-03	2 5E-04	1 8E-04	6 3E-05	4 4E-05	1.5E-04	1.1E-04	7.7E-05	5.4E-05	1.4E-05	9 4E-06	1.4E-05	9.4E-06	SKIN
NAPHTHALENE*	0 12	0 12	1 11E-06	2 78E-07	4 00E-03	5 5E-05	5 5E-05	6 8E-06	6 8E-06	3.3E-05	3.3E-05	8.3E-06	8.3E-06	2.8E-06	2.8E-06	1.5E-06	1.5E-06	BW
ARSENIC*	21 5	7 61	1 11E-06	0 00E+00	3 00E-04	1 3E-01	4 6E-02	0 0E+00	0 0E+00	8 0E-02	2 8E-02	0.0E+00	0.0E+00	7.0E-03	2.5E-03	0.0E+00	0.0E+00	SKIN
ANTIMONY*	18	4 11	1 11E-06	0 00E+00	4 00E-04	8 2E-02	1 9E-02	0.0E+00	0 0E+00	5 0E-02	1 1E-02	0.0E+00	0.0E+00	4.4E-03	1.0E-03	0.0E+00	0.0E+00	BLOOD
CADMIUM*	19 8	4 96	1 11E-06	0 00E+00	5 00E-04	7 3E-02	1.8E-02	0 0E+00	0.0E+00	4.4E-02	1.1E-02	0.0E+00	0.0E+00	3 9E-03	9.7E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	2620	292 82	1 11E-06	0 00E+00	1 00E+00	4 8E-03	5 3E-04	0 0E+00	0 0E+00	2.9E-03	3.3E-04	0.0E+00	0.0E+00	2.6E-04	2.9E-05	0.0E+00	0.0E+00	LIVER
LEAD*	285	137 87	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	54 6	15 96	1 11E-06	5 55E-08	3 00E-04	3 3E-01	9 7E-02	8 3E-03	2 4E-03	2.0E-01	5.9E-02	1.0E-02	3.0E-03	1.8E-02	5.2E-03	1.8E-03	5.2E-04	CNS
MONOMETHYLMERCURY*	0 0263	0 0263	1 11E-06	4 20E-06	3 00E-04	1 6E-04	1 6E-04	3 1E-04	3 1E-04	9.7E-05	9.7E-05	3.7E-04	3.7E-04	8 8E-06	8.8E-06	6.6E-05	6.6E-05	CNS
DIMETHYLMERCURY*	0 0191	0 0074	1 11E-06	4 20E-06	3 00E-04	1 2E-04	4 5E-05	2 2E-04	8 7E-05	7.1E-05	2.8E-05	2.7E-04	1.1E-04	6.2E-06	2.4E-06	4.8E-05	1.9E-05	CNS
ACETONE	0 31	0 1312	1 11E-06	2 78E-06	1 00E-01	5 7E-06	2 4E-06	7.1E-06	3 0E-06	3 4E-06	1.5E-06	8.6E-06	3.6E-06	3.0E-07	1.3E-07	1.5E-06	6.4E-07	L/K
BEHP	0 91	0 7906	1 11E-06	5 55E-07	2 00E-02	8 3E-05	7 2E-05	2 1E-05	1 8E-05	5.1E-05	4.4E-05	2.5E-05	2.2E-05	4.5E-06	3.9E-06	4.5E-06	3.9E-06	LIVER
ACENAPTHYLENE	0 88	0 8188	1 11E-06	2 78E-07	4 00E-03	4 0E-04	3 7E-04	5 0E-05	4 7E-05	2.4E-04	2.3E-04	6.1E-05	5.7E-05	2.2E-05	2.0E-05	1.1E-05	1.0E-05	NS
PHENANTHRENE	7 3	1 3678	1 11E-06	2 78E-07	4 00E-03	3 3E-03	6 2E-04	4 2E-04	7.8E-05	2.0E-03	3.8E-04	5.1E-04	9.5E-05	1.8E-04	3.3E-05	8.9E-05	1.7E-05	BW
FLUORANTHENE	12	2 3317	1 11E-06	2 78E-07	4 00E-02	5 5E-04	1.1E-04	6 8E-05	1.3E-05	3.3E-04	6.5E-05	8.3E-05	1.6E-05	2.9E-05	5.7E-06	1.5E-05	2.9E-06	L/K
PYRENE	11	2 4011	1 11E-06	2 78E-07	3 00E-02	6 7E-04	1.5E-04	8.4E-05	1.8E-05	4.1E-04	9.1E-05	1.0E-04	2.3E-05	3.6E-05	8.0E-06	1.8E-05	4.0E-06	KIDNEY
BENZO(A)ANTHRACENE	4 6	1 3401	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	7 7	1 7372	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	4 4	1 4058	1 11E-06	2 78E-07		0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	3 8	1 4042	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	4 4	1 2001	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	1 8	0 7858	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
DIBENZ(AH)ANTHRACENE	0 31	0 22	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	1 6	0 7727	1 11E-06	2 78E-07	4 00E-03	7 3E-04	3.5E-04	9 1E-05	4 4E-05	4.4E-04	2.1E-04	1.1E-04	5.4E-05	3.9E-05	1.9E-05	2.0E-05	9.5E-06	NS
BARIUM	118	68 65	1 11E-06	0 00E+00	5 00E-02	4 2E-03	2 6E-03	0 0E+00	0.0E+00	2.6E-03	1.6E-03	0.0E+00	0.0E+00	2.3E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	4 3	1 52	1 11E-06	0 00E+00	5 00E-03	1 6E-03	5 6E-04	0 0E+00	0 0E+00	9.6E-04	3.4E-04	0.0E+00	0.0E+00	6.4E-05	3.0E-05	0.0E+00	0.0E+00	NS
COPPER	454	164 46	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	847	391 42	1 11E-06	0 00E+00	1 00E-01	1 8E-02	7.1E-03	0 0E+00	0 0E+00	9.4E-03	4.3E-03	0.0E+00	0.0E+00	8.3E-04	3.8E-04	0.0E+00	0.0E+00	CNS
NICKEL	86 6	28 43	1 11E-06	0 00E+00	2 00E-02	8.1E-03	2.6E-03	0.0E+00	0 0E+00	4.8E-03	1.6E-03	0.0E+00	0.0E+00	4.3E-04	1.4E-04	0.0E+00	0.0E+00	BW
SELENIUM	4	0 81	1 11E-06	0 00E+00	5 00E-03	1 5E-03	3 0E-04	0 0E+00	0 0E+00	8.9E-04	1.8E-04	0.0E+00	0.0E+00	7.8E-05	1.6E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	67 9	35 02	1 11E-06	0 00E+00	7 00E-03	1 8E-02	9 1E-03	0 0E+00	0 0E+00	1.1E-02	5.6E-03	0.0E+00	0.0E+00	9.5E-04	4.9E-04	0.0E+00	0.0E+00	NS
ZINC	435	177 06	1 11E-06	0 00E+00	2 00E-01	4 0E-03	1 6E-03	0 0E+00	0 0E+00	2.4E-03	9.8E-04	0.0E+00	0.0E+00	2.1E-04	8.7E-05	0.0E+00	0.0E+00	BLOOD
4,4-DDE	0 06	0 0321	3 33E-07	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
4,4-DDD	0 37	0 0648	3 33E-07	2 78E-07		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
NYANZA SITE CONTAMINANTS				HAZARD INDEX		6 2E-01	1 8E-01	8 4E-03	2 5E-03	3.8E-01	1.1E-01	1.0E-02	3.0E-03	3 3E-02	9.7E-03	1.8E-03	5.3E-04	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		5 8E-02	2 6E-02	7 4E-04	2 2E-04	3.5E-02	1.6E-02	9.0E-04	2.7E-04	3.1E-03	1.4E-03	1.6E-04	4 8E-05	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		6 8E-01	2.1E-01	9 1E-03	2 7E-03	4.1E-01	1.3E-01	1.1E-02	3.3E-03	3.7E-02	1.1E-02	2.0E-03	5.8E-04	

TOXICITY ENDPOINTS ABBREVIATIONS. NS NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP: BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-27B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO 3
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			EXPOSURE FACTOR		CANCER RISKS				
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
1,4-DICHLOROBENZENE*	0 1256	0 1256	3 64E-07	1 51E-07	1 1E-09	1 1E-09	4 6E-10	4 6E-10	2 40E-02 B2
124TRICHLOROBENZENE*	0 18	0 1293	3 64E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NAPHTHALENE*	0 12	0 12	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ARSENIC*	21 5	7 61	3 64E-07	0 00E+00	1 4E-05	5 0E-06	0 0E+00	0 0E+00	1 80E+00 A
ANTIMONY*	18	4 11	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CADMIUM*	19 9	4 90	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHROMIUM*	2620	292 82	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
LEAD*	265	137 07	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MERCURY*	54 8	15 98	3 64E-07	1 51E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MONOMETHYLMERCURY*	0 0283	0 0283	3 64E-07	1 18E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
DIMETHYLMERCURY*	0 0181	0 0074	3 64E-07	1 18E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ACETONE	0 31	0 1312	3 64E-07	7 56E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BEHP	0 91	0 7908	3 64E-07	1 51E-07	4 6E-09	4 0E-09	1 9E-09	1 7E-09	1 40E-02 B2
ACENAPTHYLENE	0 88	0 8180	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PHENANTHRENE	7 3	1 3678	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
FLUORANTHENE	12	2 3317	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PYRENE	11	2 4611	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BENZO(A)ANTHRACENE	4 5	1 3481	3 64E-07	7 56E-08	9 5E-06	2 9E-06	2 0E-06	5 9E-07	5 80E+00 B2
CHRYSENE	7 7	1 7372	3 64E-07	7 56E-08	1 6E-05	3 7E-06	3 4E-06	7 6E-07	5 80E+00 B2
BENZO(B)FLUORANTHENE	4 4	1 4958	3 64E-07	7 56E-08	9 3E-06	3 2E-06	1 9E-06	6 6E-07	5 80E+00 B2
BENZO(K)FLUORANTHENE	3 9	1 4842	3 64E-07	7 56E-08	8 2E-06	3 2E-06	1 7E-06	6 5E-07	5 80E+00 B2
BENZO(A)PYRENE	4 4	1 2081	3 64E-07	7 56E-08	9 3E-06	2 6E-06	1 9E-06	5 3E-07	5 80E+00 B2
INDENO(123-CD)PYRENE	1 8	0 7858	3 64E-07	7 56E-08	3 8E-06	1 7E-06	7 9E-07	3 4E-07	5 80E+00 B2
DIBENZ(AH)ANTHRACENE	0 31	0 22	3 64E-07	7 56E-08	6 5E-07	4 6E-07	1 4E-07	9 6E-08	5 80E+00 B2
BENZO(GHI)PERYLENE	1 8	0 7727	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BARIUM	110	98 85	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLLIUM	4 3	1 52	3 64E-07	0 00E+00	6 7E-06	2 4E-06	0 0E+00	0 0E+00	4 30E+00 A
COPPER	454	104 48	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MANGANESE	847	301 42	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
NICKEL	88 8	28 43	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
SELENIUM	4	0 81	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
VANADIUM	67 9	35 02	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ZINC	435	177 08	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
4,4-DDE	0 06	0 0321	1 08E-07	7 56E-08	2 2E-09	4 0E-09	1 5E-09	8 2E-10	3 40E-01 B2
4,4-DDD	0 37	0 0848	1 08E-07	7 56E-08	9 7E-09	2 2E-09	6 7E-09	1 5E-09	2 40E-01 B2
NYANZA SITE CONTAMINANTS			CANCER RISK		1 4E-05	5 0E-06	4 6E-10	4 6E-10	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		6 4E-05	2 0E-05	1 2E-05	3 6E-06	
ALL CHEMICALS OF CONCERN			CANCER RISK		7 8E-05	2 5E-05	1.2E-05	3.6E-06	

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-28A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO. 3
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
LEAD*	0 001	0 001	1 11E-03	1 38E-04		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
BEHP	0 001	0 001	1.11E-03	1.10E-04	2.00E-02	4.8E-05	4.8E-05	2.5E-06	2.5E-06	5.6E-05	5.6E-05	5.5E-06	5.5E-06	9.8E-06	9.8E-06	3.0E-06	3.0E-06	LIVER
BARIUM	0 0126	0 0006	1 11E-03	1 38E-04	6 00E-02	2 3E-04	1.0E-05	1.6E-05	7.2E-07	2.8E-04	1.2E-05	3.5E-05	1.5E-06	4.9E-05	2.2E-06	1.9E-05	8.5E-07	BLOOD
MANGANESE	0 0636	0 0634	1.11E-03	1 38E-04	1 00E-01	7 6E-04	5 6E-04	5.3E-05	4.0E-05	9.3E-04	7.0E-04	1.2E-04	8.7E-05	1.6E-04	1.2E-04	6.3E-05	4.8E-05	CNS
SELENIUM	19 3	3 8615	1 11E-03	1 38E-04	5 00E-03	3 5E+00	7.1E-01	2 5E-01	4 9E-02	4.3E+00	6.6E-01	5.3E-01	1.1E-01	7.6E-01	1.5E-01	2.9E-01	5.9E-02	SELENOSIS
SILVER	0 0119	0 0069	1 11E-03	1 38E-04	3 00E-03	3 6E-03	2.1E-03	2 5E-04	1.5E-04	4.4E-03	2.6E-03	5.5E-04	3.2E-04	7.8E-04	4.5E-04	3.0E-04	1.8E-04	ARGYRIA
ZINC	0 008	0 008	1 11E-03	1 38E-04	2.00E-01	3.7E-05	3.7E-05	2.5E-06	2.5E-06	4.4E-05	4.4E-05	5.5E-06	5.5E-06	7.8E-06	7.8E-06	3.0E-06	3.0E-06	BLOOD
NYANZA SITE CONTAMINANTS*				HAZARD INDEX		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		3 5E+00	7.1E-01	2.5E-01	4.9E-02	4.3E+00	8.6E-01	5.3E-01	1.1E-01	7.8E-01	1.5E-01	2.9E-01	5.9E-02	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		3.5E+00	7.1E-01	2.5E-01	4.9E-02	4.3E+00	8.6E-01	5.3E-01	1.1E-01	7.6E-01	1.5E-01	2.9E-01	5.9E-02	

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS: CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6-28B
RISK RESULTS FOR SURFACE WATER
REACH NO 3
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-/ WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
LEAD*	0.001	0.001	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BEHP	0.001	0.001	3.02E-04	3.37E-05	4.2E-09	4.2E-09	4.7E-10	4.7E-10	1.40E-02
BARIUM	0.0126	0.0006	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.0836	0.0634	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	19.3	3.8615	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.0119	0.0069	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	0.008	0.008	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	4.2E-09	4.2E-09	4.7E-10	4.7E-10
ALL CHEMICALS OF CONCERN	CANCER RISK	4.2E-09	4.2E-09	4.7E-10	4.7E-10

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

presented. Noncarcinogenic risk estimated for the accidental-ingestion-of-sediment exposure route exceeds those presented for the dermal-contact exposure route. If hazard indices are summed for the accidental-ingestion and dermal-contact routes of exposure, the hazard index for the sediment exposure scenarios does not exceed unity. These results suggest that adverse noncarcinogenic health effects would not be anticipated under the conditions of the recreational exposure scenarios for sediments defined in Section 6.4.

If selenium (maximum surface water concentration = 19,300 µg/L) is excluded from the assessment, the hazard index calculated for the surface water exposures does not exceed unity (Table 6-28). Assuming the accidental ingestion of surface waters while swimming or wading, the hazard quotient for selenium is greater than unity when maximum contaminant concentrations are evaluated. However, it should be noted the selenium was detected only once in Sudbury River surface waters. Selenium was not detected in the sediment samples collected from Reach 3. The positive detection of 19,300 µg/L selenium in one surface water sample may not be indicative of overall water quality in Reach 3. Lead (maximum concentration (C_{max}=1 µg/L)) was the only Nyanza Site contaminant detected in Reach 3 surface water samples. The concentration detected is lower than the current EPA Action Level for Lead (15 µg/L).

The excess lifetime cancer risks estimated for the surface water and sediment exposure scenarios slightly exceed 8 x 10^{-5} and 2.5 x 10^{-5} (risks summed for the accidental-ingestion and dermal-contact exposure routes) when maximum and average COC concentrations are evaluated, respectively. As a point of reference, cancer risks estimated for COC concentrations detected in background surface waters and sediments were 2 x 10^{-5} and 9.7 x 10^{-6}, respectively. The principal COCs contributing to the risk are the carcinogenic PAHs, arsenic, and beryllium. Cancer risks estimated for the "other Sudbury River contaminants" exceed those estimated for the Nyanza Site contaminants. Cancer risks associated with the surface water exposure scenarios are minimal when compared to those associated with the sediment exposure scenarios.

Hazard indices calculated for all COCs detected in Reservoir No. 2 fish tissue samples exceed unity for all cases presented in Table 6-29. Hazard quotients presented for antimony, arsenic, mercury, methyl mercury, thallium, and zinc exceed unity in one or more cases presented. (It should be noted that anitomy arsenic, and thallium were detected very infrequently in fish tissue samples

TABLE 6-29
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
RESERVOIR NO 2
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
						SPORTSFISHERMEN		SUBSISTENCE FISHERMEN					SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN		MAXIMUM	AVERAGE	MAXIMUM	AVERAGE		SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
ANTIMONY*	15 449	0 562	1 86E-04	1 36E-03	4 00E-04	7 1E+00	2 6E-01	5 2E+01	1 9E+00	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ARSENIC*	1 754	0 106	1 86E-04	1 36E-03	3 00E-04	1 1E+00	6 5E-02	7 9E+00	4 7E-01	SKIN	7.93E-05	5.81E-04	2.5E-04	1.5E-05	1.8E-03	1.1E-04	1.80E+00 A
CADMIUM*	0 052	0 03	1 86E-04	1 36E-03	5 00E-04	1 9E-02	1 1E-02	1 4E-01	8.1E-02	KIDNEY	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	5 669	0 580	1 86E-04	1 36E-03	1 00E+00	1 1E-03	1.1E-04	7 7E-03	7 9E-04	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0 529	0 048	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	7 6	2 106	1 86E-04	1 36E-03	3 00E-04	4 7E+00	1 3E+00	3 4E+01	9 6E+00	CNS	7.93E-05	5.81E-04	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYL MERCURY*	4 2	1 75647	1 86E-04	1 36E-03	3 00E-04	2 6E+00	1.1E+00	1 9E+01	7.9E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0 0E+00	0.0E+00	
ENDOSULFAN II	0 001	0 00073	1 86E-04	1 36E-03	5 00E-05	3 7E-03	2 7E-03	2 7E-02	2 0E-02	KIDNEY	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
DIELDRIN	0 0005	0 0005	1 86E-04	1 36E-03	5 00E-05	1 9E-03	1 9E-03	1 4E-02	1.4E-02	LIVER	7.93E-05	5.81E-04	6 3E-07	6.3E-07	4.6E-06	4.6E-06	1.60E+01 B2
4,4-DDD	0 007	0 00397	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	1.3E-07	7.5E-08	9.8E-07	5.5E-07	2.40E-01 B2
4,4-DDE	0 068	0 01825	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	LIVER	7.93E-05	5.81E-04	1.8E-06	4.9E-07	1.3E-05	3.6E-06	3.40E-01 B2
4,4-DDT	0 002	0 0012	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	LIVER	7.93E-05	5.81E-04	5.4E-08	3.2E-08	4.0E-07	2.4E-07	3.40E-01 B2
ALPHA-CHLORDANE	0 001	0 00083	1 86E-04	1 36E-03	6 00E-05	3 1E-03	2 6E-03	2 3E-02	1 9E-02	LIVER	7.93E-05	5.81E-04	1.0E-07	8.6E-08	7.6E-07	6.3E-07	1.30E+00 B2
GAMMA-CHLORDANE	0 002	0 00108	1 86E-04	1 36E-03	6 00E-05	6 2E-03	3 3E-03	4 5E-02	2 4E-02	LIVER	7.93E-05	5.81E-04	2.1E-07	1.1E-07	1.5E-06	8.0E-07	1.30E+00 B2
ALDRIN	0 001	0 00032	1 86E-04	1 36E-03	3 00E-05	6 2E-03	2 0E-03	4 5E-02	1.5E-02	LIVER	7.93E-05	5.81E-04	1.3E-06	4.4E-07	9 9E-06	3.2E-06	1.70E+01 B2
AROCLOR-1254	0 73	0 09177	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	4.5E-04	5.6E-05	3.3E-03	4.1E-04	7.70E+00 B2
AROCLOR-1260	0 093	0 07646	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	5.7E-05	4.7E-05	4.2E-04	3.4E-04	7.70E+00 B2
COPPER	9 723	0 86	1 86E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	13 752	0 820	1 86E-04	1 36E-03	1 00E-01	2 6E-02	1.5E-03	1 9E-01	1.1E-02	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0 444	0 06	1 86E-04	1 36E-03	3 00E-03	2 7E-02	3 7E-03	2 0E-01	2.7E-02	ARGYRIA	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
THALLIUM	1 349	0 078	1 86E-04	1 36E-03	7 00E-05	3 6E+00	2 1E-01	2 6E+01	1.5E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	1 161	0 322	1 86E-04	1 36E-03	7 00E-03	3 1E-02	8 5E-03	2 2E-01	6 2E-02	NS	7.93E-05	5.81E-04	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
ZINC	178 539	10 614	1 86E-04	1 36E-03	2 00E-01	1 7E-01	1 7E-02	1 2E+00	1.3E-01	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	1 3E+01	1 7E+00	9 5E+01	2.0E+01	CANCER RISKS:	2.5E-04	1.5E-05	1.8E-03	1.1E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	3 6E+00	2 6E-01	2 6E+01	1 6E+00	CANCER RISKS:	5.1E-04	1.0E-04	3 7E-03	7.7E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1 7E+01	1.9E+00	1 2E+02	2 2E+01	CANCER RISKS:	7.6E-04	1.2E-04	5.5E-03	8.8E-04

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS

NS: NOT SPECIFIED

BW: BODY WEIGHT

CNS: CENTRAL NERVOUS SYSTEM

L/K: LIVER AND KIDNEY

collected during the Sudbury River RI). The hazard indices presented for the Nyanza Site contaminants exceed those estimated for the "other Sudbury River contaminants." All of these results suggest that adverse noncarcinogenic health effects may be anticipated for the sports fishermen or subsistence fishermen consuming fish taken from Reservoir No. 2 under the conditions of the exposure scenarios defined in Section 6.4. The maximum and average mercury and methyl mercury concentrations detected in the fish tissue samples exceed the current FDA Action Level.

Cancer risks estimated for the sports fishermen and subsistence fishermen exceed 1×10^{-4} and 1×10^{-3} for the reasonable maximum- and average-case scenarios, respectively. Several pesticides/PCBs contribute to the estimated risk. However, arsenic is the only Nyanza Site contaminant contributing to the estimated excess lifetime cancer risk. As a point of reference, risks estimated for Sudbury Reservoir fish tissue samples do not exceed 5×10^{-4} even when the subsistence fisherman is the receptor of concern and maximum contaminant concentrations are evaluated.

6.5.3.10 Risk Assessment Results for Reach 4

Sudbury River Reach 4 is also a sedimentation area. The Reach includes Reservoir No. 1 and ends at Dam No. 1 at the Winter Street crossing in Framingham. The following Nyanza Site contaminants were detected in Reach 4 surface waters and sediments:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Methyl mercury

The average mercury concentration detected in Reach No. 4 sediments (C_{avg} = 3.38 mg/kg) is 12 times concentrations detected in background sediment samples (C_{avg} = 0.27 mg/kg).

Tables 6-30 and 6-31 present risk assessment results for COC concentrations detected in sediments and surface waters of Reach 4. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices presented do not exceed unity for any of the cases presented. Only the hazard quotient for arsenic exceeds 0.1 in one case presented. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated for a receptor contacting Reach 4

TABLE 6-30A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 4
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	32.3	10.68	1.11E-06	0.00E+00	3.00E-04	2.0E-01	6.5E-02	0.0E+00	0.0E+00	1.2E-01	4.0E-02	0.0E+00	0.0E+00	1.1E-02	3.5E-03	0.0E+00	0.0E+00	SKIN
CADMIUM*	14.8	4.81	1.11E-06	0.00E+00	5.00E-04	5.4E-02	1.8E-02	0.0E+00	0.0E+00	3.3E-02	1.1E-02	0.0E+00	0.0E+00	2.9E-03	9.4E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	224	71.81	1.11E-06	0.00E+00	1.00E+00	4.1E-04	1.3E-04	0.0E+00	0.0E+00	2.5E-04	8.0E-05	0.0E+00	0.0E+00	2.2E-05	7.0E-06	0.0E+00	0.0E+00	LIVER
LEAD*	218	93.86	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	7.3	3.38	1.11E-06	5.55E-08	3.00E-04	4.4E-02	2.1E-02	1.1E-03	5.1E-04	2.7E-02	1.3E-02	1.4E-03	6.3E-04	2.4E-03	1.1E-03	2.4E-04	1.1E-04	CNS
MONOMETHYLMERCURY*	0.0783	0.0267	1.11E-06	4.28E-06	3.00E-04	4.8E-04	1.6E-04	9.3E-04	3.1E-04	2.9E-04	9.9E-05	1.1E-03	3.8E-04	2.6E-05	8.7E-06	2.0E-04	6.7E-05	CNS
ACETONE	2.6	1.302	1.11E-06	2.78E-06	1.00E-01	4.7E-05	2.5E-05	5.9E-05	3.1E-05	2.9E-05	1.5E-05	7.2E-05	3.6E-05	2.5E-06	1.3E-06	1.3E-05	6.7E-06	L/K
PHENANTHRENE	0.17	0.17	1.11E-06	2.78E-07	4.00E-03	7.8E-05	7.8E-05	9.7E-06	9.7E-06	4.7E-05	4.7E-05	1.2E-05	1.2E-05	4.2E-06	4.2E-06	2.1E-06	2.1E-06	BW
FLUORANTHENE	0.27	0.26	1.11E-06	2.78E-07	4.00E-02	1.2E-05	1.2E-05	1.5E-06	1.5E-06	7.5E-06	7.2E-06	1.9E-06	1.8E-06	6.6E-07	6.4E-07	3.3E-07	3.2E-07	L/K
PYRENE	0.26	0.255	1.11E-06	2.78E-07	3.00E-02	1.6E-05	1.6E-05	2.0E-06	1.9E-06	9.6E-06	9.4E-06	2.4E-06	2.4E-06	8.5E-07	8.3E-07	4.2E-07	4.2E-07	KIDNEY
BENZO(A)ANTHRACENE	0.11	0.11	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	0.22	0.205	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	0.4	0.275	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	0.15	0.15	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0.15	0.14	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0.094	0.084	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0.092	0.092	1.11E-06	2.78E-07	4.00E-03	4.2E-05	4.2E-05	5.3E-06	5.3E-06	2.6E-05	2.6E-05	6.4E-06	6.4E-06	2.3E-06	2.3E-06	1.1E-06	1.1E-06	NS
BARIUM	135	[illegible]	1.11E-06	0.00E+00	5.00E-02	4.9E-03	2.6E-03	0.0E+00	0.0E+00	3.0E-03	1.6E-03	0.0E+00	0.0E+00	2.6E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	3.6	0.8	1.11E-06	0.00E+00	5.00E-03	1.3E-03	2.9E-04	0.0E+00	0.0E+00	8.0E-04	1.8E-04	0.0E+00	0.0E+00	7.0E-05	1.6E-05	0.0E+00	0.0E+00	NS
COPPER	332	115.85	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
NICKEL	63	28.88	1.11E-06	0.00E+00	2.00E-02	5.8E-03	2.6E-03	0.0E+00	0.0E+00	3.5E-03	1.6E-03	0.0E+00	0.0E+00	3.1E-04	1.4E-04	0.0E+00	0.0E+00	BW
SELENIUM	4	1.74	1.11E-06	0.00E+00	5.00E-03	1.5E-03	6.4E-04	0.0E+00	0.0E+00	8.9E-04	3.9E-04	0.0E+00	0.0E+00	7.8E-05	3.4E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	67.1	34.63	1.11E-06	0.00E+00	7.00E-03	1.8E-02	9.0E-03	0.0E+00	0.0E+00	1.1E-02	5.5E-03	0.0E+00	0.0E+00	9.4E-04	4.8E-04	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS	HAZARD INDEX	3.0E-01	1.0E-01	1.1E-03	5.1E-04	1.6E-01	6.3E-02	1.4E-03	6.3E-04	1.6E-02	5.5E-03	2.4E-04	1.1E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	3.1E-02	1.5E-02	7.8E-05	4.9E-05	1.9E-02	9.3E-03	9.5E-05	6.0E-05	1.7E-03	8.2E-04	1.7E-05	1.1E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3.3E-01	1.2E-01	1.2E-03	5.6E-04	2.0E-01	7.2E-02	1.4E-03	6.9E-04	1.8E-02	6.4E-03	2.5E-04	1.2E-04

TOXICITY ENDPOINTS ABBREVIATIONS   NS NOT SPECIFIED   L/K LIVER AND KIDNEY   BW: BODY WEIGHT   CNS: CENTRAL NERVOUS SYSTEM

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-30B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO. 4
NYANZA OPERABLE UNIT 3
MIDDLESEX CO., MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
ARSENIC*	32 3	10 68	3 64E-07	0.00E+00	2.1E-05	7.0E-06	0.0E+00	0.0E+00	1.80E+00 A
CADMIUM*	14 9	4 81	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	224	71 61	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	219	93 96	1 82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	7 3	3 38	3 64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MONOMETHYLMERCURY*	0 0793	0 0267	3 64E-07	1.16E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ACETONE	2.6	1.362	3 64E-07	7.56E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PHENANTHRENE	0.17	0 17	3 64E-07	7.56E-08	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
FLUORANTHENE	0 27	0 26	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PYRENE	0 26	0 255	3 64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BENZO(A)ANTHRACENE	0.11	0 11	3 64E-07	7.56E-08	2.3E-07	2.3E-07	4.8E-08	4.8E-08	5.80E+00 B2
CHRYSENE	0 22	0 205	3 64E-07	7.56E-08	4.6E-07	4.3E-07	9.6E-08	9.0E-08	5.80E+00 B2
BENZO(B)FLUORANTHENE	0 4	0 275	3.64E-07	7.56E-08	8.4E-07	5.8E-07	1.8E-07	1.2E-07	5.80E+00 B2
BENZO(K)FLUORANTHENE	0 15	0 15	3 64E-07	7.56E-08	3.2E-07	3.2E-07	6.6E-08	6.6E-08	5.80E+00 B2
BENZO(A)PYRENE	0 15	0.14	3 64E-07	7.56E-08	3.2E-07	3.0E-07	6.6E-08	6.1E-08	5.80E+00 B2
INDENO(123-CD)PYRENE	0 094	0 094	3 64E-07	7.56E-08	2.0E-07	2.0E-07	4.1E-08	4.1E-08	5.80E+00 B2
BENZO(GHI)PERYLENE	0 092	0 092	3.64E-07	7.56E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	135	69.91	3 64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	3 6	0 8	3 64E-07	0.00E+00	5.6E-06	1.3E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	332	115.85	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	63	28 69	3 64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	4	1.74	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	67.1	34.63	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	2.1E-05	7.0E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	8.0E-06	3.3E-06	4.9E-07	4.3E-07
ALL CHEMICALS OF CONCERN	CANCER RISK	2.9E-05	1.0E-05	4.9E-07	4.3E-07

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

1 6-31A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO. 4
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/ KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
CHROMIUM*	0.006	0.0046	1.11E-03	1.36E-04	1.00E+00	5.5E-06	4.1E-06	3.8E-07	2.9E-07	6.7E-06	5.0E-06	8.3E-07	6.2E-07	1.2E-06	8.8E-07	4.6E-07	3.4E-07	LIVER
LEAD*	0.0126	0.0069	1.11E-03	1.36E-04		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
BARIUM	0.0247	0.0129	1.11E-03	1.36E-04	5.00E-02	4.5E-04	2.3E-04	3.1E-05	1.6E-05	5.5E-04	2.9E-04	6.8E-05	3.5E-05	9.7E-05	5.0E-05	3.8E-05	2.0E-05	BLOOD
MANGANESE	0.209	0.1269	1.11E-03	1.36E-04	1.00E-01	1.9E-03	1.2E-03	1.3E-04	8.2E-05	2.3E-03	1.4E-03	2.9E-04	1.8E-04	4.1E-04	2.5E-04	1.6E-04	9.8E-05	CNS

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	5.5E-06	4.1E-06	3.8E-07	2.9E-07	6.7E-06	5.0E-06	8.3E-07	6.2E-07	1.2E-06	8.8E-07	4.6E-07	3.4E-07
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	2.4E-03	1.4E-03	1.6E-04	9.9E-05	2.9E-03	1.7E-03	3.6E-04	2.1E-04	5.1E-04	3.0E-04	2.0E-04	1.2E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	2.4E-03	1.4E-03	1.7E-04	9.9E-05	2.9E-03	1.7E-03	3.6E-04	2.1E-04	5.1E-04	3.0E-04	2.0E-04	1.2E-04

TOXICITY ENDPOINTS ABBREVIATIONS. NS NOT SPECIFIED L/K: LIVER AND KIDNEY

CNS CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6-31B
RISK RESULTS FOR SURFACE WATER
REACH NO 4
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/ KG		CARCINOGENIC RISK RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-/ WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
CHROMIUM*	0.006	0.0045	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.0126	0.0069	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	0.0247	0.0129	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.209	0.1289	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

surface water and sediments under the conditions of the recreational exposure scenarios defined in Section 6.4.

The excess lifetime cancer risks estimated for the sediment exposures are 2.9 x 10^{-5} and 1.0 x 10^{-5} (risks summed for the accidental-ingestion and dermal-contact exposure routes) when maximum and average contaminant concentrations are evaluated, respectively. As a point of reference, cancer risks estimated for background sediment concentrations were 1.8 x 10^{-5} and 8.2 x 10^{-6} for the reasonable maximum and average case, respectively. The principal contaminants contributing to the risk are beryllium, the carcinogenic PAHs, and arsenic, a Nyanza Site contaminant.

Risk Assessment Results for Fish Tissue Samples - Reservoir No. 1

Hazard indices calculated for all COCs and the Nyanza Site contaminants exceed unity in all cases presented in Table 6-32 except when average contaminant concentrations are evaluated and a sport fishers man is the receptor of concern. The principal contaminants contributing to the noncarcinogenic risk are mercury, methyl mercury, zinc, and arsenic. The hazard quotients calculated for mercury and methyl mercury exceed unity in all cases except when average contaminant concentrations are evaluated and the sports fishermen is considered the receptor of concern. The hazard quotient calculated for arsenic, another Nyanza Site contaminant, exceeds 0.5 when the reasonable maximum-case scenario is evaluated and the subsistence fisherman is the receptor of concern. Hazard indices calculated for "other Sudbury River contaminants" exceed unity only when maximum contaminant concentrations are evaluated and the subsistence fisherman is considered the receptor of concern. The hazard quotient calculated for zinc exceeds unity (1.8). Hazard quotients calculated for bis(2-ethylhexyl)phthalate, copper, manganese, and vanadium all exceed 0.1 when the reasonable maximum-case scenario is evaluated and the receptor is the subsistence fisherman. Hazard indices calculated on a target organ-specific basis exceed unity in one or more cases when the central nervous system, kidney, or the blood system is considered the target organ of concern. These results suggest that adverse noncarcinogenic health effects would be anticipated for the receptor routinely consuming fish taken from Reservoir No. 1.

Cancer risks estimated for the sports fishermen and subsistence fishermen exceed 1 x 10^{-5} and 1 x 10^{-4}, respectively. Several pesticides, bis(2-ethylhexyl)phthalate, and arsenic contribute to the estimated risk. These cancer risk levels are similar to those reported for fish tissue samples taken from the Sudbury Reservoir.

TABLE 6-32
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
RESERVOIR NO 1
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR-		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN		SPORTSFISHERMEN		SUBSISTENCE FISHERMEN			SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
						MAXIMUM	AVERAGE	MAXIMUM	AVERAGE				MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
PHENOL*	2 3	0 41036	1 85E-04	1 36E-03	6 00E-01	7 1E-04	1 3E-04	5 2E-03	9 3E-04	FETUS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ARSENIC*	0 114	0 08	1 85E-04	1 36E-03	3 00E-04	7 0E-02	4 9E-02	5 2E-01	3 6E-01	SKIN	7.93E-05	5.81E-04	1.6E-05	1.1E-05	1.2E-04	8.4E-05	1.80E+00 A
CHROMIUM*	8 318	1 086	1 85E-04	1 36E-03	1 00E+00	1 5E-03	2 0E-04	1 1E-02	1 5E-03	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	2 157	0 042	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	4 185	0 748	1 85E-04	1 36E-03	3 00E-04	2 6E+00	4 6E-01	1 9E+01	3.4E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0 0E+00	0.0E+00	
METHYL MERCURY*	3 78	0 98075	1 85E-04	1 36E-03	3 00E-04	2 3E+00	6 1E-01	1 7E+01	4 5E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BEPH	3 3	0 65866	1 85E-04	1 36E-03	2 00E-02	3 1E-02	6 1E-03	2 2E-01	4 5E-02	LIVER	7.93E-05	5.81E-04	3.7E-06	7.3E-07	2.7E-05	5.4E-06	1.40E-02 B2
4,4-DDD	0 02	0 00131	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	LIVER	7.93E-05	5.81E-04	3.8E-07	2.5E-08	2.8E-06	1.8E-07	2.40E-01 B2
4,4-DDE	0 032	0 01773	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	LIVER	7.93E-05	5.81E-04	8.6E-07	4.8E-07	6.3E-06	3.5E-06	3.40E-01 B2
4,4-DDT	0 001	0 00074	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	LIVER	7.93E-05	5.81E-04	2.7E-08	2.0E-08	2.0E-07	1.5E-07	3.40E-01 B2
ALPHA-CHLORDANE	0 0025	0 00164	1 85E-04	1 36E-03	6 00E-05	7 7E-03	5 1E-03	5 7E-02	3 7E-02	LIVER	7.93E-05	5.81E-04	2.6E-07	1.7E-07	1.9E-06	1.2E-06	1.30E+00 B2
GAMMA-CHLORDANE	0 0015	0 001	1 85E-04	1 36E-03	6 00E-05	4 6E-03	3 1E-03	3 4E-02	2.3E-02	LIVER	7.93E-05	5.81E-04	1.5E-07	1.0E-07	1.1E-06	7.6E-07	1.30E+00 B2
AROCLOR-1254	0 039	0 00838	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	2.4E-05	5.1E-06	1.7E-04	3 7E-05	7.70E+00 B2
AROCLOR-1260	0 069	0 0068	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	4.2E-05	4.1E-06	3.1E-04	3.0E-05	7.70E+00 B2
BARIUM	0 167	0 058	1 85E-04	1 36E-03	5 00E-02	6 2E-04	2 1E-04	4 5E-03	1 6E-03	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	8 313	0 57	1 85E-04	1 36E-03		0 0E+00	0 0E+00	0 0E+00	0 0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	10 682	2 264	1 85E-04	1 36E-03	1 00E-01	2 0E-02	4 2E-03	1 4E-01	3.1E-02	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	1 572	0 497	1 85E-04	1 36E-03	7 00E-03	4 2E-02	1 3E-02	3 0E-01	9.6E-02	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	262 464	31 718	1 85E-04	1 36E-03	2 00E-01	2 4E-01	2 9E-02	1 8E+00	2 2E-01	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	2.7E+00	5 1E-01	1 9E+01	3.7E+00	CANCER RISKS:	1.6E-05	1.1E-05	1.2E-04	8.4E-05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	3 5E-01	6 1E-02	2 5E+00	4.5E-01	CANCER RISKS:	7.1E-05	1.1E-05	5.2E-04	7.9E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3 0E+00	5 7E-01	2 2E+01	4 2E+00	CANCER RISKS:	8.8E-05	2.2E-05	6.4E-04	1.6E-04

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS:

NS: NOT SPECIFIED

BW: BODY WEIGHT

CNS: CENTRAL NERVOUS SYSTEM

L/K: LIVER AND KIDNEY

6.5.3.11 Risk Assessment Results for Reach 5

As described in Section 1.0, Sudbury River Reach 5 extends from Dam No. 1 to the Massachusetts Turnpike (Interstate 90) overpass where the River widens. The river flow velocities are higher than in the impounded reservoirs; however, there are low-flow velocity areas present throughout Reach which are conducive to sediment deposition. Four Nyanza Site contaminants where detected in Reach 5 sediments and surface waters:

- Arsenic
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 5 sediments is greater than three times the concentration detected in background sediment samples.

Tables 6-33 and 6-34 present risk assessment results for COC concentrations detected in sediments and surface waters of Reach 5. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices do not exceed unity in any case presented. None of the hazard quotients presented exceed 0.1. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Excess lifetime cancer risks estimated for maximum and average COC concentrations detected in Reach 5 sediments are similar to those estimated for background COC concentrations. Arsenic was the only Nyanza Site contaminant contributing to the risk. Background arsenic sediment concentrations exceed those detected in Reach 5.

As summarized on Table 6-34, cancer risks estimated for surface water exposure scenarios do not exceed 1 x 10^{-6} (risks summed for the accidental-ingestion and dermal-contact exposure routes). Arsenic is the only COC contributing to the estimated risk. As a point of reference, the 1 x 10^{-4} to 1 x 10^{-6} cancer risk range is often evaluated in the development of health-based standards/criteria and in the determination of cleanup goals at hazardous waste sites.

TABLE 6-33A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 5
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS. ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	9 2	3 83	1 11E-06	0 00E+00	3 00E-04	5 6E-02	2 3E-02	0 0E+00	0 0E+00	3 4E-02	1.4E-02	0.0E+00	0.0E+00	3.0E-03	1.2E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	60 6	17 95	1 11E-06	0 00E+00	1 00E+00	1 1E-04	3 3E-05	0 0E+00	0 0E+00	6 7E-05	2.0E-05	0.0E+00	0.0E+00	5.9E-06	1 8E-06	0.0E+00	0.0E+00	UVER
LEAD*	809	237 88	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0.0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0 0E+00	0 0E+00	0.0E+00	CNS
MERCURY*	4 1	0 98	1 11E-06	5 55E-08	3 00E-04	2 5E-02	6.0E-03	6 2E-04	1 5E-04	1.5E-02	3.6E-03	7.6E-04	1.8E-04	1.3E-03	3.2E-04	1.3E-04	3.2E-05	CNS
BEHP	0 33	0 33	1 11E-06	5 55E-07	2 00E-02	3 0E-05	3 0E-05	7.5E-06	7 5E-06	1.8E-05	1.8E-05	9.2E-06	9.2E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	UVER
3/4METHYLPHENOL	0 13	0 13	1 11E-06	5 55E-07	5 00E-02	4 7E-06	4 7E-06	1 2E-06	1 2E-06	2 9E-06	2 9E-06	1.4E-06	1.4E-06	2.5E-07	2.5E-07	2 5E-07	2.5E-07	BW,CNS
ACENAPTHYLENE	0 16	0 16	1 11E-06	2 78E-07	4 00E-03	7 3E-05	7 3E-05	9 1E-06	9 1E-06	4 4E-05	4.4E-05	1.1E-05	1.1E-05	3.9E-06	3.9E-06	2.0E-06	2.0E-06	NS
PHENANTHRENE	0 54	0 54	1 11E-06	2 78E-07	4 00E-03	2 5E-04	2 5E-04	3 1E-05	3.1E-05	1.5E-04	1.5E-04	3.7E-05	3.7E-05	1.3E-05	1.3E-05	6.6E-06	6.6E-06	BW
FLUORANTHENE	1 1	1 1	1 11E-06	2 78E-07	4 00E-02	5 0E-05	5 0E-05	6 3E-06	6 3E-06	3.1E-05	3.1E-05	7.6E-06	7.6E-06	2.7E-06	2.7E-06	1.3E-06	1.3E-06	L/K
PYRENE	1 1	1 1	1 11E-06	2 78E-07	3 00E-02	6 7E-05	6 7E-05	8 4E-06	8.4E-06	4 1E-05	4.1E-05	1.0E-05	1.0E-05	3.6E-06	3.6E-06	1.8E-06	1.8E-06	KIDNEY
BENZO(A)ANTHRACENE	0 47	0 47	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	0 7	0 7	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	1 4	1 4	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0 32	0 32	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0 24	0 24	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0 27	0 27	1 11E-06	2 78E-07	4 00E-03	1 2E-04	1 2E-04	1 5E-05	1 5E-05	7 5E-05	7.5E-05	1 9E-05	1.9E-05	6.6E-06	6.6E-06	3.3E-06	3.3E-06	NS
BARIUM	225	73 18	1 11E-06	0 00E+00	5 00E-02	8 2E-03	2.7E-03	0.0E+00	0 0E+00	5.0E-03	1.6E-03	0.0E+00	0.0E+00	4.4E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD
BERYLUUM	0 25	0 25	1 11E-06	0 00E+00	5 00E-03	9 1E-05	9 1E-05	0 0E+00	0 0E+00	5 6E-05	5.6E-05	0 0E+00	0.0E+00	4.9E-06	4.9E-06	0.0E+00	0 0E+00	NS
COPPER	158	41 67	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1935	699 63	1 11E-06	0 00E+00	1 00E-01	3 5E-02	1 3E-02	0 0E+00	0 0E+00	2.1E-02	7 8E-03	0 0E+00	0.0E+00	1.9E-03	6.8E-04	0.0E+00	0.0E+00	CNS
NICKEL	16 1	6 78	1 11E-06	0 00E+00	2 00E-02	1 5E-03	6 2E-04	0 0E+00	0 0E+00	8.9E-04	3.8E-04	0 0E+00	0.0E+00	7.9E-05	3 3E-05	0.0E+00	0 0E+00	BW
SILVER	6 4	1 9	1 11E-06	0 00E+00	3 00E-03	3 9E-03	1 2E-03	0.0E+00	0 0E+00	2.4E-03	7.0E-04	0.0E+00	0.0E+00	2.1E-04	6 2E-05	0.0E+00	0.0E+00	ARGYRIA
SELENIUM	0 44	0 43	1 11E-06	0 00E+00	5 00E-03	1 6E-04	1 6E-04	0.0E+00	0.0E+00	9.8E-05	9.6E-05	0.0E+00	0.0E+00	8.6E-06	8.4E-06	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	30 7	17 05	1 11E-06	0 00E+00	7 00E-03	8 0E-03	4 4E-03	0.0E+00	0.0E+00	4.9E-03	2.7E-03	0.0E+00	0.0E+00	4.3E-04	2.4E-04	0.0E+00	0.0E+00	NS
ZINC	765	199 88	1 11E-06	0 00E+00	2 00E-01	7 0E-03	1.8E-03	0.0E+00	0.0E+00	4.2E-03	1.1E-03	0.0E+00	0.0E+00	3.7E-04	9.8E-05	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	8 1E-02	2 9E-02	6 2E-04	1 5E-04	4 9E-02	1.8E-02	7.6E-04	1.8E-04	4.3E-03	1.6E-03	1.3E-04	3.2E-05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	6 5E-02	2 4E-02	7 9E-05	7.9E-05	3 9E-02	1.5E-02	9 6E-05	9.6E-05	3.5E-03	1.3E-03	1.7E-05	1.7E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1 5E-01	5 4E-02	7.0E-04	2 3E-04	8.8E-02	3.3E-02	8.5E-04	2.8E-04	7.8E-03	2.9E-03	1.5E-04	4.9E-05

TOXICITY ENDPOINTS ABBREVIATIONS NS: NOT SPECIFIED L/K: UVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP.BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-33B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO 5
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
ARSENIC*	9 2	3 83	3 64E-07	0 00E+00	6 0E-06	2.5E-06	0 0E+00	0 0E+00	1.80E+00 A
CHROMIUM*	60 6	17 95	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
LEAD*	809	237 99	1 62E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MERCURY*	4 1	0 98	3 64E-07	1 51E-08	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
BEHP	0 33	0 33	3 64E-07	1 51E-07	1 7E-09	1.7E-09	7 0E-10	7.0E-10	1.40E-02 B2
3/4METHYLPHENOL	0 13	0 13	3 64E-07	1 51E-07	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
ACENAPTHYLENE	0 16	0 16	3 64E-07	7 56E-08	0 0F+00	0 0E+00	0 0E+00	0.0E+00	
PHENANTHRENE	0 54	0 54	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
FLUORANTHENE	1 1	1 1	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
PYRENE	1 1	1 1	3 64F-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
BENZO(A)ANTHRACENE	0 47	0 47	3 64E-07	7 56E-08	9 9E-07	9 9E-07	2 1E-07	2.1E-07	5.80E+00 B2
CHRYSENE	0 7	0 7	3 64E-07	7 56E-08	1 5E-06	1 5E-06	3.1E-07	3.1E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	1 4	1 4	3 64E-07	7 56E-08	3 0E-06	3 0E-06	6.1E-07	6.1E-07	5.80E+00 B2
BENZO(A)PYRENE	0 32	0 32	3 64E-07	7 56E-08	6 8E-07	6 8E-07	1 4E-07	1.4E-07	5.80E+00 B2
INDENO(123-CD)PYRENE	0 24	0 24	3 64E-07	7 56E-08	5 1E-07	5 1E-07	1 1E-07	1.1E-07	5.80E+00 B2
BENZO(GHI)PERYLENE	0 27	0 27	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
BARIUM	225	73 18	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
BERYLLIUM	0 25	0 25	3 64E-07	0 00E+00	3 9E-07	3.9E-07	0.0E+00	0.0E+00	4.30E+00 A
COPPER	158	41 67	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
MANGANESE	1035	999 83	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	16 1	6 79	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
SILVER	6 4	1 9	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
SELENIUM	0 44	0 43	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	30 7	17 05	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	765	199 88	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	6 0E-06	2.5E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	7 0E-06	7.0E-06	1.4E-06	1.4E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	1.3E-05	9.5E-06	1.4E-06	1.4E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-34A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO 5
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																TOXICITY END-POINT
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT			
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	0.0011	0.00106	1.11E-03	1.38E-04	3.00E-04	3.3E-03	3.2E-03	2.3E-04	2.2E-04	4.1E-03	3.9E-03	5.1E-04	4.8E-04	7.2E-04	6.8E-04	2.8E-04	2.7E-04	SKIN
BARIUM	0.01275	0.01275	1.11E-03	1.38E-04	5.00E-02	2.3E-04	2.3E-04	1.6E-05	1.6E-05	2.6E-04	2.6E-04	3.5E-05	3.5E-05	5.0E-05	5.0E-05	1.9E-05	1.9E-05	BLOOD
MANGANESE	0.106	0.06945	1.11E-03	1.38E-04	1.00E-01	9.7E-04	6.3E-04	6.8E-05	4.4E-05	1.2E-03	7.7E-04	1.5E-04	9.6E-05	2.1E-04	1.4E-04	8.0E-05	5.3E-05	CNS
NYANZA SITE CONTAMINANTS*				HAZARD INDEX		3.3E-03	3.2E-03	2.3E-04	2.2E-04	4.1E-03	3.9E-03	5.1E-04	4.8E-04	7.2E-04	6.8E-04	2.8E-04	2.7E-04	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		1.2E-03	8.7E-04	8.4E-05	6.1E-05	1.5E-03	1.1E-03	1.8E-04	1.3E-04	2.6E-04	1.9E-04	1.0E-04	7.2E-05	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		4.5E-03	4.1E-03	3.2E-04	2.8E-04	5.5E-03	4.9E-03	6.9E-04	6.1E-04	9.7E-04	8.7E-04	3.8E-04	3.4E-04	

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS: CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6-34B
RISK RESULTS FOR SURFACE WATER
REACH NO 5
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-/ WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	0.0011	0.00105	3.02E-04	4.21E-05	6.0E-07	5.7E-07	8.3E-08	8.0E-08	1.80E+00 A
BARIUM	0.01275	0.01275	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.106	0.06945	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS*			CANCER RISK		6.0E-07	5.7E-07	8.3E-08	8.0E-08	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN			CANCER RISK		6.0E-07	5.7E-07	8.3E-08	8.0E-08	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

6.5.3.12 Risk Assessment Results for Reach 6

Sudbury River Reach 6 extends from the Massachusetts Turnpike to the Saxonville Dam at the Central Street crossing. Reach 6 includes ponded areas (depositional areas) behind the Saxonville Dam. Five Nyanza Site contaminants were detected in Reach 6 surface waters and sediments:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 6 sediment samples is greater than 12 times the concentration detected in background samples.

Tables 6-35 and 6-36 present risk assessment results for COC concentrations detected in sediments and surface waters of Reach 6. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices do not exceed unity in any of the cases presented. Only the hazard quotients presented for arsenic and mercury exceed 0.1 (accidental-exposure route, maximum concentrations, child receptor). If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

The excess lifetime cancer risks estimated for sediment exposures are 4.2×10^{-5} and 2.4×10^{-5} (risks summed for the accidental-ingestion and dermal-contact exposure routes) when maximum and average contaminant concentrations are evaluated, respectively. As a point of reference, cancer risks estimated for background sediment concentrations were 1.8×10^{-5} and 8.2×10^{-6} for the reasonable maximum and average case, respectively. The COCs contributing to the risk are bis(2-ethylhexyl)phthalate, the carcinogenic PAHs, 4,4-DDD, beryllium, and arsenic, a Nyanza Site contaminant. The arsenic concentrations detected in Reach 6 sediments (average concentration (C_{MT}=11.1 mg/kg)) are similar to those detected in background samples.

TABLE 6-35A
RISK ASSESSMENT RESULTS FOR SEDIME POSURE SCENARIOS
REACH NO 6
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	24	11.1	1.11E-06	0.00E+00	3.00E-04	1.5E-01	6.9E-02	0.0E+00	0.0E+00	8.9E-02	4.1E-02	0.0E+00	0.0E+00	7.8E-03	3.6E-03	0.0E+00	0.0E+00	SKIN
CADMIUM*	13.6	3.83	1.11E-06	0.00E+00	5.00E-04	5.0E-02	1.4E-02	0.0E+00	0.0E+00	3.0E-02	8.5E-03	0.0E+00	0.0E+00	2.7E-03	7.5E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	281	66.6	1.11E-06	0.00E+00	1.00E+00	5.1E-04	1.2E-04	0.0E+00	0.0E+00	3.1E-04	7.4E-05	0.0E+00	0.0E+00	2.7E-05	6.5E-06	0.0E+00	0.0E+00	LIVER
LEAD*	876	285.85	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	17.8	3.3	1.11E-06	5.55E-08	3.00E-04	1.1E-01	2.0E-02	2.7E-03	5.0E-04	6.5E-02	1.2E-02	3.3E-03	6.1E-04	5.7E-03	1.1E-03	5.7E-04	1.1E-04	CNS
ACETONE	0.57	0.4013	1.11E-06	2.78E-06	1.00E-01	1.0E-05	7.3E-06	1.3E-05	9.2E-06	6.3E-06	4.5E-06	1.6E-05	1.1E-05	5.6E-07	3.9E-07	2.8E-06	2.0E-06	L/K
BEHP	1.9	1.4167	1.11E-06	5.55E-07	2.00E-02	1.7E-04	1.3E-04	4.3E-05	3.2E-05	1.1E-04	7.9E-05	5.3E-05	3.9E-05	9.3E-06	6.9E-06	9.3E-06	6.9E-06	LIVER
PHENANTHRENE	1.6	1.1713	1.11E-06	2.78E-07	4.00E-03	7.3E-04	5.3E-04	9.1E-05	6.7E-05	4.4E-04	3.3E-04	1.1E-04	8.1E-05	3.9E-05	2.9E-05	2.0E-05	1.4E-05	BW
FLUORANTHENE	2.6	1.975	1.11E-06	2.78E-07	4.00E-02	1.2E-04	9.0E-05	1.5E-05	1.1E-05	7.2E-05	5.5E-05	1.8E-05	1.4E-05	6.4E-06	4.8E-06	3.2E-06	2.4E-06	L/K
PYRENE	2.9	2.075	1.11E-06	2.78E-07	3.00E-02	1.8E-04	1.3E-04	2.2E-05	1.6E-05	1.1E-04	7.7E-05	2.7E-05	1.9E-05	9.5E-06	6.8E-06	4.7E-06	3.4E-06	KIDNEY
BENZO(A)ANTHRACENE	1.5	1.0175	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	1.5	1.3067	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	3.4	1.6263	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	0.98	0.8833	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	1.1	0.7883	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0.74	0.5317	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0.82	0.5783	1.11E-06	2.78E-07	4.00E-03	3.7E-04	2.8E-04	4.7E-05	3.3E-05	2.3E-04	1.6E-04	5.7E-05	4.0E-05	2.0E-05	1.4E-05	1.0E-05	7.1E-06	NS
BARIUM	143	85.8	1.11E-06	0.00E+00	5.00E-02	5.2E-03	3.1E-03	0.0E+00	0.0E+00	3.2E-03	1.9E-03	0.0E+00	0.0E+00	2.8E-04	1.7E-04	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	2	0.49	1.11E-06	0.00E+00	5.00E-03	7.3E-04	1.6E-04	0.0E+00	0.0E+00	4.4E-04	1.1E-04	0.0E+00	0.0E+00	3.9E-05	9.6E-06	0.0E+00	0.0E+00	NS
COPPER	303	113.5	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1415	589.3	1.11E-06	0.00E+00	1.00E-01	2.8E-02	1.1E-02	0.0E+00	0.0E+00	1.6E-02	6.5E-03	0.0E+00	0.0E+00	1.4E-03	5.8E-04	0.0E+00	0.0E+00	CNS
NICKEL	78.4	20.3	1.11E-06	0.00E+00	2.00E-02	7.2E-03	1.9E-03	0.0E+00	0.0E+00	4.4E-03	1.1E-03	0.0E+00	0.0E+00	3.6E-04	9.9E-05	0.0E+00	0.0E+00	BW
SELENIUM	6.1	1.37	1.11E-06	0.00E+00	5.00E-03	2.2E-03	5.0E-04	0.0E+00	0.0E+00	1.4E-03	3.0E-04	0.0E+00	0.0E+00	1.2E-04	2.7E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	83	55.8	1.11E-06	0.00E+00	7.00E-03	2.2E-02	1.5E-02	0.0E+00	0.0E+00	1.3E-02	8.9E-03	0.0E+00	0.0E+00	1.2E-03	7.8E-04	0.0E+00	0.0E+00	NS
ZINC	564	292.3	1.11E-06	0.00E+00	2.00E-01	5.2E-03	2.7E-03	0.0E+00	0.0E+00	3.1E-03	1.6E-03	0.0E+00	0.0E+00	2.8E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD
4,4-DDD	0.7	0.3984	3.33E-07	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS	HAZARD INDEX	3.0E-01	1.0E-01	2.7E-03	5.0E-04	1.8E-01	6.2E-02	3.3E-03	6.1E-04	1.6E-02	5.5E-03	5.7E-04	1.1E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	7.0E-02	3.5E-02	2.3E-04	1.7E-04	4.2E-02	2.1E-02	2.8E-04	2.0E-04	3.7E-03	1.9E-03	5.0E-05	3.6E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3.7E-01	1.4E-01	2.9E-03	6.7E-04	2.3E-01	8.3E-02	3.5E-03	6.2E-04	2.0E-02	7.3E-03	6.2E-04	1.4E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-35B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO 6
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	24	11 1	3 64E-07	0 00E+00	1.6E-05	7.3E-06	0.0E+00	0 0E+00	1.80E+00 A
CADMIUM*	13 6	3 63	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
CHROMIUM*	281	66 6	3 64E-07	0 00E+00	0.0E+00	0 0E+00	0 0E+00	0 0E+00	
LEAD*	876	285 65	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
MERCURY*	17 6	3 3	3 64E-07	1 51E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
ACETONE	0 57	0 4013	3 64E-07	7 56E-07	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
BEHP	1 9	1 4167	3 64E-07	1 51E-07	9 7E-09	7 2E-09	4.0E-09	3 0E-09	1.40E-02 B2
PHENANTHRENE	1 6	1 1713	3 64E-07	7 56E-08	0 0E+00	0.0E+00	0.0E+00	0 0E+00	
FLUORANTHENE	2 6	1 975	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
PYRENE	2 9	2 075	3 64E -07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
BENZO(A)ANTHRACENE	1 5	1 0175	3 64E-07	7 56F-08	3 2E-06	2 1E-06	6 6E-07	4.5E-07	5.80E+00 B2
CHRYSENE	1 5	1 3067	3 64E 07	7 56E-08	3.2E-06	2 8E-06	6.6E-07	5.7E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	3 4	1 6263	3 64E-07	7 56E-08	7 2E-06	3.4E-06	1.5E-06	7.1E-07	5.80E+00 B2
BENZO(K)FLUORANTHENE	0 96	0 8833	3 64E-07	7 56E-08	2 1E-06	1.9E-06	4.3E-07	3 9E-07	5.80E+00 B2
BENZO(A)PYRENE	1 1	0 7683	3 64E-07	7 56E-08	2 3E-06	1.7E-06	4.8E-07	3.5E-07	5.80E+00 B2
INDENO(123-CD)PYRENE	0 74	0 5317	3 64E-07	7 56E-08	1 6E-06	1.1E-06	3 2E-07	2.3E-07	5.80E+00 B2
BENZO(GHI)PERYLENE	0 82	0 5763	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0.0E+00	0 0E+00	
BARIUM	143	85 8	3 64E-07	0 00E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	2	0 49	3 64E-07	0 00E+00	3 1E-06	7 7E-07	0.0E+00	0.0E+00	4.30E+00 A
COPPER	303	113 5	3 64E-07	0 00E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
MANGANESE	1415	589 3	3 64E-07	0 00E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
NICKEL	78 4	20 3	3 64E-07	0 00E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	
SELENIUM	8 1	1 37	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	
VANADIUM	63	55 9	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
ZINC	564	292 3	3 64E-07	0 00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
4,4-DDD	0 7	0 3994	1 09E-07	7 56E-08	1.8E-08	1.0E-08	1.3E-08	7.2E-09	2.40E-01 B2

NYANZA SITE CONTAMINANTS	CANCER RISK	1.6E-05	7 3E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	2.3E-05	1.4E-05	4.1E-06	2.7E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	3.8E-05	2.1E-05	4.1E-06	2.7E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-36A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO 6
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/ KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS. CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
LEAD*	0 0024	0 0014	1 11E-03	1 38E-04		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	CNS
BARIUM	0 0162	0 0048	1 11E-03	1 38E-04	8 00E-02	3 0E-04	8 8E-05	2.1E-05	8.1E-06	3.6E-04	1.1E-04	4.5E-05	1.3E-05	6.3E-05	1.9E-05	2.5E-05	7.3E-06	BLOOD
MANGANESE	0 187	0 0984	1 11E-03	1 38E-04	1 00E-01	1 5E-03	8 8E-04	1 1E-04	8.1E-05	1.9E-03	1.1E-03	2.3E-04	1.3E-04	3.3E-04	1.9E-04	1.3E-04	7.3E-05	CNS
NYANZA SITE CONTAMINANTS*				HAZARD INDEX		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		1 8E-03	9 7E-04	1 3E-04	6 8E-05	2 2E-03	1.2E-03	2.7E-04	1.5E-04	3.9E-04	2.1E-04	1.5E-04	8.0E-05	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		1 8E-03	9 7E-04	1 3E-04	6 8E-05	2 2E-03	1.2E-03	2.7E-04	1.5E-04	3.9E-04	2.1E-04	1.5E-04	8.0E-05	

TOXICITY ENDPOINTS ABBREVIATIONS.
NS: NOT SPECIFIED
L/K: LIVER AND KIDNEY
CNS. CENTRAL NERVOUS SYSTEM

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6-36B
RISK RESULTS FOR SURFACE WATER
REACH NO 6
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/ KG		CARCINOGENIC RISK RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)- / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
LEAD*	0.0024	0.0014	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	0.0162	0.0048	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.167	0.0964	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS*			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

The Saxonville impoundment is located within Reach 6 of the Sudbury River basin. The maximum concentration of mercury in the fish tissue samples taken from the impoundment slightly exceeds the FDA Action Level for mercury in fish. Risk assessment results for the fish tissue samples taken are presented in Table 6-37. Hazard quotients calculated for mercury, methyl mercury, and thallium exceed unity in one or more cases except when average contaminant concentrations a sport fishers man is the receptor of concern. presented for all COCs exceed unity for all cases presented are evaluated and Hazard indices presented. It should be noted; however, that thallium was detected very infrequently in fish tissue samples collected from the Sudbury River Study Area. Based on the results presented on Table 6-37, adverse noncarcinogenic health effects are anticipated for the receptors of concern due principally to the mercury and methyl mercury concentrations detected in the fish tissue samples. Adverse noncarcinogenic health effects are anticipated for the sports fisherman only when maximum COC concentrations are evaluated.

Several pesticides and PCBs contribute to the cancer risks estimated for the fish tissue samples collected from the Saxonville impoundment. Cancer risks summed for all COCs exceed 1 x 10^{-5} in all cases presented and approach 1 x 10^{-3} when the subsistence fisherman is evaluated as the receptor of concern. However, the majority of the risk is attributable to COCs that are not Nyanza site-specific contaminants. Cancer risks associated with arsenic, the only Nyanza Site contaminant contributing to the overall cancer risk, do not exceed 5 x 10^{-5} in any case presented in Table 6-37.

6.5.3.13 Risk Assessment Results for Reach 7

As described in Section 1.0, Reach 7 extends from the Saxonville Dam downstream to the Route 20 overpass in Wayland. Downstream of the Saxonville Dam, the low stream gradient results in a slow meandering river with high depositional potential. Five Nyanza Site contaminants were detected in the Reach 7 sediments:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 7 sediments is greater than five times the concentration detected in background sediment samples.

TABLE 6-37
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
SAXONVILLE IMPOUNDMENT
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
						SPORTSFISHERMEN		SUBSISTENCE FISHERMEN					SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN		MAXIMUM	AVERAGE	MAXIMUM	AVERAGE		SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
NAPHTHALENE*	1.9	0.12825	1.85E-04	1.36E-03	4.00E-03	8.8E-02	6.0E-03	6.4E-01	4.4E-02	BW	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
PHENOL*	0.12	0.04475	1.85E-04	1.36E-03	6.00E-01	3.7E-05	1.4E-05	2.7E-04	1.0E-04	FETUS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ANTIMONY*	0.14	0.14	1.85E-04	1.36E-03	4.00E-04	6.5E-02	6.5E-02	4.7E-01	4.7E-01	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ARSENIC*	0.046	0.04	1.85E-04	1.36E-03	3.00E-04	2.8E-02	2.5E-02	2.1E-01	1.8E-01	SKIN	7.93E-05	5.81E-04	6.6E-06	5.7E-06	4.8E-05	4.2E-05	1.80E+00 A
CHROMIUM*	4.278	0.653	1.85E-04	1.36E-03	1.00E+00	7.9E-04	1.2E-04	5.8E-03	8.9E-04	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	0.69	0.031	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	1.8	0.63	1.85E-04	1.36E-03	3.00E-04	1.1E+00	3.9E-01	8.1E+00	2.8E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYL MERCURY*	1.37	0.40285	1.85E-04	1.36E-03	3.00E-04	8.4E-01	2.5E-01	6.2E+00	1.8E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BEPH	0.68	0.16888	1.85E-04	1.36E-03	2.00E-02	6.3E-03	1.6E-03	4.6E-02	1.1E-02	LIVER	7.93E-05	5.81E-04	7.5E-07	1.9E-07	5.5E-06	1.4E-06	1.40E-02 B2
ENDOSULFAN I	0.0015	0.00125	1.85E-04	1.36E-03	5.00E-05	5.5E-03	4.6E-03	4.1E-02	3.4E-02	KIDNEY	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ENDOSULFAN SULFATE	0.001	0.001	1.85E-04	1.36E-03	5.00E-05	3.7E-03	3.7E-03	2.7E-02	2.7E-02	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
DIELDRIN	0.0005	0.00025	1.85E-04	1.36E-03	5.00E-05	1.8E-03	9.2E-04	1.4E-02	6.8E-03	LIVER	7.93E-05	5.81E-04	6.3E-07	3.2E-07	4.6E-06	2.3E-06	1.60E+01 B2
4,4-DDD	0.014	0.00468	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	2.7E-07	8.9E-08	2.0E-06	6.5E-07	2.40E-01 B2
4,4-DDE	0.02	0.0074	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	5.4E-07	2.0E-07	4.0E-06	1.5E-06	3.40E-01 B2
4,4-DDT	0.002	0.00133	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	5.4E-08	3.6E-08	4.0E-07	2.6E-07	3.40E-01 B2
ALPHA-CHLORDANE	0.002	0.002	1.85E-04	1.36E-03	6.00E-05	6.2E-03	6.2E-03	4.5E-02	4.5E-02	LIVER	7.93E-05	5.81E-04	2.1E-07	2.1E-07	1.5E-06	1.5E-06	1.30E+00 B2
GAMMA-CHLORDANE	0.001	0.00084	1.85E-04	1.36E-03	6.00E-05	3.1E-03	2.6E-03	2.3E-02	1.9E-02	LIVER	7.93E-05	5.81E-04	1.0E-07	8.6E-08	7.6E-07	6.3E-07	1.30E+00 B2
HEPTACLOR	0.006	0.00169	1.85E-04	1.36E-03	5.00E-04	2.2E-03	6.2E-04	1.6E-02	4.6E-03	LIVER	7.93E-05	5.81E-04	2.1E-06	6.0E-07	1.6E-05	4.4E-06	4.50E+00 B2
AROCLOR-1254	0.04	0.02018	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	2.4E-05	1.2E-05	1.8E-04	9.0E-05	7.70E+00 B2
AROCLOR-1260	0.11	0.04687	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	6.7E-05	2.9E-05	4.9E-04	2.1E-04	7.70E+00 B2
COPPER	6.1	0.384	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	19.7	2.108	1.85E-04	1.36E-03	1.00E-01	3.6E-02	3.9E-03	2.7E-01	2.9E-02	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	1.24	0.23	1.85E-04	1.36E-03	2.00E-02	1.1E-02	2.1E-03	8.4E-02	1.6E-02	BW	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	0.62	0.164	1.85E-04	1.36E-03	5.00E-03	2.3E-02	6.1E-03	1.7E-01	4.4E-02	SELENOSIS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.24	0.052	1.85E-04	1.36E-03	3.00E-03	1.5E-02	3.2E-03	1.1E-01	2.4E-02	ARGYRIA	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
THALLIUM	1.16	0.056	1.85E-04	1.36E-03	7.00E-05	3.1E+00	1.5E-01	2.3E+01	1.1E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	1.216	0.427	1.85E-04	1.36E-03	7.00E-03	3.2E-02	1.1E-02	2.4E-01	8.3E-02	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	94.763	18.018	1.85E-04	1.36E-03	2.00E-01	8.8E-02	1.7E-02	6.4E-01	1.2E-01	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	1.3E+00	4.8E-01	9.5E+00	5.4E+00		CANCER RISKS:	6.6E-06	5.7E-06	4.8E-05	4.2E-05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	3.4E+00	2.1E-01	2.5E+01	1.5E+00		CANCER RISKS:	9.6E-05	4.3E-05	7.1E-04	3.1E-04
ALL CHEMICALS OF CONCERN	HAZARD INDEX	4.7E+00	6.9E-01	3.4E+01	6.9E+00		CANCER RISKS:	1.0E-04	4.8E-05	7.5E-04	3.5E-04

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS

NS NOT SPECIFIED

BW BODY WEIGHT

CNS: CENTRAL NERVOUS SYSTEM

L/K LIVER AND KIDNEY

Tables 6-38 and 6-39 present risk assessment results for COC concentrations detected in sediments and surface waters of Reach 7. The hazard quotients and hazard indices do not exceed unity in any case presented. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Excess lifetime cancer risks estimated for maximum and average COC concentrations in Reach 7 sediments are approximately two times those estimated for background. The carcinogenic PAHs, beryllium, Aroclor-1254, and arsenic are the principal COCs contributing to the estimated cancer risk. Arsenic is the only Nyanza Site contaminant contributing to risk. However, the average arsenic concentration in Reach 7 sediments (C_{avg}=10.13 mg/kg) is similar to background arsenic concentrations (C_{avg}=8.74 mg/kg).

6.5.3.14 Risk Assessment Results for Reach 8

Sudbury River Reach 8 is a meandering stretch of river with extensive bordering swamps and marshes. The Reach extends from the Route 20 overpass in Wayland to the area of the Route 117 overpass, upstream of the inlet at Fairhaven Bay. Reach 8 includes the Great Meadows National Wildlife Refuge. Five Nyanza Site contaminants were detected in the Reach 8 sediments:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 8 sediments is approximately six times the concentration detected in background samples. Organic contaminant analyses were not conducted in Reach 8 sediment samples.

Table 6-40 presents risk assessment results for COC concentrations detected in sediments of Reach 8. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. (No surface water samples were collected in this Reach.) The hazard quotients and hazard indices calculated do not exceed unity in any of the cases presented. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard

TABLE 6-36A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 7
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	40 6	10 13	1 11E-06	0.00E+00	3 00E-04	2 5E-01	6 2E-02	0 0E+00	0 0E+00	1 5E-01	3.8E-02	0.0E+00	0.0E+00	1.3E-02	3.3E-03	0.0E+00	0.0E+00	SKIN
CADMIUM*	17 9	2 21	1 11E-06	0 00E+00	5.00E-04	6 5E-02	8.1E-03	0.0E+00	0.0E+00	4.0E-02	4.9E-03	0.0E+00	0.0E+00	3.5E-03	4.3E-04	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	209	47 95	1 11E-06	0 00E+00	1.00E+00	3 8E-04	8.8E-05	0.0E+00	0.0E+00	2.3E-04	5.3E-05	0.0E+00	0.0E+00	2.0E-05	4.7E-06	0.0E+00	0.0E+00	LIVER
LEAD*	526	117 94	5 55E-07	0 00E+00		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	5 5	1 62	1 11E-06	5 55E-08	3 00E-04	3 3E-02	9.3E-03	8.4E-04	2.3E-04	2.0E-02	5.6E-03	1.0E-03	2.8E-04	1.8E-03	5.0E-04	1.8E-04	5.0E-05	CNS
ACETONE	1 6	0 871	1 11E-06	2 78E-06	1 00E-01	2 9E-05	1.6E-05	3 7E-05	2 0E-05	1.8E-05	9.7E-06	4.4E-05	2.4E-05	1.6E-06	8.5E-07	7.8E-06	4.3E-06	LIVER
BEHP	1 1	0 846	1 11E-06	5 55E-07	2 00E-02	1 0E-04	7.7E-05	2 5E-05	1 9E-05	6.1E-05	4.7E-05	3.1E-05	2.3E-05	5.4E-06	4.1E-06	5.4E-06	4.1E-06	LIVER
2-METHYLNAPHTHALENE	0 076	0 076	1 11E-06	2.78E-07		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	BW
PHENANTHRENE	1 2	0 593	1 11E-06	2 78E-07	4 00E-03	5 5E-04	2.7E-04	6 8E-05	3.4E-05	3.3E-04	1.6E-04	8.3E-05	4.1E-05	2.9E-05	1.5E-05	1.5E-05	7.3E-06	BW
FLUORANTHENE	1 9	0 953	1 11E-06	2 78E-07	4 00E-02	8 7E-05	4.4E-05	1.1E-05	5.4E-06	5.3E-05	2.6E-05	1.3E-05	6.6E-06	4.6E-06	2.3E-06	2.3E-06	1.2E-06	L/K
PYRENE	1 7	0 876	1 11E-06	2 78E-07	3 00E-02	1 0E-04	5 3E-05	1.3E-05	6 7E-06	6.3E-05	3.2E-05	1.6E-05	8.1E-06	5.5E-06	2.9E-06	2.8E-06	1.4E-06	KIDNEY
BENZO(A)ANTHRACENE	0 88	0 43	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
CHRYSENE	1 2	0 64	1 11E-06	2 78E-07		0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(B)FLUORANTHENE	0 91	0 616	1 11E-06	2.78E-07		0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(K)FLUORANTHENE	0 85	0 446	1 11E-06	2 78E-07		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(A)PYRENE	0 88	0 72	1 11E-06	2 78E-07		0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
INDENO(123-CD)PYRENE	0 64	0 54	1.11E-06	2.78E-07		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
BENZO(GHI)PERYLENE	0 61	0 61	1.11E-06	2 78E-07	4 00E-03	2 8E-04	2 8E-04	3 5E-05	3.5E-05	1.7E-04	1.7E-04	4.2E-05	4.2E-05	1.5E-05	1.5E-05	7.5E-06	7.5E-06	
BARIUM	272	92 42	1.11E-06	0 00E+00	5 00E-02	9 9E-03	3 4E-03	0.0E+00	0 0E+00	6.0E-03	2 1E-03	0.0E+00	0.0E+00	5.3E-04	1.8E-04	0.0E+00	0.0E+00	BLOOD
BERYLUUM	0 61	0 57	1.11E-06	0 00E+00	5 00E-03	2 2E-04	2.1E-04	0 0E+00	0 0E+00	1.4E-04	1.3E-04	0.0E+00	0.0E+00	1.2E-05	1.1E-05	0.0E+00	0.0E+00	NS
COPPER	278	85 94	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1430	366 29	1 11E-06	0 00E+00	1 00E-01	2 6E-02	6.7E-03	0 0E+00	0.0E+00	1.6E-02	4.1E-03	0.0E+00	0.0E+00	1.4E-03	3.6E-04	0.0E+00	0.0E+00	CNS
NICKEL	44 1	11 29	1 11E-06	0 00E+00	2 00E-02	4 0E-03	1 0E-03	0 0E+00	0 0E+00	2.4E-03	6.3E-04	0.0E+00	0.0E+00	2.2E-04	5.5E-05	0.0E+00	0.0E+00	BW
SELENIUM	7 2	1 16	1 11E-06	0 00E+00	5 00E-03	2 6E-03	4.3E-04	0 0E+00	0 0E+00	1.6E-03	2.6E-04	0.0E+00	0.0E+00	1.4E-04	2.3E-05	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	47	19 55	1.11E-06	0 00E+00	7 00E-03	1 2E-02	5.1E-03	0.0E+00	0 0E+00	7 5E-03	3.1E-03	0.0E+00	0.0E+00	6.6E-04	2.7E-04	0.0E+00	0.0E+00	NS
ZINC	646	170 06	1 11E-06	0 00E+00	2 00E-01	5 9E-03	1 6E-03	0 0E+00	0 0E+00	3.6E-03	9.4E-04	0.0E+00	0.0E+00	3.2E-04	8.3E-05	0 0E+00	0.0E+00	BLOOD
CHLORDANE	0 018	0 018	3 33E-07	2 78E-07	6 00E-05	1 6E-04	1 6E-04	6 8E-05	6 8E-05	1 0E-04	1.0E-04	8 3E-05	8.3E-05	8.8E-06	8.8E-06	1.5E-05	1.5E-05	LIVER
AROCLOR 1254	0 51	0 51	3 33E-07	0 00E+00		0 0E+00	0.0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS

NYANZA SITE CONTAMINANTS	HAZARD INDEX	3 5E-01	7.9E-02	8.4E-04	2 3E-04	2.1E-01	4.8E-02	1.0E-03	2.8E-04	1.9E-02	4.2E-03	1.8E-04	5.0E-05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	6 2E-02	1 9E-02	2 6E-04	1 9E-04	3.8E-02	1 2E-02	3.1E-04	2.3E-04	3 3E-03	1.0E-03	5.5E-05	4.0E-05
ALL CHEMICALS OF CONCERN	HAZARD INDEX	4 1E-01	9.8E-02	1 1E-03	4 2E-04	2 5E-01	6.0E-02	1.3E-03	5.1E-04	2.2E-02	5.3E-03	2.3E-04	9.0E-05

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-38B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO 7
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
ARSENIC*	40 6	10 13	3 64E-07	0 00E+00	2 7E-05	6 6E-06	0 0E+00	0 0E+00	1.80E+00 A
CADMIUM*	17 9	2 21	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHROMIUM*	209	47 95	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
LEAD*	526	117 94	1 82E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
MERCURY*	5 5	1 52	3 64E-07	1 51E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
ACETONE	1 6	0 871	3 64E-07	7 56E-07	4 4E-09	2 4E-09	9 1E-09	4 9E-09	7.50E-03 B2
BEHP	1 1	0 846	3 64E-07	1 51E-07	5 6E-09	4 3E-09	2 3E-09	1 8E-09	1.40E-02 B2
2-METHYLNAPHTHALENE	0 078	0 078	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PHENANTHRENE	1 2	0 593	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
FLUORANTHENE	1 9	0 953	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
PYRENE	1 7	0 878	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BENZO(A)ANTHRACENE	0 88	0 43	3 64E-07	7 56E-08	1 9E-06	9 1E-07	3 9E-07	1 9E-07	5 80E+00 B2
CHRYSENE	1 2	0 64	3 64E-07	7 56E-08	2 5E-06	1 4E-06	5 3E-07	2 6E-07	5.80E+00 B2
BENZO(B)FLUORANTHENE	0 91	0 516	3 64E-07	7 56E-08	1 9E-06	1 1E-06	4 0E-07	2 3E-07	5.80E+00 B2
BENZO(K)FLUORANTHENE	0 85	0 446	2 15E-07	5 15E-08	1 1E-06	5 6E-07	2 5E-07	1.3E-07	5.80E+00 B2
BENZO(A)PYRENE	0 88	0 72	3 64E-07	7 56E-08	1 9E-06	1 5E-06	3 9E-07	3 2E-07	5.80E+00 B2
INDENO(123-CD)PYRENE	0 54	0 54	3 64E-07	7 56E-08	1 1E-06	1 1E-06	2 4E-07	2 4E-07	5 80E+00 B2
BENZO(GHI)PERYLENE	0 61	0 61	3 64E-07	7 56E-08	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BARIUM	272	92 42	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
BERYLUUM	0 61	0 57	3 64E-07	0 00E+00	9 5E-07	8 9E-07	0 0E+00	0 0E+00	4.30E+00 A
COPPER	278	65 94	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
MANGANESE	1430	366 29	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
NICKEL	44 1	11 29	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
SELENIUM	7 2	1 18	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
VANADIUM	47	19 55	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	
ZINC	646	170 06	3 64E-07	0 00E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	
CHLORDANE	0 018	0 018	1 09E-07	7 56E-08	2 6E-09	2 6E-09	1 8E-09	1 8E-09	1.30E+00 B2
AROCLOR 1254	0 51	0 51	1 09E-07	0 00E+00	4 3E-07	4 3E-07	0 0E+00	3.0E-07	7.70E+00 B2

NYANZA SITE CONTAMINANTS	CANCER RISK	2 7E-05	6 6E-06	0 0E+00	0 0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	1 2E-05	7.9E-06	2.2E-06	1 7E-06
ALL CHEMICALS OF CONCERN	CANCER RISK	3 8E-05	1.5E-05	2.2E-06	1.7E-06

BEHP:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-39A
RISK ASSESSMENT RESULTS FOR SURFACE WATER EXPOSURE SCENARIOS
REACH NO 7
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD (MG-KG-DAY)	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXICITY END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
BARIUM	0.0213	0.0074	1.11E-03	1.38E-04	5.00E-02	3.9E-04	1.4E-04	2.7E-05	9.4E-06	4.7E-04	1.6E-04	5.9E-05	2.0E-05	8.3E-05	2.9E-05	3.2E-05	1.1E-05	BLOOD
MANGANESE	0.119	0.0745	1.11E-03	1.38E-04	1.00E-01	1.1E-03	6.8E-04	7.6E-05	4.7E-05	1.3E-03	8.3E-04	1.6E-04	1.0E-04	2.3E-04	1.5E-04	9.0E-05	5.7E-05	CNS
SILVER	0.0066	0.0036	1.11E-03	1.38E-04	3.00E-03	2.0E-03	1.1E-03	1.4E-04	7.4E-05	2.4E-03	1.3E-03	3.0E-04	1.6E-04	4.2E-04	2.3E-04	1.6E-04	8.9E-05	ARGYRIA
NYANZA SITE CONTAMINANTS*			HAZARD INDEX			0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			HAZARD INDEX			3.5E-03	1.9E-03	2.4E-04	1.3E-04	4.2E-03	2.3E-03	5.2E-04	2.8E-04	7.4E-04	4.0E-04	2.9E-04	1.6E-04	
ALL CHEMICALS OF CONCERN			HAZARD INDEX			3.5E-03	1.9E-03	2.4E-04	1.3E-04	4.2E-03	2.3E-03	5.2E-04	2.8E-04	7.4E-04	4.0E-04	2.9E-04	1.6E-04	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY
CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-39B
RISK RESULTS FOR SURFACE WATER
REACH NO 7
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN			CARCINOGENIC RISK RESULTS						
	CONCENTRATION MG/ KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)⁻ / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
BARIUM	0.0213	0.0074	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	0.119	0.0745	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SILVER	0.0065	0.0035	3.02E-04	4.21E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS*			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	

BEPH: BIS(2ETHYL HEXYL)PHTHALATE

TABLE 6 - 40A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 8
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG - KG - DAY)	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	30	12 13	1 11E - 06	0 00E + 00	3 00E - 04	1 8E - 01	7 4E - 02	0 0E + 00	0 0E + 00	1.1E - 01	4 5E - 02	0.0E + 00	0.0E + 00	9 8E - 03	4.0E - 03	0.0E + 00	0.0E + 00	SKIN
CADMIUM*	4 3	2 06	1 11E - 06	0 00E + 00	5 00E - 04	1 6E - 02	7 6E - 03	0 0E + 00	0 0E + 00	9 8E - 03	4 6E - 03	0.0E + 00	0.0E + 00	8.4E - 04	4.1E - 04	0.0E + 00	0.0E + 00	KIDNEY
CHROMIUM*	36 4	22	1 11E - 06	0 00E + 00	1 00E + 00	6 6E - 05	4 0E - 05	0 0E + 00	0 0E + 00	4 0E - 05	2.4E - 05	0 0E + 00	0.0E + 00	3.6E - 06	2.2E - 06	0.0E + 00	0.0E + 00	LIVER
LEAD*	100	66 7	5 55E - 07	0 00E + 00		0 0E + 00	0 0E + 00	0 0E + 00	0 0E + 00	0 0E + 00	0 0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	CNS
MERCURY*	2 1	1 62	1 11E - 06	5 55E - 06	3 00E - 04	1 3E - 02	9 8E - 03	3 2E - 04	2 5E - 04	7 8E - 03	6 0E - 03	3 9E - 04	3.0E - 04	6 8E - 04	5.3E - 04	6.8E - 05	5.3E - 05	CNS
BARIUM	222	113 41	1 11E - 06	0 00E + 00	5 00E - 02	8 1E - 03	4 1E - 03	0 0E + 00	0 0E + 00	4 9E - 03	2.5E - 03	0.0E + 00	0.0E + 00	4 3E - 04	2.2E - 04	0.0E + 00	0.0E + 00	BLOOD
COPPER	96	67 61	1 11E - 06	0 00E + 00		0 0E + 00	0 0E + 00	0 0E + 00	0 0E + 00	0 0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	0 0E + 00	0.0E + 00	0.0E + 00	0.0E + 00	NS
MANGANESE	5860	1680 1	1 11E - 06	0 00E + 00	1 00E - 01	1 1E - 01	3 1E - 02	0 0E + 00	0 0E + 00	6 5E - 02	1 9E - 02	0.0E + 00	0.0E + 00	5.7E - 03	1.6E - 03	0.0E + 00	0.0E + 00	CNS
NICKEL	13 1	7 06	1 11E - 06	0 00E + 00	2 00E - 02	1 2E - 03	6 5E - 04	0 0E + 00	0 0E + 00	7 3E - 04	3.9E - 04	0.0E + 00	0.0E + 00	6.4E - 05	3.5E - 05	0.0E + 00	0.0E + 00	BW
SELENIUM	1 8	0 75	1 11E - 06	0 00E + 00	5 00E - 03	6 6E - 04	2 7E - 04	0 0E + 00	0 0E + 00	4 0E - 04	1.7E - 04	0.0E + 00	0.0E + 00	3.5E - 05	1.5E - 05	0.0E + 00	0.0E + 00	SELENOSIS
VANADIUM	12 8	9 72	1 11E - 06	0 00E + 00	7 00E - 03	3 3E - 03	2 5E - 03	0 0E + 00	0 0E + 00	2 0E - 03	1.5E - 03	0.0E + 00	0.0E + 00	1.8E - 04	1 4E - 04	0.0E + 00	0.0E + 00	NS
ZINC	329	187 36	1 11E - 06	0 00E + 00	2 00E - 01	3 0E - 03	1 7E - 03	0 0E + 00	0 0E + 00	1.8E - 03	1.0E - 03	0.0E + 00	0.0E + 00	1.6E - 04	9.2E - 05	0.0E + 00	0 0E + 00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	2 1E - 01	9 1E - 02	3 2E - 04	2 5E - 04	1 3E - 01	5 6E - 02	3.9E - 04	3.0E - 04	1.1E - 02	4.9E - 03	6 8E - 05	5.3E - 05
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1 2E - 01	4 0E - 02	0 0E + 00	0 0E + 00	7.5E - 02	2 4E - 02	0.0E + 00	0.0E + 00	6.6E - 03	2.1E - 03	0.0E + 00	0.0E + 00
ALL CHEMICALS OF CONCERN	HAZARD INDEX	3 3E - 01	1 3E - 01	3 2E - 04	2 5E - 04	2 0E - 01	8.0E - 02	3.9E - 04	3.0E - 04	1.8E - 02	7.0E - 03	6 8E - 05	5.3E - 05

TOXICITY ENDPOINTS ABBREVIATIONS NS NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

FINAL

TABLE 6-40B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO. 8
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	30	12.13	3.64E-07	0.00E+00	2.0E-05	7.9E-06	0.0E+00	0.0E+00	1.80E+00 A
CADMIUM*	4.3	2.08	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	36.4	22	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	100	66.7	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	2.1	1.62	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	222	113.41	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	96	67.61	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	5860	1680.1	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	13.1	7.08	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	1.8	0.75	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	12.8	9.72	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	329	187.36	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	2.0E-05	7.9E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	2.0E-05	7.9E-06	0.0E+00	0.0E+00

index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Arsenic is the only COC contributing to the excess lifetime cancer risk calculated for the sediment exposure scenarios. The arsenic concentrations detected in Reach 8 sediments and the associated estimated cancer risks are similar to those estimated for background arsenic concentrations.

6.5.3.15 Risk Assessment Results for Reach 9

Sudbury River Reach 9 includes Fairhaven Bay. The following five Nyanza Site contaminants were detected in Reach 9 sediments:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 9 sediments is greater than 11 times the concentrations detected in background samples. Organic contaminant analyses were not conducted in Reach 9 sediment samples. No surface water samples were collected from this Reach.

Table 6-41 presents risk assessment results for COC concentrations detected in the sediments of Reach 9. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices do not exceed unity for any of the cases presented. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes and then combined for surface water and sediment exposures, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Arsenic is the only COC contributing to the excess lifetime cancer risk estimated for Reach 9 sediments. The arsenic concentrations detected in the Reach 9 sediments and the associated estimated cancer risks are approximately 3.5 times those estimated for background.

TABLE 6-41A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 9
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

NONCARCINOGENIC RISK ANALYSIS RESULTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	64.6	32	1.11E-06	0.00E+00	3.00E-04	3.9E-01	1.9E-01	0.0E+00	0.0E+00	2.4E-01	1.2E-01	0.0E+00	0.0E+00	2.1E-02	1.0E-02	0.0E+00	0.0E+00	SKIN
CADMIUM*	8.6	7.05	1.11E-06	0.00E+00	5.00E-04	3.1E-02	2.6E-02	0.0E+00	0.0E+00	1.9E-02	1.6E-02	0.0E+00	0.0E+00	1.7E-03	1.4E-03	0.0E+00	0.0E+00	KIDNEY
CHROMIUM*	78	50.26	1.11E-06	0.00E+00	1.00E+00	1.4E-04	9.2E-05	0.0E+00	0.0E+00	8.7E-05	5.6E-05	0.0E+00	0.0E+00	7.8E-06	4.9E-06	0.0E+00	0.0E+00	LIVER
LEAD*	184	115.26	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	3.8	3.15	1.11E-06	5.55E-08	3.00E-04	2.4E-02	1.9E-02	5.9E-04	4.8E-04	1.4E-02	1.2E-02	7.2E-04	5.8E-04	1.3E-03	1.0E-03	1.3E-04	1.0E-04	CNS
BARIUM	151	118	1.11E-06	0.00E+00	5.00E-02	5.5E-03	4.2E-03	0.0E+00	0.0E+00	3.4E-03	2.6E-03	0.0E+00	0.0E+00	3.0E-04	2.3E-04	0.0E+00	0.0E+00	BLOOD
COPPER	135	83.33	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	516	429.33	1.11E-06	0.00E+00	1.00E-01	9.4E-03	7.8E-03	0.0E+00	0.0E+00	5.7E-03	4.8E-03	0.0E+00	0.0E+00	5.0E-04	4.2E-04	0.0E+00	0.0E+00	CNS
NICKEL	28.1	24.85	1.11E-06	0.00E+00	2.00E-02	2.6E-03	2.3E-03	0.0E+00	0.0E+00	1.6E-03	1.4E-03	0.0E+00	0.0E+00	1.4E-04	1.2E-04	0.0E+00	0.0E+00	BW
VANADIUM	23.1	18.4	1.11E-06	0.00E+00	7.00E-03	6.0E-03	4.8E-03	0.0E+00	0.0E+00	3.7E-03	2.9E-03	0.0E+00	0.0E+00	3.2E-04	2.6E-04	0.0E+00	0.0E+00	NS
ZINC	318	197.13	1.11E-06	0.00E+00	2.00E-01	2.9E-03	1.8E-03	0.0E+00	0.0E+00	1.8E-03	1.1E-03	0.0E+00	0.0E+00	1.6E-04	9.6E-05	0.0E+00	0.0E+00	BLOOD
NYANZA SITE CONTAMINANTS				HAZARD INDEX		4.5E-01	2.4E-01	5.9E-04	4.8E-04	2.7E-01	1.5E-01	7.2E-04	5.8E-04	2.4E-02	1.3E-02	1.3E-04	1.0E-04	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		2.6E-02	2.1E-02	0.0E+00	0.0E+00	1.6E-02	1.3E-02	0.0E+00	0.0E+00	1.4E-03	1.1E-03	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		4.8E-01	2.6E-01	5.9E-04	4.8E-04	2.9E-01	1.6E-01	7.2E-04	5.8E-04	2.5E-02	1.4E-02	1.3E-04	1.0E-04	

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-41B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO. 9
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
ARSENIC*	64.6	32	3.64E-07	0.00E+00	4.2E-05	2.1E-05	0.0E+00	0.0E+00	1.80E+00 A
CADMIUM*	8.6	7.05	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	78	50.26	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	184	115.26	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	3.9	3.15	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	151	116	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	135	83.33	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	516	429.33	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	28.1	24.95	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	23.1	18.4	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	319	197.13	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	4.2E-05	2.1E-05	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	4.2E-05	2.1E-05	0.0E+00	0.0E+00

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

6.5.3.16 Risk Assessment Results for Reach 10

Sudbury River Reach 10 extends from the area of the outlet of Fairhaven Bay to the confluence of the Sudbury and Assabet Rivers. The following four Nyanza Site contaminants were detected in Reach 10 sediments:

- Arsenic
- Chromium
- Lead
- Mercury

The average mercury concentration detected in Reach 10 sediments(C_{avg} = 0.16 mg/kg) is similar to mercury concentrations detected in background samples(C_{avg} = 0.27). No organic contaminant analyses were conducted in Reach 10 sediments. No surface water samples were collected in the Reach.

Table 6-42 presents risk assessment results for COC concentrations detected in the sediments of Reach 10. The accidental-ingestion and dermal-contact routes of exposure (surface waters and sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients and hazard indices do not exceed unity for any of the cases presented. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational exposure scenarios defined in Section 6.4.

Excess lifetime cancer risks estimated for maximum and average COC concentrations in Reach 10 sediments are 8×10^{-6} and 3.9×10^{-6}, respectively. These risk values are similar to those estimated for background. Arsenic, the only COC contributing to risk, was detected at concentrations similar to those observed in background samples.

6.5.3.17 Risk Assessment Results for Fairhaven Bay

This section presents the results of the risk assessment of COC concentrations detected in fish tissue samples taken from Fairhaven Bay. Hazard quotients, hazard indices, and cancer risks estimated by the risk assessment are presented in Table 6-43.

Hazard indices calculated for all COCs exceed unity in all cases presented except when average contaminant concentrations are evaluated and the sport fisherman is the receptor of concern. The majority of the noncarcinogenic risk is attributable to Nyanza Site contaminants; hazard indices calculated for other Sudbury River

TABLE 6-42A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
REACH NO 10
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	12.2	5.88	1.11E-06	0.00E+00	3.00E-04	7.4E-02	3.6E-02	0.0E+00	0.0E+00	4.5E-02	2.2E-02	0.0E+00	0.0E+00	4.0E-03	2.0E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	17.1	11.24	1.11E-06	0.00E+00	1.00E+00	3.1E-05	2.1E-05	0.0E+00	0.0E+00	1.9E-05	1.2E-05	0.0E+00	0.0E+00	1.7E-06	1.1E-06	0.0E+00	0.0E+00	LIVER
LEAD*	33.8	22.48	5.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	0.53	0.161	1.11E-06	5.55E-08	3.00E-04	3.2E-03	9.8E-04	8.1E-05	2.5E-05	2.0E-03	6.0E-04	9.6E-05	3.0E-05	1.7E-04	5.3E-05	1.7E-05	5.3E-06	CNS
BARIUM	64.3	33.81	1.11E-06	0.00E+00	5.00E-02	2.3E-03	1.2E-03	0.0E+00	0.0E+00	1.4E-03	7.5E-04	0.0E+00	0.0E+00	1.3E-04	6.8E-05	0.0E+00	0.0E+00	BLOOD
COPPER	31	14.115	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	336	178.04	1.11E-06	0.00E+00	1.00E-01	6.1E-03	3.3E-03	0.0E+00	0.0E+00	3.7E-03	2.0E-03	0.0E+00	0.0E+00	3.3E-04	1.7E-04	0.0E+00	0.0E+00	CNS
NICKEL	11.1	7.37	1.11E-06	0.00E+00	2.00E-02	1.0E-03	6.7E-04	0.0E+00	0.0E+00	6.2E-04	4.1E-04	0.0E+00	0.0E+00	5.4E-05	3.6E-05	0.0E+00	0.0E+00	BW
VANADIUM	15.8	9.15	1.11E-06	0.00E+00	7.00E-03	4.1E-03	2.4E-03	0.0E+00	0.0E+00	2.5E-03	1.5E-03	0.0E+00	0.0E+00	2.2E-04	1.3E-04	0.0E+00	0.0E+00	NS
ZINC	53.4	38.35	1.11E-06	0.00E+00	2.00E-01	4.9E-04	3.5E-04	0.0E+00	0.0E+00	3.0E-04	2.1E-04	0.0E+00	0.0E+00	2.8E-05	1.9E-05	0.0E+00	0.0E+00	BLOOD
NYANZA SITE CONTAMINANTS				HAZARD INDEX		7.8E-02	3.7E-02	8.1E-05	2.5E-05	4.7E-02	2.3E-02	9.8E-05	3.0E-05	4.2E-03	2.0E-03	1.7E-05	5.3E-06	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		1.4E-02	7.9E-03	0.0E+00	0.0E+00	8.6E-03	4.8E-03	0.0E+00	0.0E+00	7.6E-04	4.2E-04	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		9.2E-02	4.5E-02	8.1E-05	2.5E-05	5.6E-02	2.8E-02	9.8E-05	3.0E-05	4.9E-03	2.4E-03	1.7E-05	5.3E-06	

TOXICITY ENDPOINTS ABBREVIATIONS. NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-42B
RISK RESULTS FOR SEDIMENT EXPOSURE
REACH NO. 10
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS								
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
			INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG			MAX	AVG	MAX	AVG	
ARSENIC*	12.2	5.99	3.64E-07	0.00E+00	8.0E-06	3.9E-06	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	17.1	11.24	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	33.8	22.48	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	0.53	0.161	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	64.3	33.61	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	31	14.115	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	336	178.04	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	11.1	7.37	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	15.9	9.15	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	53.4	38.35	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NYANZA SITE CONTAMINANTS			CANCER RISK		8.0E-06	3.9E-06	0.0E+00	0.0E+00	
OTHER SUDBURY RIVER CONTAMINANTS			CANCER RISK		0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN			CANCER RISK		8.0E-06	3.9E-06	0.0E+00	0.0E+00	

TABLE 6-43
RISK ASSESSMENT RESULTS FOR FISH INGESTION EXPOSURE SCENARIOS
FAIRHAVEN BAY
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS OF CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS										CARCINOGENIC RISK ANALYSIS RESULTS						
	CONCENTRATION MG/KG		EXPOSURE FACTOR		RFD (MG-KG-DAY)	HAZARD QUOTIENTS				TOXICITY END-POINT	EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN		SPORTSFISHERMEN		SUBSISTENCE FISHERMEN			SPORTS FISHER-MEN	SUBSIS-TENCE FISHER-MEN	SPORT FISHERMEN		SUBSISTENCE FISHERMEN		
						MAXIMUM	AVERAGE	MAXIMUM	AVERAGE				MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	
PHENOL*	8.2	1.079	1.85E-04	1.36E-03	6.00E-01	2.5E-03	3.3E-04	1.9E-02	2.4E-03	FETUS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NITROBENZENE*	0.024	0.024	1.85E-04	1.36E-03	5.00E-04	8.9E-03	8.9E-03	6.5E-02	6.5E-02	L/K	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
CHROMIUM*	3.4	0.453	1.85E-04	1.36E-03	1.00E+00	6.3E-04	8.4E-05	4.6E-03	6.1E-04	LIVER	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	5.6	0.270	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	3.2	1.054	1.85E-04	1.36E-03	3.00E-04	2.0E+00	6.5E-01	1.4E+01	4.8E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYL MERCURY*	1.2	0.56283	1.85E-04	1.36E-03	3.00E-04	7.4E-01	3.5E-01	5.4E+00	2.5E+00	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
3/4 METHYL PHENOL	1.9	0.138	1.85E-04	1.36E-03	5.00E-02	7.0E-03	5.1E-04	5.2E-02	3.8E-03	BW,CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
METHYLENE CHLORIDE	14	0.5074	1.85E-04	1.36E-03	6.00E-02	4.3E-02	1.6E-03	3.2E-01	1.1E-02	LIVER	7.93E-05	5.81E-04	8.3E-06	3.0E-07	6.1E-05	2.2E-06	7.50E-03 B2
ACETONE	1.6	0.39828	1.85E-04	1.36E-03	1.00E-01	3.0E-03	7.4E-04	2.2E-02	5.4E-03	L/K	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BEPH	0.037	0.0325	1.85E-04	1.36E-03	2.00E-02	3.4E-04	3.0E-04	2.5E-03	2.2E-03	LIVER	7.93E-05	5.81E-04	4.1E-08	3.6E-08	3.0E-07	2.6E-07	1.40E-02 B2
BENZO(B)FLUORANTHENE	0.087	0.07783	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	4.0E-05	3.6E-05	2.9E-04	2.6E-04	5.80E+00 B2
BENZO(A)PYRENE	0.026	0.026	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	1.2E-05	1.2E-05	8.8E-05	8.8E-05	5.80E+00 B2
4,4-DDE	0.036	0.01782	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	LIVER	7.93E-05	5.81E-04	9.7E-07	4.8E-07	7.1E-06	3.5E-06	3.40E-01 B2
AROCLOR-1254	0.46	0.19783	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	2.8E-04	1.2E-04	2.1E-03	8.8E-04	7.70E+00 B2
AROCLOR-1260	0.03	0.01016	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	1.8E-05	6.2E-06	1.3E-04	4.6E-05	7.70E+00 B2
BARIUM	1.1	0.637	1.85E-04	1.36E-03	5.00E-02	4.1E-03	2.4E-03	3.0E-02	1.7E-02	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	3.4	0.884	1.85E-04	1.36E-03		0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	33.2	2.860	1.85E-04	1.36E-03	1.00E-01	6.1E-02	5.3E-03	4.5E-01	3.9E-02	CNS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	2	0.32	1.85E-04	1.36E-03	2.00E-02	1.8E-02	3.0E-03	1.4E-01	2.2E-02	BW	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	0.27	0.094	1.85E-04	1.36E-03	5.00E-03	1.0E-02	3.5E-03	7.3E-02	2.5E-02	SELENOSIS	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	21.2	8.963	1.85E-04	1.36E-03	2.00E-01	2.0E-02	8.3E-03	1.4E-01	6.1E-02	BLOOD	7.93E-05	5.81E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS*	HAZARD INDEX	2.0E+00	6.6E-01	1.5E+01	4.8E+00	CANCER RISKS:	0.0E+00	0.0E+00	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	1.7E-01	2.5E-02	1.2E+00	1.9E-01	CANCER RISKS:	3.6E-04	1.8E-04	2.6E-03	1.3E-03
ALL CHEMICALS OF CONCERN	HAZARD INDEX	2.2E+00	6.8E-01	1.6E+01	5.0E+00	CANCER RISKS:	3.6E-04	1.8E-04	2.6E-03	1.3E-03

BEPH: BIS(2-ETHYL HEXYL)PHTHALATE

TOXICITY ENDPOINT ABBREVIATIONS
NS: NOT SPECIFIED
BW: BODY WEIGHT
CNS: CENTRAL NERVOUS SYSTEM
L/K: LIVER AND KIDNEY

contaminants do not exceed unity. Hazard quotients calculated for mercury and methyl mercury exceed unity when the reasonable maximum-case and average-case scenarios are evaluated and the subsistence fisherman is the receptor of concern. The hazard quotient calculated for mercury also exceeds unity when maximum contaminant concentrations are evaluated and a sports fisherman is considered the receptor of concern. Because mercury compounds affect the central nervous system and the kidney (they are primary target organs), hazard indices calculated for the kidney and/or central nervous system exceed unity in one or more cases presented in Table 6-43. The maximum and average mercury and the maximum methyl mercury concentrations detected in the Fairhaven fish tissue samples exceed the current FDA Action Level for mercury in fish (1 mg/kg). These results suggest that adverse noncarcinogenic health affects would be anticipated for the receptor routinely ingesting fish taken from Fairhaven Bay at the fish ingestion rate and frequency assumed in Section 6.4.

Although the excess lifetime cancer risk estimated for the Fairhaven Bay fish tissue samples exceeds 1 x 10^{-4} in all cases presented, it should be noted that Nyanza Site contaminants are not contributing to the estimated risks. (Cancer risks exceed 1 x 10^{-3} when the subsistence fisherman is evaluated as the receptor of concern.) Two PCB compounds, Aroclor-1254, and Aroclor-1260, are the principal contaminants contributing to the estimated excess lifetime cancer risk. As a point of reference, cancer risks estimated for subsistence fishermen equal 5 x 10^{-5} when maximum and average COC concentrations in the Sudbury Reservoir fish tissue samples are evaluated (the Sudbury Reservoir is considered as part of the background area for the Study Area).

6.5.3.18 Risk Assessment Results for the Bordering Wetlands

A number of wetlands along the Sudbury River adjoin or are located in the general vicinity of the residential areas. Consequently, this section presents risks assessment results for residential as well as recreational land-use scenarios. As discussed in Section 6.4, the exposure assumptions for the residential and recreational scenarios are similar except that a receptor is expected to be exposed 270 days/year under a residential land-use scenario instead of the 50 to 150 days/year assumed for receptors for the recreational land-use scenarios.

Tables 6-44 and 6-45 present the noncarcinogenic risk assessment results for the recreational and residential land-use scenarios, respectively. The accidental-ingestion and dermal-contact routes

TABLE 6-44A
RISK RESULTS FOR SEDIMENT EXPOSURE
BORDERING WETLANDS RECREATIONAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
						ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		·DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	11 8	6 22	1 11E-06	0 00E+00	3 00E-04	7 2E-02	3 8E-02	0 0E+00	0 0E+00	4 4E-02	2 3E-02	0.0E+00	0 0E+00	3 9E-03	2.0E-03	0 0E+00	0.0E+00	SKIN
CHROMIUM*	101	24 01	1 11E-06	0 00E+00	1 00E+00	1 8E-04	4 4E-05	0 0E+00	0 0E+00	1.1E-04	2.7E-05	0.0E+00	0.0E+00	9.8E-06	2.3E-06	0.0E+00	0.0E+00	LIVER
LEAD*	254	71 18	5 55E-07	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	CNS
MERCURY*	7 6	1 071	1 11E-06	5 55E-08	3 00E-04	4 6E-02	6 5E-03	1 2E-03	1 6E-04	2 8E-02	4.0E-03	1.4E-03	2.0E-04	2.5E-03	3.5E-04	2 5E-04	3.5E-05	CNS
BARIUM	67 5	38 125	1 11E-06	0 00E+00	5 00E-02	2 5E-03	1 4E-03	0 0E+00	0 0E+00	1.5E-03	8.5E-04	0.0E+00	0.0E+00	1.3E-04	7.5E-05	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	1 9	0 818	1 11E-06	0 00E+00	5 00E-03	6 9E-04	3 0E-04	0 0E+00	0 0E+00	4.2E-04	1.8E-04	0.0E+00	0.0E+00	3.7E-05	1.6E-05	0.0E+00	0.0E+00	NS
COPPER	83 4	18 013	1 11E-06	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	NS
MANGANESE	1070	297 87	1 11E-06	0 00E+00	1 00E-01	2 0E-02	5 4E-03	0 0E+00	0 0E+00	1 2E-02	3.3E-03	0.0E+00	0.0E+00	1.0E-03	2.9E-04	0 0E+00	0.0E+00	CNS
NICKEL	21 8	7 18	1 11F-06	0 00E+00	2 00E-02	2 0E-03	6 6E-04	0 0E+00	0 0E+00	1 2E-03	4.0E-04	0.0E+00	0.0E+00	1.1E-04	3.5E-05	0.0E+00	0.0E+00	BW
SELENIUM	1 2	0 07	1 11F-06	0 00E+00	5 00E-03	4 4E-04	2 6E-05	0 0E+00	0 0E+00	2.7E-04	1.6E-05	0.0E+00	0.0E+00	2.3E-05	1.4E-06	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	57 5	28 085	1 11E-06	0 00E+00	7 00E-03	1 5E-02	7 3E-03	0 0E+00	0 0E+00	9.1E-03	4.5E-03	0.0E+00	0.0E+00	8.0E-04	3.9E-04	0.0E+00	0.0E+00	NS
ZINC	127	41 078	1 11E-06	0 00E+00	2 00E-01	1 2E-03	3 8E-04	0 0E+00	0 0E+00	7 1E-04	2.3E-04	0.0E+00	0.0E+00	6.2E-05	2.0E-05	0.0E+00	0.0E+00	BLOOD
NYANZA SITE CONTAMINANTS				HAZARD INDEX		1 2E-01	4 4E-02	1 2E-03	1 6E-04	7.2E-02	2.7E-02	1.4E-03	2.0E-04	6.4E-03	2.4E-03	2.5E-04	3.5E-05	
OTHER SUDBURY RIVER CONTAMINANTS				HAZARD INDEX		4 1E-02	1 6E-02	0 0E+00	0 0E+00	2 5E-02	9.4E-03	0.0E+00	0.0E+00	2.2E-03	8.3E-04	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN				HAZARD INDEX		1 6E-01	6 0E-02	1 2E-03	1 6E-04	9.7E-02	3 6E-02	1.4E-03	2.0E-04	8.6E-03	3.2E-03	2.5E-04	3.5E-05	

TOXICITY ENDPOINTS ABBREVIATIONS NS NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6- .B
RISK RESULTS FOR SEDIMENT EXPOSURE
BORDERING WETLANDS: RECREATIONAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	11.9	6.22	3.64E-07	0.00E+00	7.8E-06	4.1E-06	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	101	24.01	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	254	71.19	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	7.6	1.071	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	67.5	38.125	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	1.9	0.818	3.64E-07	0.00E+00	3.0E-06	1.3E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	83.4	18.013	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	1070	297.92	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	21.8	7.18	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	1.2	0.07	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	57.5	28.065	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	127	41.078	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	7.8E-06	4.1E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	3.0E-06	1.3E-06	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	1.1E-05	5.4E-06	0.0E+00	0.0E+00

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-45A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
BORDERING WETLANDS: RECREATIONAL (270 DAYS / YEAR)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																			
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	11.9	6.22	2.00E-06	0.00E+00	3.00E-04	3.9E-01	2.0E-01	0.0E+00	0.0E+00	7.9E-02	4.1E-02	0.0E+00	0.0E+00	2.1E-02	1.1E-02	0.0E+00	0.0E+00	SKIN
CHROMIUM*	101	24.01	2.00E-06	0.00E+00	1.00E+00	1.0E-03	2.4E-04	0.0E+00	0.0E+00	2.0E-04	4.8E-05	0.0E+00	0.0E+00	5.3E-05	1.3E-05	0.0E+00	0.0E+00	LIVER
LEAD*	254	71.19	1.00E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	7.6	1.071	2.00E-06	1.00E-07	3.00E-04	2.5E-01	3.5E-02	6.2E-03	8.8E-04	5.1E-02	7.1E-03	2.5E-03	3.6E-04	1.3E-02	1.9E-03	1.3E-03	1.9E-04	CNS
BARIUM	67.5	38.125	2.00E-06	0.00E+00	5.00E-02	1.3E-02	7.5E-03	0.0E+00	0.0E+00	2.7E-03	1.5E-03	0.0E+00	0.0E+00	7.1E-04	4.0E-04	0.0E+00	0.0E+00	BLOOD
BERYLLUUM	1.9	0.816	2.00E-06	0.00E+00	5.00E-03	3.7E-03	1.6E-03	0.0E+00	0.0E+00	7.6E-04	3.3E-04	0.0E+00	0.0E+00	2.0E-04	8.6E-05	0.0E+00	0.0E+00	NS
COPPER	83.4	18.013	2.00E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1070	297.92	2.00E-06	0.00E+00	1.00E-01	1.1E-01	2.9E-02	0.0E+00	0.0E+00	2.1E-02	6.0E-03	0.0E+00	0.0E+00	5.7E-03	1.6E-03	0.0E+00	0.0E+00	CNS
NICKEL	21.6	7.16	2.00E-06	0.00E+00	2.00E-02	1.1E-02	3.5E-03	0.0E+00	0.0E+00	2.2E-03	7.2E-04	0.0E+00	0.0E+00	5.6E-04	1.9E-04	0.0E+00	0.0E+00	BW
SELENIUM	1.2	0.07	2.00E-06	0.00E+00	5.00E-03	2.4E-03	1.4E-04	0.0E+00	0.0E+00	4.8E-04	2.8E-05	0.0E+00	0.0E+00	1.3E-04	7.4E-06	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	57.5	28.065	2.00E-06	0.00E+00	7.00E-03	8.1E-02	4.0E-02	0.0E+00	0.0E+00	1.6E-02	8.0E-03	0.0E+00	0.0E+00	4.3E-03	2.1E-03	0.0E+00	0.0E+00	NS
ZINC	127	41.078	2.00E-06	0.00E+00	2.00E-01	6.3E-03	2.0E-03	0.0E+00	0.0E+00	1.3E-03	4.1E-04	0.0E+00	0.0E+00	3.4E-04	1.1E-04	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	6.4E-01	2.4E-01	6.2E-03	8.8E-04	1.3E-01	4.9E-02	2.5E-03	3.6E-04	3.4E-02	1.3E-02	1.3E-03	1.9E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	2.2E-01	8.4E-02	0.0E+00	0.0E+00	4.5E-02	1.7E-02	0.0E+00	0.0E+00	1.2E-02	4.5E-03	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	HAZARD INDEX	8.7E-01	3.2E-01	6.2E-03	8.8E-04	1.8E-01	6.6E-02	2.5E-03	3.6E-04	4.6E-02	1.7E-02	1.3E-03	1.9E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-45B
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
BORDERING WETLANDS: RECREATIONAL (270 DAYS / YEAR)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		CARCINOGENIC RISK ANALYSIS RESULTS						
			EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
					ACCIDENTAL INGESTION		DERMAL CONTACT		
	MAX	AVG	INGESTION	DERMAL CONTACT	MAX	AVG	MAX	AVG	
ARSENIC*	11.9	6.22	1.28E-06	0.00E+00	2.7E-05	1.4E-05	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	101	24.01	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	254	71.19	6.39E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	7.6	1.071	1.28E-06	4.73E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	67.5	38.125	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	1.9	0.818	1.28E-06	0.00E+00	1.0E-05	4.5E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	83.4	18.013	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	1070	297.92	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	21.8	7.18	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	1.2	0.07	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	57.5	28.065	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	127	41.078	1.28E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	2.7E-05	1.4E-05	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	1.0E-05	4.5E-06	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	3.8E-05	1.9E-05	0.0E+00	0.0E+00

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

of exposure (sediments) were evaluated. The chemical-specific hazard quotients and the hazard indices calculated for each exposure route do not exceed unity for either land-use scenario even when maximum contaminant concentrations are evaluated. Also, if hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. Thus, adverse noncarcinogenic health effects are not anticipated under the conditions of the recreational or residential exposure scenarios defined in Section 6.4. If the days per year of exposure for the residential exposure scenario are increased from 270 to 350 (Table 6-46), the hazard index calculated for the accidental-ingestion exposure route exceeds unity when a young child is considered as the receptor of concern and maximum contaminant concentrations are evaluated. However, hazard indices calculated on a target organ or target effect basis would not exceed unity.

Cancer risks presented on Tables 6-44, 6-45, and 6-46 do not exceed 1 x 10^{-4} in any of the cases presented. Arsenic and beryllium are the only COCs contributing to the estimated excess lifetime cancer risks. It should be noted that the maximum and average arsenic and beryllium concentrations detected in the sediment samples collected from the bordering wetlands are similar to or less than background arsenic and beryllium concentrations.

6.5.3.19 Risk Assessment Results for Heard Pond

Heard Pond is located in Reach 7. It was evaluated as part of the remedial investigation because the Pond is reported to be occasionally flooded by the Sudbury River. These two surface water bodies are not otherwise connected. Four Nyanza Site contaminants were detected in the sediment samples collected during the RI: arsenic, chromium, mercury, and lead. The organic COCs were not detected. Surface water samples were not collected from Heard Pond.

Table 6-47 presents risk assessment results for COC concentrations detected in Heard Pond sediment samples. The accidental-ingestion and dermal-contact routes of exposure (sediments) were evaluated assuming recreational land/water use scenarios. The hazard quotients calculated for each COC and hazard indices calculated for each exposure route do not exceed unity. If hazard indices are summed for the accidental-ingestion and dermal-contact exposure routes, the total hazard index does not exceed unity. These results indicate that adverse noncarcinogenic health effects would not be anticipated for a receptor contacting the sediments under

TABLE 6-46A
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
BORDERING WETLANDS RESIDENTIAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																		
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS: CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	11 9	6 22	2 59E-08	0 00E+00	3 00E-04	8 1E-01	2.7E-01	0 0E+00	0 0E+00	1.0E-01	5.4E-02	0.0E+00	0.0E+00	2.7E-02	1.4E-02	0.0E+00	0.0E+00	SKIN
CHROMIUM*	101	24 01	2 59E-08	0 00E+00	1 00E+00	1 3E-03	3 1E-04	0 0E+00	0 0E+00	2.6E-04	6.2E-05	0.0E+00	0.0E+00	6.9E-05	1.6E-05	0.0E+00	0.0E+00	LIVER
LEAD*	254	71 19	1 30E-08	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	7 6	1 071	2 59E-08	1 30E-07	3 00E-04	3 2E-01	4.6E-02	8 1E-03	1.1E-03	6.6E-02	9.3E-03	3.3E-03	4.6E-04	1.7E-02	2.4E-03	1.7E-03	2.4E-04	CNS
BARIUM	67 5	38 125	2 59E-08	0 00E+00	5 00E-02	1 7E-02	9 7E-03	0 0E+00	0 0E+00	3 5E-03	2.0E-03	0.0E+00	0.0E+00	9.2E-04	5.2E-04	0.0E+00	0.0E+00	BLOOD
BERYLLIUM	1 9	0 818	2 59E-08	0 00E+00	5 00E-03	4 9E-03	2.1E-03	0 0E+00	0 0E+00	9 6E-04	4 2E-04	0.0E+00	0.0E+00	2.6E-04	1.1E-04	0.0E+00	0.0E+00	NS
COPPER	83 4	18 013	2 59E-08	0 00E+00		0 0E+00	0 0E+00	0 0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	1070	297 92	2 59E-08	0 00E+00	1 00E-01	1.4E-01	3 6E-02	0 0E+00	0 0E+00	2 6E-02	7.7E-03	0.0E+00	0.0E+00	7.3E-03	2.0E-03	0.0E+00	0.0E+00	CNS
NICKEL	21 8	7 18	2 59E-08	0 00E+00	2 00E-02	1 4E-02	4 6E-03	0.0E+00	0.0E+00	2.8E-03	9.3E-04	0.0E+00	0.0E+00	7.5E-04	2.5E-04	0.0E+00	0.0E+00	BW
SELENIUM	1 2	0 07	2 59E-08	0 00E+00	5 00E-03	3 1E-03	1 8E-04	0 0E+00	0 0E+00	6 2E-04	3.6E-05	0.0E+00	0.0E+00	1.6E-04	9.6E-06	0.0E+00	0.0E+00	SELENOSIS
VANADIUM	57 5	28 066	2 59E-08	0 00E+00	7 00E-03	1 1E-01	5 1E-02	0 0E+00	0 0E+00	2.1E-02	1.0E-02	0.0E+00	0.0E+00	5.6E-03	2.7E-03	0.0E+00	0.0E+00	NS
ZINC	127	41 078	2 59E-08	0 00E+00	2 00E-01	8 1E-03	2 6E-03	0.0E+00	0 0E+00	1.6E-03	5.3E-04	0.0E+00	0.0E+00	4.3E-04	1.4E-04	0.0E+00	0.0E+00	BLOOD

NYANZA SITE CONTAMINANTS	HAZARD INDEX	8 3E-01	3.1E-01	8.1E-03	1.1E-03	1.7E-01	6.3E-02	3.3E-03	4.6E-04	4.5E-02	1.7E-02	1.7E-03	2.4E-04
OTHER SUDBURY RIVER CONTAMINANTS	HAZARD INDEX	2 9E-01	1.1E-01	0 0E+00	0 0E+00	5 9E-02	2.2E-02	0.0E+00	0.0E+00	1.5E-02	5.8E-03	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	HAZARD INDEX	1 1E+00	4.2E-01	8 1E-03	1.1E-03	2.3E-01	6.5E-02	3.3E-03	4.6E-04	6.0E-02	2.2E-02	1.7E-03	2.4E-04

TOXICITY ENDPOINTS ABBREVIATIONS: NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-46B
RISK ASSESSMENT RESULTS FOR SEDIMENT EXPOSURE SCENARIOS
BORDERING WETLANDS: RESIDENTIAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	CARCINOGENIC RISK ANALYSIS RESULTS									
	CONCENTRATION MG/KG		EXPOSURE FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTION	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	11.9	6.22	1.66E-06	0.00E+00	3.6E-05	1.9E-05	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	101	24.01	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	254	71.19	8.29E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	7.6	1.071	1.66E-06	6.14E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	67.5	38.125	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BERYLLIUM	1.9	0.818	1.66E-06	0.00E+00	1.4E-05	5.8E-06	0.0E+00	0.0E+00	4.30E+00 A
COPPER	83.4	18.013	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	1070	297.92	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	21.8	7.18	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
SELENIUM	1.2	0.07	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	57.5	28.065	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	127	41.078	1.66E-06	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	3.6E-05	1.9E-05	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	1.4E-05	5.8E-06	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	4.9E-05	2.4E-05	0.0E+00	0.0E+00

BEPH:BIS(2-ETHYL HEXYL)PHTHALATE

TABLE 6-4(

RISK ASSESSMENT RESULTS FOR SEDIME.. EXPOSURE SCENARIOS
HEARD POND
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CONTAMINANTS of CONCERN	NONCARCINOGENIC RISK ANALYSIS RESULTS																	
	CONCENTRATION MG/KG		EXPOSURE FACTOR RECEPTOR = TEEN		RFD	HAZARD QUOTIENTS CHILD				HAZARD QUOTIENTS: TEEN				HAZARD QUOTIENTS: ADULT				TOXIC END-POINT
	MAX	AVG	INGESTION	DERMAL CONTACT	(MG-KG-DAY)	ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		ACCIDENTAL INGESTION		DERMAL CONTACT		
						MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	
ARSENIC*	10.85	10.85	1.11E-06	0.00E+00	3.00E-04	6.6E-02	6.6E-02	0.0E+00	0.0E+00	4.0E-02	4.0E-02	0.0E+00	0.0E+00	3.5E-03	3.5E-03	0.0E+00	0.0E+00	SKIN
CHROMIUM*	40.2	40.2	1.11E-06	0.00E+00	1.00E+00	7.3E-05	7.3E-05	0.0E+00	0.0E+00	4.5E-05	4.5E-05	0.0E+00	0.0E+00	3.9E-06	3.9E-06	0.0E+00	0.0E+00	LIVER
LEAD*	149	149	9.55E-07	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	CNS
MERCURY*	3.5	3.5	1.11E-06	5.55E-08	3.00E-04	2.1E-02	2.1E-02	5.3E-04	5.3E-04	1.3E-02	1.3E-02	6.5E-04	6.5E-04	1.1E-03	1.1E-03	1.1E-04	1.1E-04	CNS
BARIUM	89.6	89.6	1.11E-06	0.00E+00	5.00E-02	3.3E-03	3.3E-03	0.0E+00	0.0E+00	2.0E-03	2.0E-03	0.0E+00	0.0E+00	1.8E-04	1.8E-04	0.0E+00	0.0E+00	BLOOD
COPPER	136	136	1.11E-06	0.00E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	NS
MANGANESE	333.5	333.5	1.11E-06	0.00E+00	1.00E-01	6.1E-03	6.1E-03	0.0E+00	0.0E+00	3.7E-03	3.7E-03	0.0E+00	0.0E+00	3.3E-04	3.3E-04	0.0E+00	0.0E+00	CNS
NICKEL	11.3	11.3	1.11E-06	0.00E+00	2.00E-02	1.0E-03	1.0E-03	0.0E+00	0.0E+00	6.3E-04	6.3E-04	0.0E+00	0.0E+00	5.5E-05	5.5E-05	0.0E+00	0.0E+00	BW
VANADIUM	21.7	21.7	1.11E-06	0.00E+00	7.00E-03	5.7E-03	5.7E-03	0.0E+00	0.0E+00	3.4E-03	3.4E-03	0.0E+00	0.0E+00	3.0E-04	3.0E-04	0.0E+00	0.0E+00	NS
ZINC	302	302	1.11E-06	0.00E+00	2.00E-01	2.8E-03	2.8E-03	0.0E+00	0.0E+00	1.7E-03	1.7E-03	0.0E+00	0.0E+00	1.5E-04	1.5E-04	0.0E+00	0.0E+00	BLOOD
NYANZA SITE CONTAMINANTS			HAZARD INDEX			8.7E-02	8.7E-02	5.3E-04	5.3E-04	5.3E-02	5.3E-02	6.5E-04	6.5E-04	4.7E-03	4.7E-03	1.1E-04	1.1E-04	
OTHER SUDBURY RIVER CONTAMINANTS			HAZARD INDEX			1.9E-02	1.9E-02	0.0E+00	0.0E+00	1.1E-02	1.1E-02	0.0E+00	0.0E+00	1.0E-03	1.0E-03	0.0E+00	0.0E+00	
ALL CHEMICALS OF CONCERN			HAZARD INDEX			1.1E-01	1.1E-01	5.3E-04	5.3E-04	6.5E-02	6.5E-02	6.5E-04	6.5E-04	5.7E-03	5.7E-03	1.1E-04	1.1E-04	

TOXICITY ENDPOINTS ABBREVIATIONS NS: NOT SPECIFIED L/K: LIVER AND KIDNEY BW: BODY WEIGHT CNS: CENTRAL NERVOUS SYSTEM

TABLE 6-47B
RISK RESULTS FOR SEDIMENT EXPOSURE
HEARD POND
NYANZA OPERABLE UNIT 3
MIDDLESEX CO., MASSACHUSETTS

			CARCINOGENIC RISK ANALYSIS RESULTS						
CONTAMINANTS of CONCERN	CONCENTRATION MG/KG		EXPOSUR FACTOR		CANCER RISKS				CANCER SLOPE FACTOR (MG/KG/D)-1 / WEIGHT OF EVIDENCE
	MAX	AVG	INGESTIO	DERMAL CONTACT	ACCIDENTAL INGESTION		DERMAL CONTACT		
					MAX	AVG	MAX	AVG	
ARSENIC*	10.85	10.85	3.64E-07	0.00E+00	7.1E-06	7.1E-06	0.0E+00	0.0E+00	1.80E+00 A
CHROMIUM*	40.2	40.2	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
LEAD*	149	149	1.82E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MERCURY*	3.5	3.5	3.64E-07	1.51E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
BARIUM	89.6	89.6	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
COPPER	136	136	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
MANGANESE	333.5	333.5	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
NICKEL	11.3	11.3	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
VANADIUM	21.7	21.7	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
ZINC	302	302	3.64E-07	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

NYANZA SITE CONTAMINANTS	CANCER RISK	7.1E-06	7.1E-06	0.0E+00	0.0E+00
OTHER SUDBURY RIVER CONTAMINANTS	CANCER RISK	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ALL CHEMICALS OF CONCERN	CANCER RISK	7.1E-06	7.1E-06	0.0E+00	0.0E+00

the conditions of the recreational exposure scenarios defined in Section 6.4.

Arsenic is the only COC contributing to the estimated cancer risk which approaches 1E-05. Arsenic concentrations detected in the sediments (C_{avg}=10.85 mg/kg) are similar to those detected in background sediment samples (C_{avg}=8.74).

6.6 Summary of Risk Assessment Results

This section summarizes the results of the risk assessment conducted for the Sudbury River Study Area. The baseline public health risk assessment evaluated the carcinogenic and noncarcinogenic risks associated with human exposures to contaminated surface waters and sediments of the Sudbury River Study Area. Risks associated with the routine ingestion of fish taken from surface water bodies within the Study Area were also evaluated. Mercury and methyl mercury are the principal contaminants of concern. However, several other organic and inorganic contaminants, identified by the EPA as Nyanza Site contaminants (arsenic), were also detected in surface water, sediment, and/or fish tissue samples collected from the Study Area. These contaminants and other Sudbury River COCs (several pesticides, PCBs, metals) contribute significantly to the carcinogenic and noncarcinogenic risks estimated for some of the river reaches and surface water bodies evaluated.

Table 6-48 presents a summary of risk results for each compound in each reach of the study area these summary values are specific to media, but not specific to exposure pathway.

The following items summarize the results of the risk assessment of COC concentrations detected in fish tissue samples collected in the Study Area:

- The fish-ingestion exposure scenarios presented in the risk assessment considered a sports fisherman and subsistence fisherman as receptors of concern. Hazard indices calculated for all COCs detected in fish tissue samples collected during the RI exceed unity in at least one of the cases presented for each surface water body evaluated. The cases presented include an evaluation of maximum and average COC concentrations assuming that the sports fisherman and the subsistence fisherman are the receptors of concern.

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

PARAMETER	RISK VALUES: FISH INGESTION															
	SUDBURY RESERVOIR								CEDAR SWAMP POND							
	SUBSISTENCE FISHERMAN				SPORT FISHERMAN				SUBSISTENCE FISHERMAN				SPORT FISHERMAN			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
NAPHTHALENE*																
PHENOL*	1 3E-04	1 3E-04	0 0E+00	0 0E+00	1 7E-05	1.7E-05	0 0E+00	0.0E+00								
NITROBENZENE*																
ANTIMONY*									2.8E+00	1.9E+00	0.0E+00	0 0E+00	3.8E-01	2.6E-01	0.0E+00	0.0E+00
ARSENIC*	2 7E-01	2 7E-01	8 3E-05	8 3E-05	3 7E-02	3 7E-02	8 6E-06	8 6E-06								
CADMIUM*																
CHROMIUM*	3 8E-03	1 5E-03	0 0E+00	0 0E+00	5 3E-04	2 1E-04	0 0E+00	0 0E+00	8 7E-04	2.9E-04	0.0E+00	0 0E+00	1.2E-04	3.9E-05	0.0E+00	0.0E+00
LEAD*									0.0E+00	0 0E+00	0.0E+00	0.0E+00	0.0E+00	0 0E+00	0.0E+00	0.0E+00
MERCURY*	5 3E+00	4 0E+00	0 0E+00	0 0E+00	7 3E-01	5 5E-01	0 0E+00	0 0E+00	4.3E+01	3.3E+00	0 0E+00	0 0E+00	5.9E+00	4.5E-01	0 0E+00	0.0E+00
METHYL MERCURY*	2 9E+00	2 2E+00	0 0E+00	0 0E+00	4 0E-01	3 0E-01	0 0E+00	0 0E+00								
3/4 METHYL PHENOL																
METHYLENE CHLORIDE																
ACETONE																
BEPH																
BENZO(B)FLUORANTHENE																
BENZO(A)PYRENE																
ENDOSULFAN I																
ENDOSULFAN II																
ENDOSULFAN SULFATE	1 2E-01	7 5E-02	0 0E+00	0 0E+00	1 7E-02	1.0E-02	0 0E+00	0 0E+00								
DIELDRIN	1 4E-02	1 4E-02	4 8E-06	4 8E-06	1 8E-03	1 8E-03	6 3E-07	6 3E-07								
4,4-DDD	0 0E+00	0 0E+00	9 8E-07	5 2E-07	0 0E+00	0 0E+00	1 3E-07	7.1E-08								
4,4-DDE	0 0E+00	0 0E+00	8 1E-06	3 9E-06	0 0E+00	0 0E+00	1 1E-06	5 3E-07								
4,4-DDT	0 0E+00	0 0E+00	4 0E-07	1 8E-07	0 0E+00	0 0E+00	5 4E-08	2 4E-08								
ALPHA-CHLORDANE	2 3E-02	2 3E-02	7 6E-07	7 6E-07	3 1E-03	3 1E-03	1 0E-07	1 0E-07								
GAMMA-CHLORDANE																
ALDRIN																
HEPTACLOR																
AROCHLOR 1248																
AROCLOR-1254																
AROCLOR-1260	0 0E+00	0 0E+00	4 3E-04	2 9E-04	0 0E+00	0.0E+00	5 8E-05	3.9E-05								
BARIUM																
COPPER																
MANGANESE	3 3E-02	1 4E-02	0 0E+00	0 0E+00	4 5E-03	2 0E-03	0 0E+00	0 0E+00								
NICKEL									4.1E-01	3.3E-02	0.0E+00	0.0E+00	5.5E-02	4.6E-03	0 0E+00	0.0E+00
SELENIUM	4 9E-01	1 2E-01	0 0E+00	0 0E+00	6 7E-02	1.7E-02	0 0E+00	0 0E+00	1.1E+00	8.5E-02	0.0E+00	0.0E+00	1.5E-01	1 2E-02	0 0E+00	0.0E+00
SILVER									9.9E-01	7.4E-02	0.0E+00	0.0E+00	1.4E-01	1 0E-02	0 0E+00	0 0E+00
THALLIUM									1.5E+00	9.5E-01	0.0E+00	0.0E+00	2.1E-01	1 3E-01	0 0E+00	0 0E+00
VANADIUM	1 5E-01	6 3E-02	0 0E+00	0 0E+00	2 0E-02	8 6E-03	0 0E+00	0 0E+00								
ZINC	4 2E-01	2 2E-01	0 0E+00	0 0E+00	5 7E-02	3 0E-02	0 0E+00	0 0E+00	3 9E-01	6 8E-02	0.0E+00	0.0E+00	5.3E-02	9 2E-03	0 0E+00	0.0E+00
SUM	9 9E+00	4 8E+00	8 0E-04	3 9E-04	9 3E-01	6 8E-01	8.9E-05	4 9E-05	5.1E+01	6.4E+00	0.0E+00	0 0E+00	6.9E+00	6.8E-01	0.0E+00	0.0E+00

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 2

PARAMETER	RISK VALUES - FISH INGESTION															
	SOUTHVILLE POND								MILL POND							
	SUBSISTENCE FISHERMAN				SPORT FISHERMAN				SUBSISTENCE FISHERMAN				SPORT FISHERMAN			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
NAPHTHALENE*																
PHENOL*																
NITROBENZENE*																
ANTIMONY*																
ARSENIC*																
CADMIUM*																
CHROMIUM*	8.5E-04	3.4E-04	0.0E+00	0.0E+00	1.3E-04	4.7E-05	0.0E+00	0.0E+00								
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00								
MERCURY*	4.0E+00	1.4E+00	0.0E+00	0.0E+00	5.5E-01	1.8E-01	0.0E+00	0.0E+00	9.0E+00	1.4E+00	0.0E+00	0.0E+00	1.2E+00	1.9E-01	0.0E+00	0.0E+00
METHYL MERCURY*									3.3E+00	8.7E-01	0.0E+00	0.0E+00	4.5E-01	1.3E-01		
3/4 METHYL PHENOL																
METHYLENE CHLORIDE																
ACETONE																
BEPH																
BENZO(B)FLUORANTHENE																
BENZO(A)PYRENE																
ENDOSULFAN I																
ENDOSULFAN II																
ENDOSULFAN SULFATE																
DIELDRIN																
4,4-DDD																
4,4-DDE									0.0E+00	0.0E+00	5.9E-06	2.1E-06	0.0E+00	0.0E+00	6.1E-07	2.9E-07
4,4-DDT																
ALPHA-CHLORDANE																
GAMMA-CHLORDANE																
ALDRIN																
HEPTACLOR																
AROCHLOR 1248									0.0E+00	0.0E+00	2.2E-03	3.2E-04	0.0E+00	0.0E+00	3.1E-04	4.4E-05
AROCLOR-1254																
AROCLOR-1260																
BARIUM																
COPPER																
MANGANESE	6.2E-03	6.2E-03	0.0E+00	0.0E+00	7.0E-04	7.0E-04	0.0E+00	0.0E+00	4.2E-03	1.7E-03	0.0E+00	0.0E+00	5.8E-04	2.3E-04	0.0E+00	0.0E+00
NICKEL																
SELENIUM	4.1E-02	2.0E-02	0.0E+00	0.0E+00	6.5E-03	3.8E-03	0.0E+00	0.0E+00								
SILVER									1.1E-02	1.1E-02	0.0E+00	0.0E+00	1.5E-03	1.5E-03	0.0E+00	0.0E+00
THALLIUM																
VANADIUM									8.9E-03	6.8E-03	0.0E+00	0.0E+00	1.2E-03	9.2E-04	0.0E+00	0.0E+00
ZINC	1.5E-01	6.3E-02	0.0E+00	0.0E+00	2.0E-02	8.8E-03	0.0E+00	0.0E+00	2.7E-02	2.2E-02	0.0E+00	0.0E+00	3.8E-03	3.0E-03	0.0E+00	0.0E+00
SUM	4.2E+00 *	1.5E+00 **	0.0E+00 *	0.0E+00 *	5.8E-01 *	2.0E-01 **	0.0E+00 *	0.0E+00 *	9.1E+00 *	1.4E+00 **	2.2E-03 *	3.2E-04 *	1.2E+00 *	2.0E-01 **	3.1E-04 *	4.4E-05

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 3

PARAMETER	RISK VALUES: FISH INGESTION															
	RESERVOIR NO 2								RESERVOIR 1							
	SUBSISTENCE FISHERMAN				SPORT FISHERMAN				SUBSISTENCE FISHERMAN				SPORT FISHERMAN			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
NAPHTHALENE*																
PHENOL*									5.2E-03	9.3E-04	0.0E+00	0.0E+00	7.1E-04	1.3E-04	0.0E+00	0.0E+00
NITROBENZENE*																
ANTIMONY*	5.2E+01	1.9E+00	0.0E+00	0.0E+00	7.1E+00	2.6E-01	0.0E+00	0.0E+00								
ARSENIC*	7.8E+00	4.7E-01	1.8E-03	1.1E-04	1.1E+00	6.5E-02	2.5E-04	1.5E-05	5.2E-03	9.3E-04	0.0E+00	0.0E+00	7.1E-04	1.3E-04	0.0E+00	0.0E+00
CADMIUM*	1.4E-01	8.1E-02	0.0E+00	0.0E+00	1.9E-02	1.1E-02	0.0E+00	0.0E+00	5.2E-01	3.6E-01	1.2E-04	8.4E-05	7.0E-02	4.9E-02	1.6E-05	1.1E-05
CHROMIUM*	7.7E-03	7.9E-04	0.0E+00	0.0E+00	1.1E-03	1.1E-04	0.0E+00	0.0E+00								
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	3.4E+01	9.0E+00	0.0E+00	0.0E+00	4.7E+00	1.3E+00	0.0E+00	0.0E+00	1.9E+01	3.4E+00	0.0E+00	0.0E+00	2.6E+00	4.6E-01	0.0E+00	0.0E+00
METHYL MERCURY*	1.9E+01	7.9E+00	0.0E+00	0.0E+00	2.6E+00	1.1E+00	0.0E+00	0.0E+00	1.7E+01	4.5E+00	0.0E+00	0.0E+00	2.3E+00	6.1E-01	0.0E+00	0.0E+00
3/4 METHYL PHENOL																
METHYLENE CHLORIDE																
ACETONE																
BEPH									2.2E-01	4.5E-02	2.7E-05	5.4E-06	3.1E-02	6.1E-03	3.7E-06	7.3E-07
BENZO(B)FLUORANTHENE																
BENZO(A)PYRENE																
ENDOSULFAN I																
ENDOSULFAN II	2.7E-02	2.0E-02	0.0E+00	0.0E+00	3.7E-03	2.7E-03	0.0E+00	0.0E+00								
ENDOSULFAN SULFATE																
DIELDRIN	1.4E-02	1.4E-02	4.6E-06	4.6E-06	1.9E-03	1.9E-03	6.3E-07	6.3E-07								
4,4-DDD	0.0E+00	0.0E+00	9.6E-07	5.5E-07	0.0E+00	0.0E+00	1.3E-07	7.5E-08	0.0E+00	0.0E+00	2.8E-08	1.6E-07	0.0E+00	0.0E+00	3.8E-07	2.5E-08
4,4-DDE	0.0E+00	0.0E+00	1.3E-05	3.6E-06	0.0E+00	0.0E+00	1.8E-06	4.9E-07	0.0E+00	0.0E+00	6.3E-06	3.5E-06	0.0E+00	0.0E+00	8.6E-07	4.8E-07
4,4-DDT	0.0E+00	0.0E+00	4.0E-07	2.4E-07	0.0E+00	0.0E+00	5.4E-08	3.2E-08	0.0E+00	0.0E+00	2.0E-07	1.5E-07	0.0E+00	0.0E+00	2.7E-08	2.0E-08
ALPHA-CHLORDANE	2.3E-02	1.9E-02	7.6E-07	6.3E-07	3.1E-03	2.6E-03	1.0E-07	8.6E-08	5.7E-02	3.7E-02	1.9E-06	1.2E-06	7.7E-03	5.1E-03	2.6E-07	1.7E-07
GAMMA-CHLORDANE	4.5E-02	2.4E-02	1.5E-06	8.0E-07	6.2E-03	3.3E-03	2.1E-07	1.1E-07	3.4E-02	2.3E-02	1.1E-06	7.6E-07	4.6E-03	3.1E-03	1.5E-07	1.0E-07
ALDRIN	4.5E-02	1.5E-02	9.6E-06	3.2E-06	6.2E-03	2.0E-03	1.3E-06	4.4E-07								
HEPTACLOR																
AROCHLOR 1248																
AROCLOR-1254	0.0E+00	0.0E+00	3.3E-03	4.1E-04	0.0E+00	0.0E+00	4.5E-04	5.6E-05	0.0E+00	0.0E+00	1.7E-04	3.8E-05	0.0E+00	0.0E+00	2.4E-05	5.1E-06
AROCLOR-1260	0.0E+00	0.0E+00	4.2E-04	3.4E-04	0.0E+00	0.0E+00	5.7E-05	4.7E-05	0.0E+00	0.0E+00	3.1E-04	3.0E-05	0.0E+00	0.0E+00	4.2E-05	4.1E-06
BARIUM									4.5E-03	1.6E-03	0.0E+00	0.0E+00	6.2E-04	2.1E-04	0.0E+00	0.0E+00
COPPER																
MANGANESE	1.9E-01	1.1E-02	0.0E+00	0.0E+00	2.6E-02	1.5E-03	0.0E+00	0.0E+00	1.4E-01	3.1E-02	0.0E+00	0.0E+00	2.0E-02	4.2E-03	0.0E+00	0.0E+00
NICKEL																
SELENIUM																
SILVER	2.0E-01	2.7E-02	0.0E+00	0.0E+00	2.7E-02	3.7E-03	0.0E+00	0.0E+00								
THALLIUM	2.6E+01	1.5E+00	0.0E+00	0.0E+00	3.6E+00	2.1E-01	0.0E+00	0.0E+00								
VANADIUM	2.2E-01	6.2E-02	0.0E+00	0.0E+00	3.1E-02	8.5E-03	0.0E+00	0.0E+00	3.0E-01	9.6E-02	0.0E+00	0.0E+00	4.2E-02	1.3E-02	0.0E+00	0.0E+00
ZINC	1.2E+00	1.3E-01	0.0E+00	0.0E+00	1.7E-01	1.7E-02	0.0E+00	0.0E+00	1.6E+00	2.2E-01	0.0E+00	0.0E+00	2.4E-01	2.9E-02	0.0E+00	0.0E+00
SUM	1.2E+02	1.4E+01	** 8.9E-03	* 8.8E-04	1.7E+01	1.9E+00	** 7.6E-04	* 1.2E-04	2.2E+01	4.2E+00	** 6.4E-04	* 1.6E-04	3.0E+00	* 5.7E-01	** 8.8E-05	* 2.2E-05

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 4

PARAMETER	RISK VALUES: FISH INGESTION															
	SAXONVILLE RESERVOIR								FAIRHAVEN BAY							
	SUBSISTENCE FISHERMAN				SPORT FISHERMAN				SUBSISTENCE FISHERMAN				SPORT FISHERMAN			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
NAPHTHALENE*	6.4E-01	4.4E-02	0.0E+00	0.0E+00	8.8E-02	6.0E-03	0.0E+00	0.0E+00								
PHENOL*	2.7E-04	1.0E-04	0.0E+00	0.0E+00	3.7E-05	1.4E-05	0.0E+00	0.0E+00	1.9E-02	2.4E-03	0.0E+00	0.0E+00	2.5E-03	3.3E-04	0.0E+00	0.0E+00
NITROBENZENE*									6.5E-02	6.5E-02	0.0E+00	0.0E+00	8.9E-03	8.9E-03	0.0E+00	0.0E+00
ANTIMONY*	4.7E-01	4.7E-01	0.0E+00	0.0E+00	6.5E-02	6.5E-02	0.0E+00	0.0E+00								
ARSENIC*	2.1E-01	1.8E-01	4.8E-05	4.2E-05	2.8E-02	2.5E-02	6.6E-06	5.7E-06								
CADMIUM*																
CHROMIUM*	5.0E-03	9.0E-04	0.0E+00	0.0E+00	7.9E-04	1.2E-04	0.0E+00	0.0E+00	4.6E-03	6.1E-04	0.0E+00	0.0E+00	6.3E-04	8.4E-05	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	$\boxed{\text{8.1E+00}}$	$\boxed{\text{2.8E+00}}$	0.0E+00	0.0E+00	$\boxed{\text{1.1E+00}}$	3.8E-01	0.0E+00	0.0E+00	$\boxed{\text{1.4E+01}}$	$\boxed{\text{4.8E+00}}$	0.0E+00	0.0E+00	$\boxed{\text{2.0E+00}}$	6.5E-01	0.0E+00	0.0E+00
METHYL MERCURY*	$\boxed{\text{8.2E+00}}$	$\boxed{\text{1.8E+00}}$	0.0E+00	0.0E+00	8.4E-01	2.5E-01	0.0E+00	0.0E+00	$\boxed{\text{5.4E+00}}$	$\boxed{\text{2.5E+00}}$	0.0E+00	0.0E+00	7.4E-01	3.5E-01	0.0E+00	0.0E+00
3/4 METHYL PHENOL									5.2E-02	3.8E-03	0.0E+00	0.0E+00	7.0E-03	5.1E-04	0.0E+00	0.0E+00
METHYLENE CHLORIDE									3.2E-01	1.1E-02	6.1E-05	2.2E-06	4.3E-02	1.6E-03	8.3E-06	3.0E-07
ACETONE									2.2E-02	5.4E-03	0.0E+00	0.0E+00	3.0E-03	7.4E-04	0.0E+00	0.0E+00
BEPH	4.0E-02	1.1E-02	5.5E-06	1.4E-06	6.3E-03	1.6E-03	7.5E-07	1.9E-07	2.5E-03	2.2E-03	3.0E-07	2.6E-07	3.4E-04	3.0E-04	4.1E-08	3.6E-08
BENZO(B)FLUORANTHENE									0.0E+00	0.0E+00	2.9E-04	2.6E-04	0.0E+00	0.0E+00	4.0E-05	3.6E-05
BENZO(A)PYRENE									0.0E+00	0.0E+00	6.6E-05	6.6E-05	0.0E+00	0.0E+00	1.2E-05	1.2E-05
ENDOSULFAN I	4.1E-02	3.4E-02	0.0E+00	0.0E+00	5.5E-03	4.6E-03	0.0E+00	0.0E+00								
ENDOSULFAN II																
ENDOSULFAN SULFATE	2.7E-02	2.7E-02	0.0E+00	0.0E+00	3.7E-03	3.7E-03	0.0E+00	0.0E+00								
DIELDRIN	1.4E-02	6.8E-03	4.8E-06	2.3E-06	1.8E-03	9.2E-04	6.3E-07	3.2E-07								
4,4-DDD	0.0E+00	0.0E+00	2.0E-06	6.5E-07	0.0E+00	0.0E+00	2.7E-07	8.9E-08								
4,4-DDE	0.0E+00	0.0E+00	4.0E-06	1.5E-06	0.0E+00	0.0E+00	5.4E-07	2.0E-07	0.0E+00	0.0E+00	7.1E-06	3.5E-06	0.0E+00	0.0E+00	9.7E-07	4.6E-07
4,4-DDT	0.0E+00	0.0E+00	4.0E-07	2.6E-07	0.0E+00	0.0E+00	5.4E-08	3.6E-08								
ALPHA-CHLORDANE	4.9E-02	4.9E-02	1.5E-06	1.5E-06	6.2E-03	6.2E-03	2.1E-07	2.1E-07								
GAMMA-CHLORDANE	2.3E-02	1.6E-02	7.6E-07	6.3E-07	3.1E-03	2.6E-03	1.0E-07	8.6E-08								
ALDRIN																
HEPTACLOR	1.8E-02	4.6E-03	1.6E-05	4.4E-06	2.2E-03	6.2E-04	2.1E-06	6.0E-07								
AROCHLOR 1248																
AROCLOR-1254	0.0E+00	0.0E+00	1.8E-04	6.0E-05	0.0E+00	0.0E+00	2.4E-05	1.2E-05	0.0E+00	0.0E+00	2.1E-03	6.6E-04	0.0E+00	0.0E+00	2.8E-04	1.2E-04
AROCLOR-1260	0.0E+00	0.0E+00	4.8E-04	2.1E-04	0.0E+00	0.0E+00	6.7E-05	2.8E-05	0.0E+00	0.0E+00	1.3E-04	4.6E-05	0.0E+00	0.0E+00	1.8E-05	6.2E-06
BARIUM									3.0E-02	1.7E-02	0.0E+00	0.0E+00	4.1E-03	2.4E-03	0.0E+00	0.0E+00
COPPER *																
MANGANESE	2.7E-01	2.9E-02	0.0E+00	0.0E+00	3.6E-02	3.8E-03	0.0E+00	0.0E+00	4.5E-01	3.9E-02	0.0E+00	0.0E+00	6.1E-02	5.3E-03	0.0E+00	0.0E+00
NICKEL	8.4E-02	1.6E-02	0.0E+00	0.0E+00	1.1E-02	2.1E-03	0.0E+00	0.0E+00	1.4E-01	2.2E-02	0.0E+00	0.0E+00	1.6E-02	3.0E-03	0.0E+00	0.0E+00
SELENIUM	1.7E-01	4.4E-02	0.0E+00	0.0E+00	2.3E-02	6.1E-03	0.0E+00	0.0E+00	7.3E-02	2.5E-02	0.0E+00	0.0E+00	1.0E-02	3.5E-03	0.0E+00	0.0E+00
SILVER	1.1E-01	2.4E-02	0.0E+00	0.0E+00	1.6E-02	3.2E-03	0.0E+00	0.0E+00								
THALLIUM	$\boxed{\text{2.3E+01}}$	$\boxed{\text{1.1E+00}}$	0.0E+00	0.0E+00	$\boxed{\text{3.1E+00}}$	1.6E-01	0.0E+00	0.0E+00								
VANADIUM	2.4E-01	6.3E-02	0.0E+00	0.0E+00	3.2E-02	1.1E-02	0.0E+00	0.0E+00								
ZINC	8.4E-01	1.2E-01	0.0E+00	0.0E+00	8.8E-02	1.7E-02	0.0E+00	0.0E+00	1.4E-01	6.1E-02	0.0E+00	0.0E+00	2.0E-02	6.3E-03	0.0E+00	0.0E+00
SUM	$\boxed{\text{3.4E+01}}$ *	$\boxed{\text{9.1E+00}}$ **	7.9E-04 *	3.6E-04 *	$\boxed{\text{4.7E+00}}$ *	6.9E-01 **	1.0E-04 *	4.6E-05 *	$\boxed{\text{1.6E+01}}$ *	$\boxed{\text{5.0E+00}}$ **	2.6E-03 *	1.3E-03 *	$\boxed{\text{2.2E+00}}$ *	6.6E-01 **	3.6E-04 *	1.6E-04

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 5

PARAMETER	RISK VALUES: SEDIMENT EXPOSURE															
	REACH 1 AND BACKGROUND				REACH 2				EASTERN WETLANDS				EASTERN WETLANDS DRILLING			
	HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TRICHLOROETHENE									0.0E+00	0.0E+00	2.1E-09	1.1E-09	0.0E+00	0.0E+00	4.2E-08	2.7E-09
12DICHLOROETHENE					1.3E-05	3.6E-06	0.0E+00	0.0E+00	5.3E-05	3.0E-05	0.0E+00	0.0E+00	2.3E-03	1.1E-04	0.0E+00	0.0E+00
CHLOROBENZENE*					6.5E-06	1.9E-06	0.0E+00	0.0E+00	3.3E-04	1.7E-04	0.0E+00	0.0E+00	7.0E-03	5.4E-04	0.0E+00	0.0E+00
NITROBENZENE*									3.0E-03	3.0E-03	0.0E+00	0.0E+00	6.4E-04	4.6E-04	0.0E+00	0.0E+00
1,2-DICHLOROBENZENE					4.6E-05	2.2E-05	0.0E+00	0.0E+00	1.6E-04	1.0E-04	0.0E+00	0.0E+00	3.3E-04	4.6E-05	0.0E+00	0.0E+00
1,3-DCB*													2.2E-05	2.1E-05	0.0E+00	0.0E+00
1,4-DCB*					0.0E+00	0.0E+00	1.4E-08	7.9E-09	0.0E+00	0.0E+00	2.0E-08	1.5E-08	0.0E+00	0.0E+00	3.8E-09	7.2E-09
1,2,4-TRICHLOROBENZENE*					1.3E-03	1.1E-03	0.0E+00	0.0E+00	5.4E-03	3.4E-03	0.0E+00	0.0E+00	5.6E-04	5.3E-04	0.0E+00	0.0E+00
NAPHTHALENE*					6.1E-04	3.1E-04	0.0E+00	0.0E+00	1.2E-03	6.0E-04	0.0E+00	0.0E+00	4.2E-05	4.2E-05	0.0E+00	0.0E+00
PHENOL*																
ARSENIC*	1.3E-01	6.3E-02	1.4E-05	5.7E-06	9.1E-02	4.2E-02	9.6E-06	4.6E-06	7.7E-02	4.0E-02	8.3E-06	4.3E-06	4.3E-02	1.0E-02	4.6E-06	1.1E-06
ANTIMONY*	3.2E-02	2.6E-02	0.0E+00	0.0E+00												
CADMIUM*													1.2E-02	2.4E-03	0.0E+00	0.0E+00
CHROMIUM*	1.0E-04	4.1E-05	0.0E+00	0.0E+00	3.6E-04	6.2E-05	0.0E+00	0.0E+00	6.4E-04	2.3E-04	0.0E+00	0.0E+00	7.7E-04	7.6E-05	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	6.6E-03	1.7E-03	0.0E+00	0.0E+00	1.6E-01	2.4E-02	0.0E+00	0.0E+00	9.5E-01	2.2E-01	0.0E+00	0.0E+00	5.7E-01	3.8E-02	0.0E+00	0.0E+00
MONOMETHYLHG*					5.9E-03	1.6E-03	0.0E+00	0.0E+00	4.1E-03	1.2E-03	0.0E+00	0.0E+00				
DIMETHYLHG*																
VINYL CHLORIDE																
BENZENE													0.0E+00	0.0E+00	1.3E-10	1.3E-10
DICHLOROMETHANE					6.6E-07	4.1E-07	6.7E-11	6.0E-11					1.1E-04	9.6E-08	1.3E-08	1.2E-09
ACETONE	4.1E-07	4.1E-07	0.0E+00	0.0E+00	1.3E-05	5.0E-06	0.0E+00	0.0E+00	6.6E-05	3.7E-05	0.0E+00	0.0E+00	4.5E-06	1.4E-06	0.0E+00	0.0E+00
BEHP					2.3E-04	7.4E-05	1.4E-08	4.7E-09					4.1E-06	2.6E-06	2.6E-10	1.6E-10
3/4-METHYLPHENOL									1.2E-05	1.2E-05	0.0E+00	0.0E+00	3.4E-06	3.4E-06	0.0E+00	0.0E+00
2-METHYLNAPH																
ACENAPTHYLENE					2.6E-04	2.5E-04	0.0E+00	0.0E+00					2.3E-05	1.6E-05	0.0E+00	0.0E+00
PHENANTHRENE	6.2E-06	7.7E-06	0.0E+00	0.0E+00	6.5E-03	6.4E-04	0.0E+00	0.0E+00	3.2E-04	3.2E-04	0.0E+00	0.0E+00	1.4E-04	4.0E-05	0.0E+00	0.0E+00
FLUORANTHENE	1.6E-06	1.1E-06	0.0E+00	0.0E+00	4.6E-04	1.0E-04	0.0E+00	0.0E+00	6.2E-05	6.2E-05	0.0E+00	0.0E+00	1.3E-05	6.7E-06	0.0E+00	0.0E+00
PYRENE	1.6E-06	1.2E-06	0.0E+00	0.0E+00	6.1E-04	1.1E-04	0.0E+00	0.0E+00	1.2E-04	6.6E-05	0.0E+00	0.0E+00	1.7E-06	1.7E-06	0.0E+00	0.0E+00
BENZO(A)ANTH					0.0E+00	0.0E+00	1.1E-05	2.6E-06					0.0E+00	0.0E+00	4.8E-07	3.2E-07
CHRYSENE	0.0E+00	0.0E+00	4.6E-07	4.1E-07	0.0E+00	0.0E+00	1.1E-05	2.6E-06	0.0E+00	0.0E+00	3.1E-08	2.6E-08	0.0E+00	0.0E+00	2.5E-07	2.0E-07
BENZO(B)FLUOR	0.0E+00	0.0E+00	5.1E-07	4.7E-07	0.0E+00	0.0E+00	9.0E-06	2.6E-06	0.0E+00	0.0E+00	6.4E-06	7.1E-06				
BENZO(K)FLUOR					0.0E+00	0.0E+00	9.7E-06	2.5E-06					0.0E+00	0.0E+00	2.2E-06	7.1E-07
BENZO(A)PYRENE	0.0E+00	0.0E+00	2.3E-07	2.3E-07	0.0E+00	0.0E+00	9.6E-06	2.6E-06	0.0E+00	0.0E+00	2.2E-06	2.1E-06	0.0E+00	0.0E+00	3.1E-07	3.1E-07
IN(123-CD)PYRENE					0.0E+00	0.0E+00	2.3E-06	1.6E-06								
DIBENZ(AH)ANTH					0.0E+00	0.0E+00	2.4E-07	2.2E-07					0.0E+00	0.0E+00	3.1E-07	3.1E-07
BENZO(GHI)PERYL					3.3E-04	3.0E-04	0.0E+00	0.0E+00								
BARIUM	6.6E-03	2.4E-03	0.0E+00	0.0E+00	7.6E-03	2.6E-03	0.0E+00	0.0E+00	2.1E-03	1.2E-03	0.0E+00	0.0E+00	2.4E-03	1.2E-03	0.0E+00	0.0E+00
BERYLLIUM	6.6E-04	3.1E-04	2.6E-06	1.3E-06	6.6E-04	3.2E-04	3.0E-06	1.4E-06	1.5E-03	6.1E-04	6.3E-06	3.5E-06	3.0E-03	6.6E-04	1.3E-05	2.8E-06
COPPER																
MANGANESE	3.0E-02	7.6E-03	0.0E+00	0.0E+00	7.6E-02	1.6E-02	0.0E+00	0.0E+00	2.4E-02	5.3E-03	0.0E+00	0.0E+00	8.7E-03	1.6E-03	0.0E+00	0.0E+00
NICKEL	4.7E-03	1.0E-03	0.0E+00	0.0E+00	1.7E-03	6.6E-04	0.0E+00	0.0E+00	3.7E-03	9.3E-04	0.0E+00	0.0E+00	2.1E-03	6.6E-04	0.0E+00	0.0E+00
SILVER																
SELENIUM	1.1E-03	3.6E-04	0.0E+00	0.0E+00					2.4E-03	5.2E-04	0.0E+00	0.0E+00				
THALLIUM													3.7E-02	1.2E-02	0.0E+00	0.0E+00
VANADIUM	1.3E-02	5.3E-03	0.0E+00	0.0E+00	1.2E-02	5.2E-03	0.0E+00	0.0E+00	9.6E-03	4.6E-03	0.0E+00	0.0E+00	5.9E-03	3.6E-03	0.0E+00	0.0E+00
ZINC	5.7E-03	1.2E-03	0.0E+00	0.0E+00	3.0E-03	1.2E-03	0.0E+00	0.0E+00	1.5E-03	6.0E-04	0.0E+00	0.0E+00	2.6E-03	3.9E-04	0.0E+00	0.0E+00
4,4-DDE					0.0E+00	0.0E+00	3.6E-09	2.5E-09								
4,4-DDD					0.0E+00	0.0E+00	1.4E-09	1.4E-09	0.0E+00	0.0E+00	7.6E-09	3.3E-09				
4,4-DDT					0.0E+00	0.0E+00	6.6E-09	1.1E-08								
CHLORDANE																
AROCLOR 1254																
SUM	2.3E-01	1.0E-01	1.6E-05	6.2E-06	3.6E-01	9.5E-02	9.6E-05	2.1E-05	$\boxed{\text{1.1E+00}}$	2.9E-01	2.8E-05	2.0E-05	7.0E-01	7.3E-02	2.1E-05	5.8E-06

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
N[illegible]ZA OPERABLE UNIT 3
M[illegible]LESEX COUNTY, MASSACHUSETTS
PAGE 6

PARAMETER	RISK VALUES: SEDIMENT EXPOSURE															
	CULVERT				OUTFALL CREEK				RACEWAY				COLD SPRING BROOK			
	HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TRICHLOROETHENE	0.0E+00	0.0E+00	8.8E-10	4.8E-10	0.0E+00	0.0E+00	4.8E-11	3.2E-08	0.0E+00	0.0E+00	5.5E-07	2.1E-07				
12DICHLOROETHENE	1.8E-05	1.0E-05	0.0E+00	0.0E+00	4.1E-07	4.1E-04	0.0E+00	0.0E+00	5.3E-04	2.3E-04	0.0E+00	0.0E+00				
CHLOROBENZENE*	1.6E-05	1.1E-05	0.0E+00	0.0E+00					4.0E-03	1.2E-03	0.0E+00	0.0E+00				
NITROBENZENE*	1.4E-03	1.4E-03	0.0E+00	0.0E+00	2.3E-03	1.8E-03	0.0E+00	0.0E+00								
1,2-DICHLOROBENZENE	4.8E-05	4.2E-05	0.0E+00	0.0E+00	7.4E-08	6.3E-08	0.0E+00	0.0E+00	1.6E-04	1.1E-04	0.0E+00	0.0E+00				
1,3-DCB*	7.8E-08	7.8E-08	0.0E+00	0.0E+00												
1,4-DCB*	0.0E+00	0.0E+00	7.3E-08	5.7E-08												
1,2,4-TRICHLOROBENZENE*	1.6E-03	1.6E-03	0.0E+00	0.0E+00	2.3E-03	1.4E-03	0.0E+00	0.0E+00								
NAPHTHALENE*	3.1E-04	2.8E-04	0.0E+00	0.0E+00	1.7E-04	1.1E-04	0.0E+00	0.0E+00	3.4E-03	2.1E-03	0.0E+00	0.0E+00				
PHENOL*																
ARSENIC*	4.0E-02	2.8E-02	4.3E-08	2.8E-08	2.6E-02	1.8E-02	2.7E-08	1.9E-08	2.3E-01	1.5E-01	2.4E-05	1.6E-05	2.8E-02	2.1E-02	2.8E-08	2.3E-08
ANTIMONY*																
CADMIUM*									2.0E-02	8.3E-03	0.0E+00	0.0E+00				
CHROMIUM*	2.9E-04	1.6E-04	0.0E+00	0.0E+00	1.8E-03	8.2E-04	0.0E+00	0.0E+00	3.8E-04	2.8E-04	0.0E+00	0.0E+00	3.1E-05	2.8E-05	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	4.4E-02	4.2E-02	0.0E+00	0.0E+00	6.2E-01	2.2E-01	0.0E+00	0.0E+00	6.1E-03	4.4E-03	0.0E+00	0.0E+00				
MONOMETHYLHG*																
DIMETHYLHG*																
VINYL CHLORIDE																
BENZENE	0.0E+00	0.0E+00	8.5E-11	8.8E-11												
DICHLOROMETHANE					3.8E-08	1.5E-08	4.8E-10	1.9E-10	4.2E-08	4.2E-08	5.2E-10	5.2E-10				
ACETONE					1.4E-08	6.5E-07	0.0E+00	0.0E+00	3.1E-05	2.0E-05	0.0E+00	0.0E+00				
BEHP	2.3E-05	1.7E-05	1.4E-08	1.1E-08	2.3E-04	1.1E-04	1.4E-08	6.9E-09	2.9E-04	2.9E-04	1.8E-08	1.8E-08				
3/4-METHYLPHENOL																
2-METHYLNAPH																
ACENAPTHYLENE	7.2E-05	7.2E-05	0.0E+00	0.0E+00	1.8E-04	1.4E-04	0.0E+00	0.0E+00								
PHENANTHRENE	4.1E-04	3.8E-04	0.0E+00	0.0E+00	4.8E-04	3.2E-04	0.0E+00	0.0E+00	8.2E-03	6.2E-03	0.0E+00	0.0E+00				
FLUORANTHENE	7.2E-05	6.7E-05	0.0E+00	0.0E+00	8.2E-05	8.7E-05	0.0E+00	0.0E+00	1.0E-03	7.3E-04	0.0E+00	0.0E+00				
PYRENE	8.2E-05	8.2E-05	0.0E+00	0.0E+00	1.7E-04	1.2E-04	0.0E+00	0.0E+00	8.9E-04	6.4E-04	0.0E+00	0.0E+00				
BENZO(A)ANTH	0.0E+00	0.0E+00	2.1E-08	1.8E-08	0.0E+00	0.0E+00	2.7E-08	2.0E-08	0.0E+00	0.0E+00	2.8E-05	1.5E-05				
CHRYSENE	0.0E+00	0.0E+00	1.8E-08	1.8E-08	0.0E+00	0.0E+00	3.6E-08	2.7E-08	0.0E+00	0.0E+00	2.2E-05	1.5E-05				
BENZO(B)FLUOR	0.0E+00	0.0E+00	2.1E-08	2.1E-08	0.0E+00	0.0E+00	4.6E-08	3.1E-08	0.0E+00	0.0E+00	1.3E-05	1.1E-05				
BENZO(K)FLUOR	0.0E+00	0.0E+00	2.0E-08	1.7E-08	0.0E+00	0.0E+00	2.6E-08	1.2E-08	0.0E+00	0.0E+00	1.6E-05	1.1E-05				
BENZO(A)PYRENE	0.0E+00	0.0E+00	2.0E-08	1.8E-08	0.0E+00	0.0E+00	3.1E-08	2.3E-08	0.0E+00	0.0E+00	1.2E-05	9.9E-06				
IN(123-CD)PYRENE	0.0E+00	0.0E+00	8.4E-07	8.4E-07	0.0E+00	0.0E+00	1.8E-08	1.2E-08								
DIBENZ(AH)ANTH																
BENZO(GHI)PERYL	1.4E-04	1.4E-04	0.0E+00	0.0E+00	3.8E-04	2.5E-04	0.0E+00	0.0E+00								
BARIUM	8.6E-04	8.8E-04	0.0E+00	0.0E+00	2.1E-03	1.2E-03	0.0E+00	0.0E+00	2.6E-03	1.6E-03	0.0E+00	0.0E+00	2.4E-03	2.2E-03	0.0E+00	0.0E+00
BERYLLIUM	2.0E-04	1.8E-04	8.8E-07	7.0E-07	8.0E-04	3.9E-04	3.4E-08	1.7E-08	3.7E-03	2.6E-03	1.6E-05	1.1E-05	6.9E-04	3.7E-04	3.0E-08	1.8E-08
COPPER																
MANGANESE	2.8E-03	1.7E-03	0.0E+00	0.0E+00	6.8E-03	3.0E-03	0.0E+00	0.0E+00	1.6E-02	8.3E-03	0.0E+00	0.0E+00	1.6E-02	1.2E-02	0.0E+00	0.0E+00
NICKEL									1.7E-02	8.2E-03	0.0E+00	0.0E+00				
SILVER																
SELENIUM																
THALLIUM																
VANADIUM	4.7E-03	3.1E-03	0.0E+00	0.0E+00	9.4E-03	4.5E-03	0.0E+00	0.0E+00	1.3E-02	1.2E-02	0.0E+00	0.0E+00	1.1E-02	8.1E-03	0.0E+00	0.0E+00
ZINC	8.4E-04	8.5E-04	0.0E+00	0.0E+00	3.6E-03	1.5E-03	0.0E+00	0.0E+00	4.9E-03	3.3E-03	0.0E+00	0.0E+00	1.5E-03	1.4E-03	0.0E+00	0.0E+00
4,4-DDE									0.0E+00	0.0E+00	1.3E-09	1.8E-09				
4,4-DDD									0.0E+00	0.0E+00	4.8E-09	1.4E-09				
4,4-DDT																
CHLORDANE																
AROCLOR 1254									0.0E+00	0.0E+00	4.9E-07	2.8E-07				
SUM	9.8E-02	7.8E-02	1.8E-05	1.4E-05	8.7E-01	2.5E-01	2.4E-05	1.6E-05	3.3E-01	2.1E-01	1.3E-04	8.9E-05	5.7E-02	4.5E-02	5.8E-08	3.9E-08

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

FINAL

TABLE 6-40
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 7

PARAMETER	RISK VALUES: SEDIMENT EXPOSURE															
	REACH 3				REACH 4				REACH 5				REACH 6			
	HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TRICHLOROETHENE																
12DICHLOROETHENE																
CHLOROBENZENE*																
NITROBENZENE*																
1,2-DICHLOROBENZENE																
1,3-DCB*																
1,4-DCB*	0.0E+00	0.0E+00	1.8E-08	1.8E-08												
1,2,4-TRICHLOROBENZENE*	3.2E-04	2.2E-04	0.0E+00	0.0E+00												
NAPHTHALENE*	6.2E-05	6.2E-06	0.0E+00	0.0E+00												
PHENOL*																
ARSENIC*	1.3E-01	4.8E-02	1.4E-06	5.0E-08	2.0E-01	8.5E-02	2.1E-05	7.0E-06	5.6E-02	2.3E-02	6.0E-06	2.5E-06	1.5E-01	6.8E-02	1.6E-05	7.3E-06
ANTIMONY*	8.2E-02	1.8E-02	0.0E+00	0.0E+00												
CADMIUM*	7.3E-02	1.8E-02	0.0E+00	0.0E+00	5.4E-02	1.8E-02	0.0E+00	0.0E+00					5.0E-02	1.4E-02	0.0E+00	0.0E+00
CHROMIUM*	4.8E-03	8.3E-04	0.0E+00	0.0E+00	4.1E-04	1.3E-04	0.0E+00	0.0E+00	1.1E-04	3.3E-05	0.0E+00	0.0E+00	5.1E-04	1.2E-04	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	3.4E-01	1.0E-01	0.0E+00	0.0E+00	4.8E-02	2.1E-02	0.0E+00	0.0E+00	2.6E-02	8.1E-03	0.0E+00	0.0E+00	1.1E-01	2.1E-02	0.0E+00	0.0E+00
MONOMETHYLHG*	4.7E-04	4.7E-04	0.0E+00	0.0E+00	1.4E-03	4.6E-04	0.0E+00	0.0E+00								
DIMETHYLHG*	3.4E-04	1.3E-04	0.0E+00	0.0E+00												
VINYL CHLORIDE																
BENZENE																
DICHLOROMETHANE																
ACETONE	1.3E-05	8.4E-06	0.0E+00	0.0E+00	1.1E-04	6.6E-05	0.0E+00	0.0E+00					2.3E-05	1.6E-05	0.0E+00	0.0E+00
BEHP	1.0E-04	8.0E-06	6.8E-09	5.7E-09					3.8E-05	3.8E-05	2.4E-09	2.4E-09	2.2E-04	1.6E-04	1.4E-08	1.0E-08
3/4-METHYLPHENOL									5.9E-06	5.9E-06	0.0E+00	0.0E+00				
2-METHYLNAPH																
ACENAPTHYLENE	4.9E-04	4.2E-04	0.0E+00	0.0E+00					8.2E-06	8.2E-06	0.0E+00	0.0E+00				
PHENANTHRENE	3.8E-03	7.0E-04	0.0E+00	0.0E+00	8.7E-05	8.7E-05	0.0E+00	0.0E+00	2.8E-04	2.8E-04	0.0E+00	0.0E+00	8.2E-04	6.0E-04	0.0E+00	0.0E+00
FLUORANTHENE	8.2E-04	1.2E-04	0.0E+00	0.0E+00	1.4E-05	1.3E-05	0.0E+00	0.0E+00	5.7E-06	5.7E-06	0.0E+00	0.0E+00	1.3E-04	1.0E-04	0.0E+00	0.0E+00
PYRENE	7.8E-04	1.7E-04	0.0E+00	0.0E+00	1.8E-05	1.7E-05	0.0E+00	0.0E+00	7.5E-06	7.5E-06	0.0E+00	0.0E+00	2.0E-04	1.4E-04	0.0E+00	0.0E+00
BENZO(A)ANTH	0.0E+00	0.0E+00	1.1E-06	3.4E-08	0.0E+00	0.0E+00	2.8E-07	2.6E-07	0.0E+00	0.0E+00	1.2E-08	1.2E-08	0.0E+00	0.0E+00	3.8E-08	2.6E-08
CHRYSENE	0.0E+00	0.0E+00	2.0E-06	4.4E-08	0.0E+00	0.0E+00	5.6E-07	5.2E-07	0.0E+00	0.0E+00	1.8E-08	1.8E-08	0.0E+00	0.0E+00	3.8E-08	3.3E-08
BENZO(B)FLUOR	0.0E+00	0.0E+00	1.1E-06	3.8E-08	0.0E+00	0.0E+00	1.0E-06	7.0E-07	0.0E+00	0.0E+00	3.6E-08	3.6E-08	0.0E+00	0.0E+00	6.7E-08	4.1E-08
BENZO(K)FLUOR	0.0E+00	0.0E+00	9.8E-08	3.8E-08	0.0E+00	0.0E+00	3.8E-07	3.8E-07					0.0E+00	0.0E+00	2.5E-08	2.3E-08
BENZO(A)PYRENE	0.0E+00	0.0E+00	1.1E-06	3.1E-08	0.0E+00	0.0E+00	3.8E-07	3.8E-07	0.0E+00	0.0E+00	8.2E-07	8.2E-07	0.0E+00	0.0E+00	2.8E-08	2.0E-08
IN(123-CD)PYRENE	0.0E+00	0.0E+00	4.8E-08	2.0E-08	0.0E+00	0.0E+00	2.4E-07	2.4E-07	0.0E+00	0.0E+00	8.1E-07	8.1E-07	0.0E+00	0.0E+00	1.9E-08	1.4E-08
DIBENZ(AH)ANTH	0.0E+00	0.0E+00	7.8E-07	6.8E-07												
BENZO(GHI)PERYL	8.2E-04	4.0E-04	0.0E+00	0.0E+00	4.7E-05	4.7E-05	0.0E+00	0.0E+00	1.4[illegible]	1.4E-04	0.0E+00	0.0E+00	4.2E-04	3.0E-04	0.0E+00	0.0E+00
BARIUM	4.3E-03	2.8E-03	0.0E+00	0.0E+00	4.8E-03	2.8E-03	0.0E+00	0.0E+00	8.2[illegible]	2.7E-03	0.0E+00	0.0E+00	5.2E-03	3.1E-03	0.0E+00	0.0E+00
BERYLLIUM	1.8E-03	5.8E-04	6.7E-08	2.4E-08	1.3E-03	2.8E-04	5.6E-06	1.3E-06	8.1[illegible]	8.1E-05	3.9E-07	3.9E-07	7.3E-04	1.6E-04	3.1E-06	7.7E-07
COPPER																
MANGANESE	1.8E-02	7.1E-03	0.0E+00	0.0E+00					3.5E-02	1.3E-02	0.0E+00	0.0E+00	2.6E-02	1.1E-02	0.0E+00	0.0E+00
NICKEL	6.1E-03	2.6E-03	0.0E+00	0.0E+00	5.8E-03	2.8E-03	0.0E+00	0.0E+00	1.5E-03	6.2E-04	0.0E+00	0.0E+00	7.2E-03	1.9E-03	0.0E+00	0.0E+00
SILVER									3.9E-03	1.2E-03	0.0E+00	0.0E+00				
SELENIUM	1.8E-03	3.0E-04	0.0E+00	0.0E+00	1.6E-03	8.4E-04	0.0E+00	0.0E+00	1.6E-04	1.6E-04	0.0E+00	0.0E+00	2.2E-03	5.0E-04	0.0E+00	0.0E+00
THALLIUM																
VANADIUM	1.8E-02	6.1E-03	0.0E+00	0.0E+00	1.8E-02	8.0E-03	0.0E+00	0.0E+00	8.0E-03	4.4E-03	0.0E+00	0.0E+00	2.2E-02	1.5E-02	0.0E+00	0.0E+00
ZINC	4.0E-03	1.8E-03	0.0E+00	0.0E+00					7.0E-03	1.8E-03	0.0E+00	0.0E+00	5.2E-03	2.7E-03	0.0E+00	0.0E+00
4,4-DDE	0.0E+00	0.0E+00	3.8E-08	4.8E-08												
4,4-DDD	0.0E+00	0.0E+00	1.8E-08	3.8E-08									0.0E+00	0.0E+00	3.1E-08	1.6E-08
4,4-DDT																
CHLORDANE																
AROCLOR 1254																
SUM	6.8E-01	2.1E-01	9.0E-06	2.8E-06	3.3E-01	1.2E-01	3.0E-05	1.1E-05	1.5E-01	5.4E-02	1.4E-05	1.1E-05	3.8E-01	1.4E-01	4.2E-05	2.4E-05

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-76
SUMMARY OF RISK RESULTS
N ZA OPERABLE UNIT 3
M ESEX COUNTY, MASSACHUSETTS
PAGE 8

PARAMETER	RISK VALUES: SEDIMENT EXPOSURE															
	REACH 7				REACH 8				REACH 9				REACH 10			
	HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TRICHLOROETHENE																
12DICHLOROETHENE																
CHLOROBENZENE*																
NITROBENZENE*																
1,2-DICHLOROBENZENE																
1,3-DCB*																
1,4-DCB*																
1,2,4-TRICHLOROBENZENE*																
NAPHTHALENE*																
PHENOL*																
ARSENIC*	2.8E-01	6.2E-02	2.7E-05	8.6E-06	1.8E-01	7.4E-02	2.0E-05	7.9E-06	3.9E-01	1.9E-01	4.2E-05	2.1E-05	7.4E-02	3.6E-02	8.0E-06	3.9E-06
ANTIMONY*																
CADMIUM*	6.5E-02	6.1E-03	0.0E+00	0.0E+00	1.8E-02	7.6E-03	0.0E+00	0.0E+00	3.1E-02	2.6E-02	0.0E+00	0.0E+00				
CHROMIUM*	3.8E-04	8.8E-05	0.0E+00	0.0E+00	6.6E-05	4.0E-05	0.0E+00	0.0E+00	1.4E-04	9.2E-05	0.0E+00	0.0E+00	3.1E-05	2.1E-05	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	3.4E-02	9.5E-03	0.0E+00	0.0E+00	1.3E-02	1.0E-02	0.0E+00	0.0E+00	2.4E-02	2.0E-02	0.0E+00	0.0E+00	3.3E-03	1.0E-03	0.0E+00	0.0E+00
MONOMETHYLHG*																
DIMETHYLHG*																
VINYL CHLORIDE																
BENZENE																
DICHLOROMETHANE																
ACETONE	6.6E-06	3.6E-06	1.3E-08	7.3E-09												
BEHP	1.3E-04	6.7E-05	7.6E-08	6.1E-08												
3/4-METHYLPHENOL																
2-METHYLNAPH																
ACENAPTHYLENE																
PHENANTHRENE	6.2E-04	3.0E-04	0.0E+00	0.0E+00												
FLUORANTHENE	9.8E-05	4.9E-05	0.0E+00	0.0E+00												
PYRENE	1.2E-04	6.0E-05	0.0E+00	0.0E+00												
BENZO(A)ANTH	0.0E+00	0.0E+00	2.2E-06	1.1E-06												
CHRYSENE	0.0E+00	0.0E+00	3.1E-08	1.6E-08												
BENZO(B)FLUOR	0.0E+00	0.0E+00	2.3E-06	1.3E-06												
BENZO(K)FLUOR	0.0E+00	0.0E+00	1.3E-06	6.6E-07												
BENZO(A)PYRENE	0.0E+00	0.0E+00	2.2E-06	1.6E-06												
IN(123-CD)PYRENE	0.0E+00	0.0E+00	1.4E-06	1.4E-06												
DIBENZ(AH)ANTH																
BENZO(GHI)PERYL	3.1E-04	3.1E-04	0.0E+00	0.0E+00												
BARIUM	9.6E-03	3.4E-03	0.0E+00	0.0E+00	8.1E-03	4.1E-03	0.0E+00	0.0E+00	5.6E-03	4.2E-03	0.0E+00	0.0E+00	2.3E-03	1.2E-03	0.0E+00	0.0E+00
BERYLLIUM	2.2E-04	2.1E-04	6.6E-07	6.6E-07												
COPPER																
MANGANESE	2.6E-02	6.7E-03	0.0E+00	0.0E+00	1.1E-01	3.1E-02	0.0E+00	0.0E+00	9.4E-03	7.6E-03	0.0E+00	0.0E+00	8.1E-03	3.3E-03	0.0E+00	0.0E+00
NICKEL	4.0E-03	1.0E-03	0.0E+00	0.0E+00	1.2E-03	6.6E-04	0.0E+00	0.0E+00	2.6E-03	2.3E-03	0.0E+00	0.0E+00	1.0E-03	6.7E-04	0.0E+00	0.0E+00
SILVER																
SELENIUM	2.6E-03	4.3E-04	0.0E+00	0.0E+00	6.6E-04	2.7E-04	0.0E+00	0.0E+00								
THALLIUM																
VANADIUM	1.2E-02	6.1E-03	0.0E+00	0.0E+00	3.3E-03	2.8E-03	0.0E+00	0.0E+00	6.0E-03	4.6E-03	0.0E+00	0.0E+00	4.1E-03	2.4E-03	0.0E+00	0.0E+00
ZINC	5.6E-03	1.6E-03	0.0E+00	0.0E+00	3.0E-03	1.7E-03	0.0E+00	0.0E+00	2.9E-03	1.6E-03	0.0E+00	0.0E+00	4.9E-04	3.5E-04	0.0E+00	0.0E+00
4,4-DDE																
4,4-DDD																
4,4-DDT																
CHLORDANE	2.3E-04	2.3E-04	4.3E-08	4.3E-08												
AROCLOR 1254	0.0E+00	0.0E+00	4.3E-07	7.3E-07												
SUM	4.1E-01	9.8E-02	4.1E-05	1.6E-05	3.3E-01	1.3E-01	2.0E-05	7.9E-06	4.6E-01	2.6E-01	4.2E-05	2.1E-05	9.2E-02	4.5E-02	8.0E-06	3.9E-06

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 9

PARAMETER	RISK VALUES: SEDIMENT EXPOSURE												RISK SUMMARIES: SEDIMENT EXPOSURE			
	BORDERING WETLANDS RECREATIONAL				BORDERING WETLANDS RECREATIONAL (270 DAYS PER YEAR)				BORDERING WETLANDS RESIDENTIAL				HEARD POND			
	HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME		HAZARD QUOTIENT CHILD		CANCER RISK LIFETIME	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TRICHLOROETHENE																
12DICHLOROETHENE																
CHLOROBENZENE*																
NITROBENZENE*																
1,2-DICHLOROBENZENE																
1,3-DCB*																
1,4-DCB*																
1,2,4-TRICHLOROBENZENE*																
NAPHTHALENE*																
PHENOL*																
ARSENIC*	7.1E-02	3.6E-02	7.6E-08	4.1E-08	3.9E-01	2.0E-01	2.7E-05	1.4E-05	5.1E-01	2.7E-01	3.6E-05	1.9E-05	6.6E-02	6.6E-02	7.1E-08	7.1E-08
ANTIMONY*																
CADMIUM*																
CHROMIUM*	1.8E-04	4.4E-05	0.0E+00	0.0E+00	1.0E-03	2.4E-04	0.0E+00	0.0E+00	1.3E-03	3.1E-04	0.0E+00	0.0E+00	7.3E-05	7.3E-05	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*	4.7E-02	6.7E-03	0.0E+00	0.0E+00	2.6E-01	3.6E-02	0.0E+00	0.0E+00	3.3E-01	4.7E-02	0.0E+00	0.0E+00	2.2E-02	2.2E-02	0.0E+00	0.0E+00
MONOMETHYLHG*																
DIMETHYLHG*																
VINYL CHLORIDE																
BENZENE																
DICHLOROMETHANE																
ACETONE																
BEHP																
3/4-METHYLPHENOL																
2-METHYLNAPH																
ACENAPTHYLENE																
PHENANTHRENE																
FLUORANTHENE																
PYRENE																
BENZO(A)ANTH																
CHRYSENE																
BENZO(B)FLUOR																
BENZO(K)FLUOR																
BENZO(A)PYRENE																
IN(123-CD)PYRENE																
DIBENZ(AH)ANTH																
BENZO(GHI)PERYL																
BARIUM	2.4E-03	1.4E-03	0.0E+00	0.0E+00	1.3E-02	7.6E-03	0.0E+00	0.0E+00	1.7E-02	9.7E-03	0.0E+00	0.0E+00	3.3E-03	3.3E-03	0.0E+00	0.0E+00
BERYLLIUM	6.6E-04	3.0E-04	3.0E-08	1.3E-08	3.7E-03	1.6E-03	1.0E-05	4.6E-06	4.9E-03	2.1E-03	1.4E-05	5.8E-06				
COPPER																
MANGANESE	2.0E-02	5.4E-03	0.0E+00	0.0E+00	1.1E-01	2.9E-02	0.0E+00	0.0E+00	1.4E-01	3.8E-02	0.0E+00	0.0E+00	6.1E-03	6.1E-03	0.0E+00	0.0E+00
NICKEL	2.0E-03	6.6E-04	0.0E+00	0.0E+00	1.1E-02	3.6E-03	0.0E+00	0.0E+00	1.4E-02	4.6E-03	0.0E+00	0.0E+00	1.0E-03	1.0E-03	0.0E+00	0.0E+00
SILVER																
SELENIUM	4.4E-04	2.6E-05	0.0E+00	0.0E+00	2.4E-03	1.4E-04	0.0E+00	0.0E+00	3.1E-03	1.8E-04	0.0E+00	0.0E+00				
THALLIUM																
VANADIUM	1.5E-02	7.3E-03	0.0E+00	0.0E+00	8.1E-02	4.0E-02	0.0E+00	0.0E+00	1.1E-01	5.1E-02	0.0E+00	0.0E+00	5.7E-03	5.7E-03	0.0E+00	0.0E+00
ZINC	1.2E-03	3.6E-04	0.0E+00	0.0E+00	6.3E-03	2.0E-03	0.0E+00	0.0E+00	8.1E-03	2.6E-03	0.0E+00	0.0E+00	2.6E-03	2.6E-03	0.0E+00	0.0E+00
4,4-DDE																
4,4-DDD																
4,4-DDT																
CHLORDANE																
AROCLOR 1254																
SUM	1.6E-01	5.8E-02	1.1E-07	5.4E-08	8.7E-01	3.2E-01	3.7E-05	1.9E-05	$\boxed{1.1E+00}$	4.2E-01	4.9E-05	2.4E-05	1.1E-01	1.1E-01	7.1E-08	7.1E-08

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

PARAMETER	RISK VALUES: SURFACE WATER															
	REACH 1 AND BACKGROUND				REACH 2				Eastern Wetlands				OUTFALL CREEK			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TCE*									0.0E+00	0.0E+00	6.9E-08	4.8E-08	0.0E+00	0.0E+00	1.4E-07	1.4E-07
1,2-DCE*					1.9E-04	1.9E-04	0.0E+00	0.0E+00	1.5E-03	9.9E-04	0.0E+00	0.0E+00	2.2E-03	2.2E-03	0.0E+00	0.0E+00
1,4-DCB*													0.0E+00	0.0E+00	9.0E-08	9.0E-08
1,2-DCB*									2.0E-04	2.0E-04	0.0E+00	0.0E+00	2.7E-04	2.7E-04	0.0E+00	0.0E+00
ARSENIC*					9.8E-03	9.8E-03	1.9E-06	1.9E-06								
CADMIUM*					1.4E-02	5.5E-03	0.0E+00	0.0E+00								
CHROMIUM*					6.8E-06	5.2E-06	0.0E+00	0.0E+00	7.7E-05	7.7E-05	0.0E+00	0.0E+00	5.5E-06	5.5E-06	0.0E+00	0.0E+00
LEAD*	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*									1.2E-02	6.8E-03	0.0E+00	0.0E+00	1.6E-03	1.6E-03	0.0E+00	0.0E+00
1,1-DCE	6.4E-04	5.6E-04	1.7E-06	1.5E-06												
BEHP													4.8E-05	4.8E-05	4.7E-09	4.7E-09
BARIUM	4.5E-04	3.1E-04	0.0E+00	0.0E+00	2.6E-03	6.6E-04	0.0E+00	0.0E+00	1.8E-04	1.7E-04	0.0E+00	0.0E+00	2.1E-04	2.1E-04	0.0E+00	0.0E+00
BERYLLIUM					1.5E-03	5.1E-04	1.1E-05	3.9E-06								
COPPER																
MANGANESE	1.1E-03	7.9E-04	0.0E+00	0.0E+00	9.8E-02	1.5E-02	0.0E+00	0.0E+00	1.1E-03	9.8E-04	0.0E+00	0.0E+00	1.4E-03	1.4E-03	0.0E+00	0.0E+00
NICKEL	8.6E-04	2.5E-04	0.0E+00	0.0E+00	3.8E-03	1.1E-03	0.0E+00	0.0E+00								
SELENIUM																
SILVER	5.5E-03	1.5E-03	0.0E+00	0.0E+00	2.2E-02	3.1E-03	0.0E+00	0.0E+00								
VANADIUM					2.2E-03	2.0E-03	0.0E+00	0.0E+00								
ZINC	3.0E-05	3.0E-05	0.0E+00	0.0E+00	6.1E-04	1.2E-04	0.0E+00	0.0E+00					2.3E-04	2.3E-04	0.0E+00	0.0E+00
SUM HAZARD QUOTIENTS	8.6E-03	3.5E-03	1.7E-06	1.5E-06	1.5E-01	3.8E-02	1.3E-05	5.7E-06	1.5E-02	9.3E-03	6.9E-06	4.8E-08	5.9E-03	5.9E-03	2.3E-07	2.3E-07

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-46
SUMMARY OF RISK RESULTS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 11

PARAMETER	RISK VALUES: SURFACE WATER															
	RACEWAY				COLD SPRING BROOK				REACH 3				REACH 4			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TCE*	0.0E+00	0.0E+00	2.1E-08	2.1E-08												
1,2-DCE*	3.7E-04	3.7E-04	0.0E+00	0.0E+00												
1,4-DCB*																
1,2-DCB*																
ARSENIC*																
CADMIUM*																
CHROMIUM*													5.9E-06	4.4E-06	0.0E+00	0.0E+00
LEAD*									0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MERCURY*																
1,1-DCE																
BEHP					2.8E-03	2.8E-03	2.7E-07	2.7E-07	4.8E-05	4.8E-05	4.7E-09	4.7E-09				
BARIUM	3.2E-04	3.2E-04	0.0E+00	0.0E+00					2.5E-04	1.1E-05	0.0E+00	0.0E+00	4.8E-04	2.5E-04	0.0E+00	0.0E+00
BERYLLIUM																
COPPER																
MANGANESE	2.6E-03	2.6E-03	0.0E+00	0.0E+00	1.1E-03	1.1E-03	0.0E+00	0.0E+00	6.2E-04	6.2E-04	0.0E+00	0.0E+00	2.0E-03	1.3E-03	0.0E+00	0.0E+00
NICKEL																
SELENIUM									3.8E+00	7.5E-01	0.0E+00	0.0E+00				
SILVER					4.5E-03	4.5E-03	0.0E+00	0.0E+00	3.9E-03	2.3E-03	0.0E+00	0.0E+00				
VANADIUM																
ZINC									3.9E-05	3.9E-05	0.0E+00	0.0E+00				
SUM HAZARD QUOTIENTS	3.3E-03	3.3E-03	2.1E-08	2.1E-08	8.4E-03	8.4E-03	2.7E-07	2.7E-07	3.8E+00	7.6E-01	4.7E-09	4.7E-09	2.5E-03	1.5E-03	0.0E+00	0.0E+00

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

TABLE 6-48
SUMMARY OF RISK RESULTS
NYANZA O ABLE UNIT 3
MIDDLESE OUNTY, MASSACHUSETTS
PAGE 12

PARAMETER	RISK VALUES: SURFACE WATER											
	REACH 5				REACH 6				REACH 7			
	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIENT		CANCER RISK	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
TCE*												
1,2-DCE*												
1,4-DCB*												
1,2-DCB*												
ARSENIC*	3.6E-03	3.4E-03	6.6E-07	6.5E-07								
CADMIUM*												
CHROMIUM*												
LEAD*					0.0E+00	0.0E+00	0.0E+00	0.0E+00				
MERCURY*												
1,1-DCE												
BEHP												
BARIUM	2.5E-04	2.5E-04	0.0E+00	0.0E+00	3.2E-04	9.4E-05	0.0E+00	0.0E+00	4.2E-04	1.4E-04	0.0E+00	0.0E+00
BERYLLIUM												
COPPER												
MANGANESE	1.0E-03	6.8E-04	0.0E+00	0.0E+00	1.6E-03	9.4E-04	0.0E+00	0.0E+00	1.2E-03	7.3E-04	0.0E+00	0.0E+00
NICKEL												
SELENIUM												
SILVER									2.1E-03	1.1E-03	0.0E+00	0.0E+00
VANADIUM												
ZINC												
SUM HAZARD QUOTIENTS	4.9E-03	4.3E-03	6.6E-07	6.5E-07	1.9E-03	1.0E-03	0.0E+00	0.0E+00	3.7E-03	2.0E-03	0.0E+00	0.0E+00

BOXED VALUES ARE HAZARD QUOTIENTS WHICH EXCEED UNITY

- The hazard index calculated for all COCs ranged from 1.5 (Southville Pond, average COC concentrations) to 120 (Reservoir No. 2, maximum COC concentrations) when the subsistence fisherman is considered the receptor of concern. The hazard index calculated for all COCs ranged from 0.21 (Southville Pond, average COC concentrations) to 17 (Reservoir No. 2, maximum COC concentrations) when the sports fisherman is considered the receptor of concern. The HQ calculated for mercury and/or methyl mercury exceeds unity in every case that the hazard index exceeds unity.

- Hazard indices calculated for fish tissue sample results from surface water bodies downstream of the Nyanza Site exceed 10 in one or more cases presented. With the exception of Cedar Swamp Pond, hazard indices calculated for surface water bodies upstream of the Nyanza Site do not exceed 10.

- With the exception of Southville Pond, maximum and/or average mercury concentrations detected in fish tissue samples collected downstream of the Nyanza Site exceed the FDA Action Level for mercury in fish.

- The fact that HQs and HIs exceed unity and the fact that mercury concentrations exceed FDA Action Levels in one or more cases presented for each surface water body evaluated suggests that adverse noncarcinogenic health effects are anticipated for the sports fisherman and subsistence fisherman under the conditions of the exposure scenarios defined in Section 6.4. With the exception of the Saxonville impoundment and the Sudbury Reservoir, hazard indices calculated for Nyanza Site contaminants exceed those calculated for "other Sudbury River contaminants in all cases presented."

- Cancer risks estimated for the fish-ingestion exposure scenarios range from not calculated (Cedar Swamp Pond and Southville Pond, no risk calculated; CSFs not available for COCs) to 5.5 x 10^{-3} (Reservoir No. 2, maximum COC concentrations, subsistence fisherman). As a point of reference, cancer risks estimated for samples collected in the Sudbury Reservoir are 5 x 10^{-4} and 3.6 x 10^{-4} when maximum and average COC concentrations are evaluated and the subsistence fisherman is considered the receptor of concern. Cancer risks estimated for surface water bodies upstream of the Nyanza Site do not exceed 1 x 10^{-3} in any case presented. Cancer risks estimated for Mill Pond, Reservoir No. 2, and Fairhaven Bay exceed 1 x 10^{-3} in at least one case presented. The principal COCs contributing to the estimated excess lifetime cancer risks are arsenic, several pesticides (e.g., 4,4-DDT), and the PCBs. In all cases presented, risks associated with "other Sudbury River contaminants" exceed those estimated for Nyanza Site contaminants.

The following items summarize the results of the risk assessment of COC concentrations detected in surface water and sediment samples collected in the Study Area:

- In all cases presented for the sediment exposure scenarios, HQs and HIs calculated for the accidental-ingestion exposure route exceed those calculated for the dermal-absorption exposure route. The hazard index calculated for the bordering wetlands (residential exposure scenario) exceeds unity when maximum concentrations are evaluated and a child is evaluated as the receptor of concern. However, hazard indices calculated on a target organ-specific basis do not exceed unity. Adverse noncarcinogenic health effects are anticipated when HQs or HIs (calculated on a target organ specific basis) exceed unity.

- With few exceptions, hazard quotients and hazard indices calculated for the recreational sediment exposure scenarios do not exceed unity. However, hazard indices calculated for the COC concentrations detected in the Eastern Wetlands sediments (recreational exposure scenarios) exceed unity when maximum contaminant concentrations are evaluated and a small child is considered the receptor of concern. (In this case, the hazard index calculated for chemicals affecting the kidney and/or central nervous system equals unity (>0.95.))

- The hazard index calculated for COC concentrations detected in background sediment samples does not exceed 0.3 in any of the cases presented. Hazard indices calculated for sediment exposure scenarios for the following reaches/surface water bodies exceeds 0.5 (but not unity) in one or more cases presented:

  - Outfall Creek
  - Reach No. 3

  The hazard index calculated for the following reaches/surface water bodies (sediment exposure scenarios) does not exceed 0.5:

  - Reach No. 2
  - Reach No. 4
  - Reach No. 5
  - Reach No. 6
  - Reach No. 7
  - Reach No. 8
  - Reach No. 9
  - Reach No. 10
  - Chemical Brook Culvert
  - Raceway
  - Cold Spring Brook

As stated previously, adverse noncarcinogenic health effects are not anticipated when HQs or HIs do not exceed unity.

- Cancer risk estimates for the background sediments (recreational sediment exposure scenario) do not exceed 2 x 10^{-5} in any case evaluated. In contrast to the fish-ingestion exposure scenarios, cancer risks estimated for the sediment exposure scenarios do not exceed 2 x 10^{-4} in any case presented for any river reach or surface water body evaluated. As a point of reference, the 1x10^{-4} to 1x10^{-6} cancer risk range is often evaluated in the development of health-based standards/criteria and in the determination of clean-up goals at hazardous waste sites.

- Generally, the cancer risks estimated for maximum COC concentrations (sediment exposure scenarios) in downstream surface water bodies range from 1 x 10^{-5} to 1 x 10^{-4}. Risks estimated for the average-case scenario range from 1 x 10^{-6} to 1 x 10^{-5}. In most cases, risks associated with "other Sudbury River contaminants" exceed those estimated for the Nyanza Site contaminants. The principal contaminants contributing to the estimated risk are arsenic, beryllium, and the carcinogenic PAHs. Risks associated with the accidental-ingestion exposure route predominate over those estimated for the dermal-contact exposure route.

- Cancer risks estimated for the following river reaches/surface water bodies (sediment exposure scenarios) exceed 5 x 10^{-5} in one or more cases presented:

  - Reach No. 2
  - The Raceway
  - Reach No. 3

  As a point of reference, the 1x10^{-4} to 1x10^{-6} cancer risk range is often evaluated in the development of health-based standards/criteria and in the determination of clean-up goals at hazardous waste sites.

- Hazard quotients and hazard indices estimated for surface water exposure scenarios are minimal (all values <0.1) when compared to the sediment exposure scenarios (the selenium concentration in Reach 3 appears to be an anomaly). None of the cancer risks estimated for the surface-water exposure scenarios exceeds 2 x 10^{-6}.

6.7 Uncertainty Analysis

The carcinogenic and noncarcinogenic health risks presented in this risk assessment are estimated using various assumptions, and the results presented are subject to a certain amount of uncertainty. These uncertainties can be categorized into two major groups, uncertainty with toxicological data and uncertainty with exposure parameters and estimations.

The toxicological data that form the basis for the risk assessment are subject to uncertainty in the following areas:

- The extrapolation of nonthreshold (carcinogenic) effects from the high doses administered to laboratory animals to the low doses received in the application of exposure scenarios.

- The extrapolation of the results of laboratory animal studies to human or environmental receptors (described in the toxicity profiles).

- The inter-species variation in toxicological endpoints used in characterizing potential health effects resulting in exposure to a chemical.

- The variations in sensitivity among individuals of any species.

- Some of the toxicity criteria used for the risk assessment are currently under review (arsenic, mercury). If toxicity criteria change radically, the conclusions of this risk assessment could be effected.

- Toxicity criteria are not currently available for parameters such as copper and 2-methyl naphthalene. Conservatively, these compounds are carried through the risk assessment although quantitative results were not presented. Because neither copper or 2 methyl napthalene were detected frequently in Study Area environmental samples, it is unlikely that the conclusions drawn by the risk assessment would be altered if toxicity criteria were available for either compound. It should be noted that the maximum concentration of copper detected in Study Area (C_{max}=454 mg/kg) sediment samples is less than the maximum concentration detected in background samples (C_{max} - background = 340.4 mg/kg). The maximum concentration of copper in Study Area surface water samples is less than the current Federal SDWA MCL.

The exposure parameters and data consolidation used in this risk assessment create some amount of uncertainty, as described below:

- The exposure scenarios assume chronic exposure to contaminant levels which are constant. In reality, contaminant levels can change with weather conditions, water levels, and chemical changes in the waters.

- 1,1-Dichloroethene and 1,4-Dichlorobenzene are Class C carcinogens. Although Class C carcinogens are evaluated in the risk assessment, there is limited evidence supporting the classification of these compounds as carcinogens. Therefore, the carcinogenic risk totals must be viewed with this information in mind.

- Data gaps exist in the risk assessment. Toxicity criteria are not available for certain chemicals detected in the Study Area (lead, aluminum, cobalt). If these data gaps could be filled, the risk results which are presented in Sections 6.5 and 6.6 could be effected.

- Although EPA guidelines were followed in the development of the exposure scenarios, these scenarios assume certain activity frequencies. The exposure dose assumptions are based on available information and are conservative in nature.

- Permeability constants necessary to evaluate dermal absorption are not currently available for many chemicals. Default values have been used in this risk assessment as necessary. Absorption of VOCs is predicted by researchers to be significant; absorption of metals may approach zero.

- The chemical database has limitations in the areas of sample location and representativeness of the actual situation. These uncertainties are present in all environmental sampling databases and cannot reasonably be avoided.

7

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 General Approach

This ecological risk assessment consists of four primary components: (1) the selection of chemicals of concern, (2) the exposure assessment, (3) the toxicity or hazard assessment, and (4) the risk characterization. Sections 7.3, 7.4, 7.5, and 7.6, respectively, describe these primary elements.

The selection of media-specific chemicals of concern (COCs) is based on selection criteria that will provide an appropriate level of conservatism. COCs selected for each media are based on concentration, frequency of detection, toxicity, bioconcentration potential, or environmental persistence. The contaminants evaluated in the ecological risk assessment include both Nyanza site-related contaminants as identified by EPA and other Study Area contaminants.

The exposure assessment includes estimated environmental concentrations (EECs) of COCs in each media of concern (surface water, sediment, and biota). EECs are based on measured concentrations and estimates of chemical fate and transport, which are described in Section 5.0. Estimates of chemical fate and transport for this assessment are based primarily on simple algebraic models, such as partitioning coefficients. Estimates of chemical concentrations in biota use a more complex computer-based model (Thomann's Bioaccumulation Model). Average and maximum EECs were calculated for each COC within each reach and each media.

The hazard assessment, also known as toxicity assessment, evaluates concentrations of COCs that are known to or are likely to result in adverse effects to biota. Species that might be of concern are those that are known to or are likely to inhabit or use the study area; these include plants, aquatic animals (invertebrates and vertebrates), terrestrial animals, and birds. Indicator species were selected to represent specific trophic levels in the assessment of impacts to food chains. Toxicity data for species that are known to exist or likely to be present in the study area are sparse; therefore, most toxicity data are based on standard test species that are representative of similar, related species that might exist within the Study Area.

Risk characterization is primarily the integration of exposure data with toxicity or hazard assessments; that is, estimated exposure concentrations for media-specific COCs are compared to toxic or hazardous concentrations of those COCs. For assessing impacts to food chains, bioaccumulation data are more appropriate than toxicity data. Although several methods have been developed to accomplish the integration of toxicity and exposure evaluations, the quotient method is the most frequently used and accepted approach. This method divides the EEC by the selected toxicity benchmark value. The resulting quotient enables the evaluation of relative toxicity between individual COCs; higher quotients are associated with greater potential toxicity. Cumulative toxicity, or the toxicity associated with chemical mixtures, is also an important component of risk characterization. This assessment addresses cumulative toxicity by summing all exposure/toxicity quotients for each media and each reach, resulting in a reach-specific total risk estimate.

Secondary components of the ecological risk assessment include the identification of potential ecological receptors, and the analysis of uncertainty. The potential ecological receptors primarily include plants and animals that are known to or are likely to inhabit or use the Study Area; among these plant and animal species, threatened and endangered species are also included. Section 7.2 identifies potential ecological receptors, or populations potentially at risk. This assessment includes uncertainty analysis as part of the discussions of exposure assessment, toxicity assessment, and risk characterization.

Figure 7-1 shows the major components of this ecological risk assessment.

7.2 Biological Description

This section describes the major plant and animal species, both aquatic and terrestrial, that might be exposed to the Study Area and Site-related contaminants. These organisms comprise the potentially exposed populations for this risk assessment. Table 7-1 lists the plant and animal species observed in the study area, and those plants and animals considered of special concern by the State of Massachusetts.

7.2.1 Vegetation

Site vegetation includes common aquatic and terrestrial species of herbaceous plants, ferns, sedges, wildflowers, woody shrubs, and trees. Observed vegetation did not appear visibly stressed; however, community effects, such as species diversity, were not evaluated. Table 7-1 lists plant species recorded during the 1989-1991 field observations.

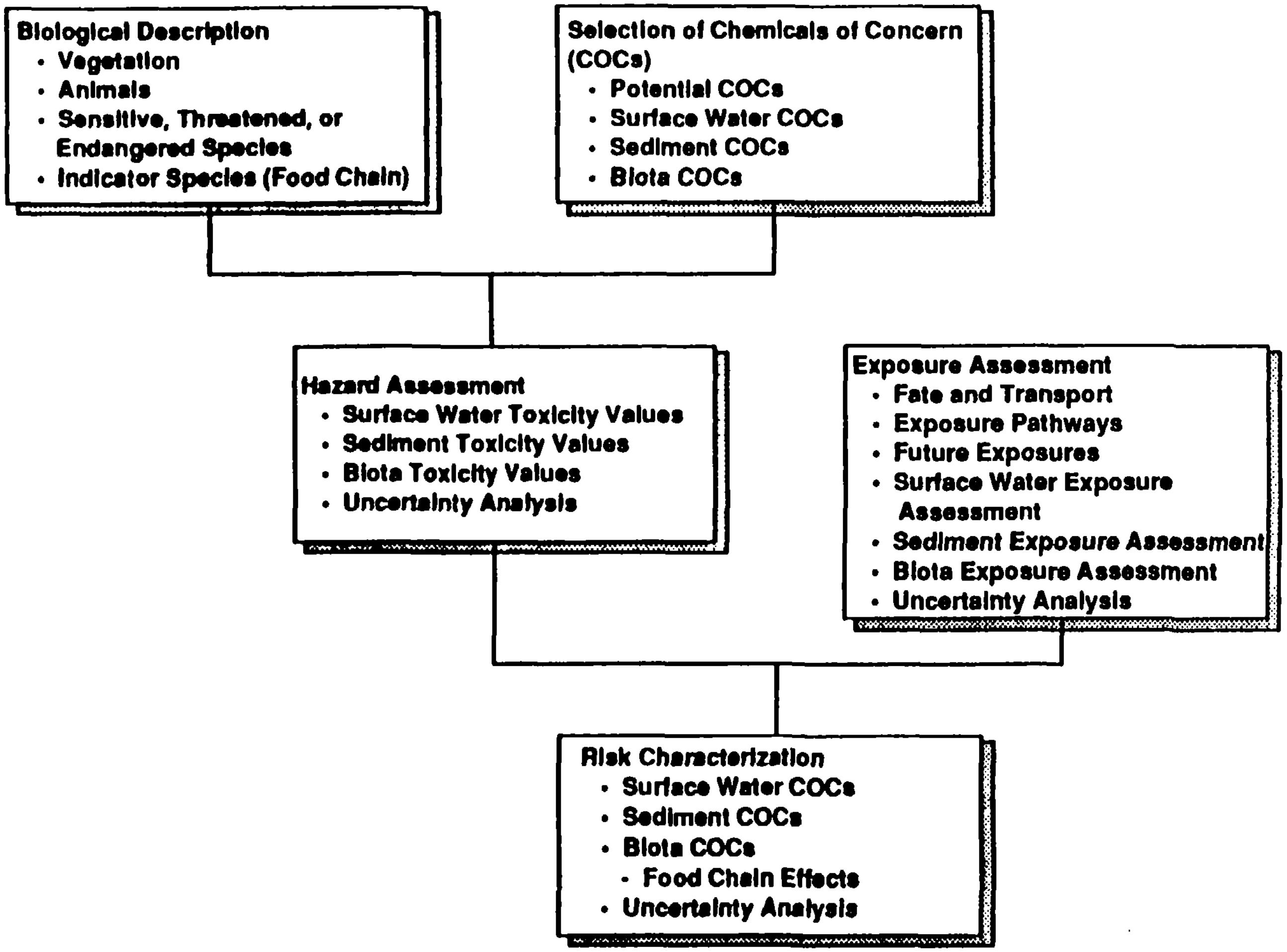


Figure 7-1. Ecological Risk Assessment Components

TABLE 7-1

SUMMARY OF STUDY AREA PLANT AND ANIMAL SPECIES (1)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

COMMON NAME	SCIENTIFIC NAME	STATUS
OBSERVED PLANTS		
NORTHERN RED OAK	Quercus borealis	COMMON – CLIMAX FOREST
WHITE PINE	Pinus strobus	COMMON – CLIMAX FOREST
SUGAR MAPLE	Acer saccharum	COMMON – CLIMAX FOREST
RED MAPLE	Acer rubrum	COMMON – CLIMAX FOREST
EASTERN COTTONWOOD	Populus deltoides	COMMON – CLIMAX FOREST
GREY BIRCH	Betula populifolia	OCCASIONAL – UPLAND CANOPY
AMERICAN ELM	Ulmus americana	COMMON – NON-DOMINANT CANOPY
SWAMP WHITE OAK	Quercus bicolor	COMMON – NON-DOMINANT CANOPY
RED PINE	Pinus resinosa	PLANTED – RESERVOIR SHORES
EASTERN WHITE CEDAR	Thuja occidentalis	PLANTED – RESERVOIR SHORES
WATER LILY	Nymphaea odorata	COMMON – AQUATIC
ARROW ARUM	Peltandra virginica	COMMON – AQUATIC
DUCKWEED	Lemna sp.	COMMON – AQUATIC
ALDER BUCKTHORN	Rhamnus frangula	COMMON – DOMINANT SHRUB
RED OSIER DOGWOOD	Cornus stolonifera	COMMON – DOMINANT SHRUB
SPECKLED ALDER	Alnus rugosa	COMMON – DOMINANT SHRUB
HIGHBUSH BLUEBERRY	Vaccinium corymbosum	COMMON – DOMINANT SHRUB
ARROWOOD VIBURNUM	Viburnum dentatum	COMMON – DOMINANT SHRUB
SWEET PEPPERBUSH	Clethra alnifolia	COMMON – NON-DOMINANT SHRUB
SWAMP AZALEA	Rhododendron viscosum	COMMON – NON-DOMINANT SHRUB
BUTTONBUSH	Cephalanthus occidentalis	COMMON – NON-DOMINANT SHRUB
ASTER	Aster sp.	OCCASIONAL – WILDFLOWER
GOLDENROD	Solidago sp.	OCCASIONAL – WILDFLOWER
WINTERGREEN	Gaultheria procumbens	OCCASIONAL – WILDFLOWER
FALSE NETTLE	Boehmeria cylindrica	OCCASIONAL – WILDFLOWER
CINNAMON FERN	Osmunda cinnamonea	COMMON – GROUNDCOVER
ROYAL FERN	Osmunda regalis	COMMON – GROUNDCOVER
SENSITIVE FERN	Onoclea sensibilis	COMMON – GROUNDCOVER
MARSH FERN	Thelypteris palustris	COMMON – GROUNDCOVER
POISON IVY	Toxicodendron radicans	COMMON – WOODY VINES
COMMON GREENBRIER	Smilax rotundifolia	COMMON – WOODY VINES
BRAMBLES	Rubus spp.	COMMON – WOODY VINES

TABLE 7 -1
SUMMARY OF STUDY AREA PLANTS AND ANIMAL SPECIES (1)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

PAGE 2

COMMON NAME	SCIENTIFIC NAME	STATUS
SEDGES	*Carex spp.*	COMMON – IMPOUNDMENT SHORES
RUSHES	*Juncus spp.*	COMMON – IMPOUNDMENT SHORES
LOOSESTRIFE	*Lythrum salicaria*	COMMON – CLEARED UPLANDS
JEWELWEED	*Impatiens capensis*	LOCALLY DOMINANT – WILDFLOWER
LADYSTHUMB	*Polygonum persicaria*	LOCALLY DOMINANT – WILDFLOWER
ARROW LEAVED TEARTHUMB	*Polygonum sagittatum*	LOCALLY DOMINANT – WILDFLOWER
ARROW ARUM	*Peltandra virginica*	COMMON – AQUATIC
WATER WILLOW	*Decodon verticillatus*	DOMINANT – IMPOUNDMENT SHORES
COMMON COONTAIL	*Ceratophyllum demursum*	COMMON – IMPOUNDMENT COVES
PLANTS OF SPECIAL CONCERN		
ENGELMANN'S UMBRELLA SEDGE	*Cyperus engelmannii*	STATE SPECIAL CONCERN
RIVER BULRUSH	*Scirpus fluviatilis*	STATE SPECIAL CONCERN
LINEAR-LEAVED MILKWEED	*Asclepias verticillata*	STATE THREATENED
CLIMBING FUMITORY	*Adlumia fungosa*	STATE THREATENED
SWAMP OATS	*Sphenopholis pensylvanica*	STATE THREATENED
OBSERVED ANIMALS		
RACCOON	*Procyon lotor*	COMMON
EASTERN CHIPMUNK	*Tamias striatus*	COMMON
BLUE JAY	*Cyanocitta cristata*	COMMON
CROW	*Corvus brachyrhynchos*	COMMON
HAWK	*Buteo sp.*	COMMON
DOCKCREST CHICKADEE	*Parus sp.*	COMMON
OSPREY	*Pandion haliaetus*	COMMON
GREAT BLUE HERON	*Ardea herodias*	COMMON
MALLARD DUCK	*Anas platyrhynchos*	COMMON
CANADA GOOSE	*Branta canadensis*	COMMON
PAINTED TURTLE	*Chrysemys picta*	COMMON
GREEN FROG	*Rana clamitans*	COMMON
AMERICAN EEL	*Anguilla rostrata*	UNCOMMON
BULLHEAD	*Ictalurus spp.*	COMMON
BLACK CRAPPIE	*Pomoxis nigromaculatus*	COMMON

TABLE 7-1
SUMMARY OF STUDY AREA PLANTS AND ANIMAL SPECIES (1)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 3

COMMON NAME	SCIENTIFIC NAME	STATUS
BROOK TROUT	Salvelinus fontinalis	UNCOMMON
CARP	Cyprinus carpio	UNCOMMON TO COMMON
CREEK CHUBSUCKER	Erimyzon oblongus	UNCOMMON
CHAIN PICKEREL	Esox niger	UNCOMMON TO COMMON
GOLDEN SHINER	Notemigonus crysoleucas	COMMON
LARGEMOUTH BASS	Micropterus salmoides	COMMON
REDFIN PICKEREL	Esox americanus americanus	UNCOMMON
SUNFISH	Lepomis spp.	COMMON
WHITE PERCH	Morone americana	UNCOMMON TO COMMON
YELLOW PERCH	Perca flavescens	COMMON
ANIMALS OF SPECIAL CONCERN		
GOLDEN-WINGED WARBLER	Vermivora chrysoptera	STATE ENDANGERED
LEAST BITTERN	Ixobrychus exilis	STATE THREATENED
AMERICAN BITTERN	Botaurus lentiginosus	STATE SPECIAL CONCERN
KING RAIL	Rallus elegans	STATE THREATENED
COMMON MOORHEN	Gallinula chloropus	STATE SPECIAL CONCERN
BLUE-SPOTTED SALAMANDER	Ambystoma laterale	STATE SPECIAL CONCERN
EASTERN BOX TURTLE	Terrapene carolina	STATE SPECIAL CONCERN

(1) INCLUDES SPECIES OBSERVED FROM 1989 TO 1991 AND SPECIES OF SPECIAL CONCERN

7.2.2 Animals

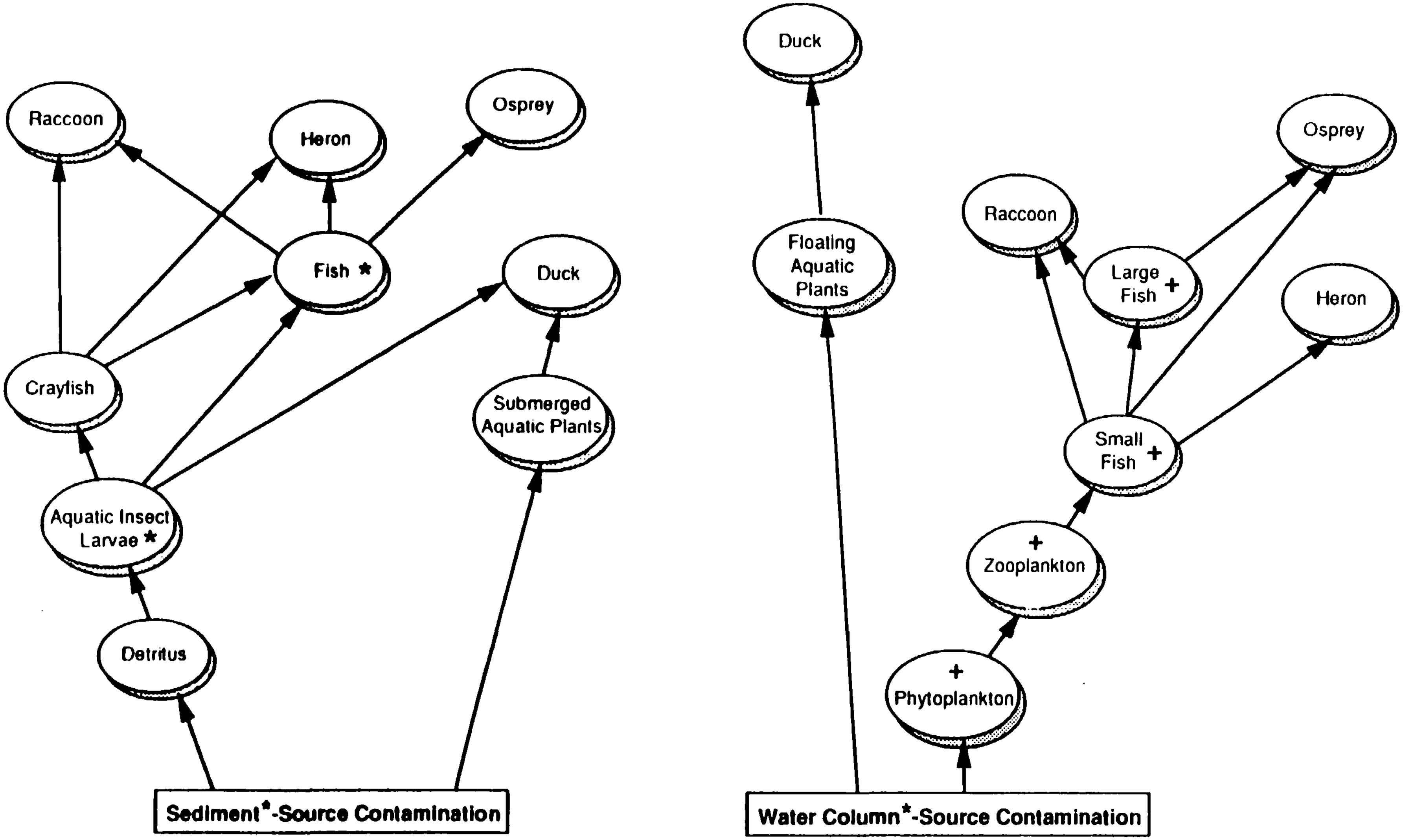
Animal species recorded in the Study Area primarily include those easily observed because of size, habits, or recognizable sounds. Many additional species of invertebrates, fish, amphibians, reptiles, birds, and mammals probably inhabit the site either permanently or seasonally. Sufficient cover and food resources are available in the Study Area to provide habitats for a large and diverse aquatic and terrestrial community. Table 7-1 lists some of the common, easily observed species recorded from 1989 to 1991; however, this list is not intended to include all species present at the site.

7.2.3 Sensitive, Threatened, or Endangered Species

Several animal and a few plant species that are known to use Study Area habitats are threatened, endangered, or of special concern to the Commonwealth of Massachusetts. Table 7-1 lists species that meet Commonwealth criteria to be considered as Plants and Animals of Special Concern.

7.2.4 Indicator Species for Evaluating Food Chain Effects

This assessment considered several trophic levels for food chain/web evaluation. These levels included detritus, phytoplankton, zooplankton, aquatic invertebrates, small fish (defined as primarily zooplanktivores), large fish (defined as primarily piscivorous species), and top-level predators likely to consume fish. The terms "small fish" and "large fish" are based on terminology associated with the simplified food chain model used to estimate body burdens of biota COCs in organisms representing lower trophic levels in the aquatic food chain. Representative top-level predators that were selected as indicator species included raccoons, blue herons, and ospreys. Chemical analyses of tissues from small and large individuals of three species of fish (largemouth bass, yellow perch, and bullheads), were conducted. In addition, some caddis fly larvae were analyzed, but the data were of limited value. Figure 7-2 shows simplified food webs for sediment and water-column source contamination.



Legend

★ = Sampled

+ = Modeled

Figure 7-2. Food Web for Selected Representative Organisms

7.3 Selection of Chemicals of Concern (COCs)

This section discusses the processes used to identify the primary study area contaminants, including those that are naturally occurring, and both site related and non-site related anthropogenic contaminants. Analytical results of environmental sampling performed for this risk assessment are presented in Appendix A, and are summarized in Section 4.0.

7.3.1 Potential Chemicals of Concern (PCOCs)

The Technical Directive Memorandum for Phase I Activities of the Remedial Investigation/Feasibility Study (NUS, 1990), the history of site activities, and several rounds of environmental sampling in the Study Area suggest that the risks associated with several potential COCs might require assessment. Tables 7-2, 7-3, and 7-4 list chemicals that can be considered potential COCs in each media (surface water, sediment, and biota). Figure 7-3 shows the process used for the selection of the final media-specific COCs.

7.3.2 Selection of Surface Water COCs

The criteria used for the selection of surface water COCs included frequency of detection, bioconcentration potential, and toxicity. The selection process was based on a tiered approach. The first tier consisted of evaluating the frequency of detection, and the second tier consisted of evaluating both bioconcentration potential and toxicity.

With this approach, chemicals are retained for consideration as surface water COCs if they were detected in more than five percent of the surface water samples, and either the maximum measured surface water concentration exceeded benchmark toxicity values, or the potential COCs are associated with bioconcentration factors (BCFs) greater than 3,000. Chemicals associated with BCFs of less than 3,000, or chemicals with log octanol/water partitioning coefficients (Kow) of less than 3.5, have low bioconcentration potential (EPA, 1991).

The first criterion for selecting surface water COCs was frequency of detection. Chemicals that were measured above detection limits in site surface waters in five percent or more of either filtered or unfiltered surface water samples were considered to be potential surface water COCs. Because of the relatively small number of filtered surface water samples collected, both filtered and unfiltered samples were evaluated by the frequency of detection criterion at this screening stage of

TABLE 7-2
SURFACE WATER COC
BASED ON FREQUENCY OF DETECTION, TOXICITY, AND BIOCONCENTRATION POTENTIAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

POTENTIAL SURFACE WATER COCS	BENCHMARK TOXICITY VALUE (TV) (ug/L)	TOX REF*	TV/10	MAX SW+ CONC (ug/L)	(MAX SW CONC)/ (TV/10) RATIO	TOXICITY SW COC	GEOMETRIC MEAN BCF	BCF REF*	BICON SW COC	FINAL SW COC
ALUMINUM	87	1	8.7	3220.0	370.1	YES	82	3	NO	YES
ARSENIC	190	1	19	3.0	0.2	NO	8	4	NO	NO
CHROMIUM	11	1	1.1	7.0	6.4	YES	23	3	NO	YES
COPPER	3.6	1	0.36	27.7	76.9	YES	856	3	NO	YES
LEAD	0.54	1	0.054	21.1	390.7	YES	403	3	NO	YES
MERCURY (INORGANIC)	0.23	1	0.023	3.8	165.2	YES	1852	3	NO	YES
NICKEL	49	1	4.9	17.7	3.6	YES	926	4	NO	YES
SILVER	0.12	1	0.012	68.9	5741.7	YES	36	3	NO	YES
ZINC	33	1	3.3	47.9	14.5	YES	378	3	NO	YES
1,1-DICHLOROETHENE	22400	2	2240	3.0	<0.1	NO	25	5	NO	NO
1,2-DICHLOROETHENE	22400	2	2240	12.0	<0.1	NO	25	5	NO	NO
BIS-(2-ETHYLHEXYL) PHTHALAT	0.3	2	0.03	58.0	1933.3	YES	2680	3	NO	YES
TRICHLOROETHENE	2190	2	219	13.0	0.1	NO	17	5	NO	NO

* REFERENCES

\+ SURFACE WATER

1: TV = CHRONIC AMBIENT WATER QUALITY CRITERIA (EPA, 1980-88). ARSENIC TV BASED ON As III, CHROMIUM ON Cr VI.
BASED ON WATER HARDNESS = 25 mg CaCO3/L FOR HARDNESS-DEPENDENT METALS

2: TV = LOEC (LOWEST OBSERVED EFFECT CONCENTRATION) / 10
LOEC/10 = ESTIMATED NOEC (NO OBSERVED EFFECT CONCENTRATION)

3: AMBIENT WATER QUALITY CRITERIA DOCUMENT (EPA, 1980-88)

4: ACQUIRE DATABASE, (EPA, 1990)

5: SYRACUSE RESEARCH CORPORATION, CHEMFATE DATABASE (SRC, 1990)

TABLE 7-3

SEDIMENT COC
BASED ON THE FREQUENCY OF DETECTION, TOXICITY, AND BIOCONCENTRATION POTENTIAL
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

POTENTIAL SEDIMENT COCS	ER-L OR SURROGAT (ug/kg)	TOX REF*	MAX SED CONC (ug/kg)	MAX SED CONC/ER-L RATIO	TOXICITY SED COC	GEOMETRIC MEAN BCF	BCF REF*	BIOCON SED+ COC	FINAL SED COC
ALUMINUM	174000	1	22900000	131.6	YES	82	6	NO	YES
ARSENIC	33000	2	64600	2.0	YES	8	7	NO	YES
BERYLLIUM	10600	1	4000	0.4	NO	19	6	NO	NO
CADMIUM	5000	2	19900	4.0	YES	404	6	NO	YES
CHROMIUM	80000	2	988000	12.4	YES	23	6	NO	YES
COPPER	70000	2	454000	6.5	YES	856	6	NO	YES
LEAD	35000	2	876000	25.0	YES	403	6	NO	YES
MERCURY (INORGANIC)	150	2	152000	1013.3	YES	1852	6	NO	YES
NICKEL	30000	2	88800	3.0	YES	926	7	NO	YES
SELENIUM	6000	1	7200	1 2	YES	120	6	NO	YES
ZINC	*120000*	*2*	*765000*	*6.4*	*YES*	*378*	*6*	NO	YES
1,2,4-TRICHLOROBENZENE	10000	1	3100	0.3	NO	1460	8	NO	NO
1,2-DICHLOROBENZENE	10000	1	7200	0.7	NO	278	7	NO	NO
1,2-DICHLOROETHENE	10000	1	130	<0.1	NO	25	8	NO	NO
1,4-DICHLOROBENZENE	10000	1	1600	0.2	NO	71	8	NO	NO
2-METHYLNAPHTHALENE	110000	4	820	<0.1	NO	300	9	NO	NO
4,4'-DDD	2	3	700	350.0	YES	79439	8	YES	YES
4,4'-DDE	2	3	60	30.0	YES	2166	8	NO	YES
4,4'-DDT	1	3	1400	1400.0	YES	93332	8	YES	YES
ACENAPHTHENE	150	3	1235	8.2	YES	389	7	NO	YES
ACENAPHTHYLENE	60	3	880	14.7	YES	575	8	NO	YES
ACETONE	1000000	5	2600	<0.1	NO	NA	10	NO	NO
ANTHRACENE	85	2	2900	34.1	YES	1458	8	NO	YES
BENZOIC ACID	16000000	5	1300	<0.1	NO	NA	10	NO	NO
BENZO(A)ANTHRACENE	230	2	4500	19.6	YES	2099	7	NO	YES
BENZO(A)PYRENE	400	2	4400	11.0	YES	920	8	NO	YES
BENZO(B)FLUORANTHENE	60	3	4400	73.3	YES	23990	8	YES	YES
BENZOBUTYLPHTHALATE	44000	1	630	<0.1	NO	663	6	NO	NO
BENZO(G,H,I)PERYLENE	60	3	1600	26.7	YES	147752	11	YES	YES
BENZO(K)FLUORANTHENE	60	3	3900	65.0	YES	33887	8	YES	YES

TABLE 7-3
SEDIMENT CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 2

POTENTIAL SEDIMENT COCS	ER-L OR SURROGAT (ug/kg)	TOX REF*	MAX SED CONC (ug/kg)	MAX SED CONC/ER-L RATIO	TOXICITY SW COC	GEOMETRIC MEAN BCF	BCF REF*	BIOCON SED COC	FINAL SED COC
BIS(2-ETHYLHEXYL)PHTHALATE	600	1	2000	3.3	YES	378	6	NO	YES
CHLOROBENZENE	10000	1	1600	0.2	NO	1768	7	NO	NO
CHRYSENE	60	3	7700	128.3	YES	5755	7	YES	YES
DIBENZOFURAN	60	3	1060	17.7	YES	716	11	NO	YES
DIBENZO(A,H)ANTHRACENE	60	2	310	5.2	YES	50122	7	YES	YES
DI-N-BUTYLPHTHALATE	88000	1	5200	0.1	NO	10472	11	YES	YES
FLUORANTHENE	600	2	12000	20.0	YES	1738	7	NO	YES
FLUORENE	600	2	1500	2.5	YES	501	7	NO	YES
INDENO(1,2,3-CD)PYRENE	60	3	1800	30.0	YES	32362	8	YES	YES
METHYLENE CHLORIDE	19300000	5	55	<0.1	NO	5	8	NO	NO
METHYLETHYLKETONE	560000000	5	450	<0.1	NO	NA	10	NO	NO
METHYLMERCURY	150	2	312	2.1	YES	26919	6	YES	YES
NAPHTHALENE	340	2	2300	6.8	YES	14	7	NO	YES
NITROBENZENE	2700000	4	650	<0.1	NO	19	8	NO	NO
N-NITROSODIPHENYLAMINE	585000	4	290	<0.1	NO	217	6	NO	NO
PHENANTHRENE	225	2	10650	47.3	YES	2630	7	NO	YES
PYRENE	350	2	11000	31.4	YES	457	8	NO	YES
TRICHLOROETHENE	43800000	4	170	<0.1	NO	17	8	NO	NO
(3-AND/OR 4-)METHYLPHENOL	350000	5	260	<0.1	NO	NA	10	NO	NO

* REFERENCES
\+ SEDIMENT

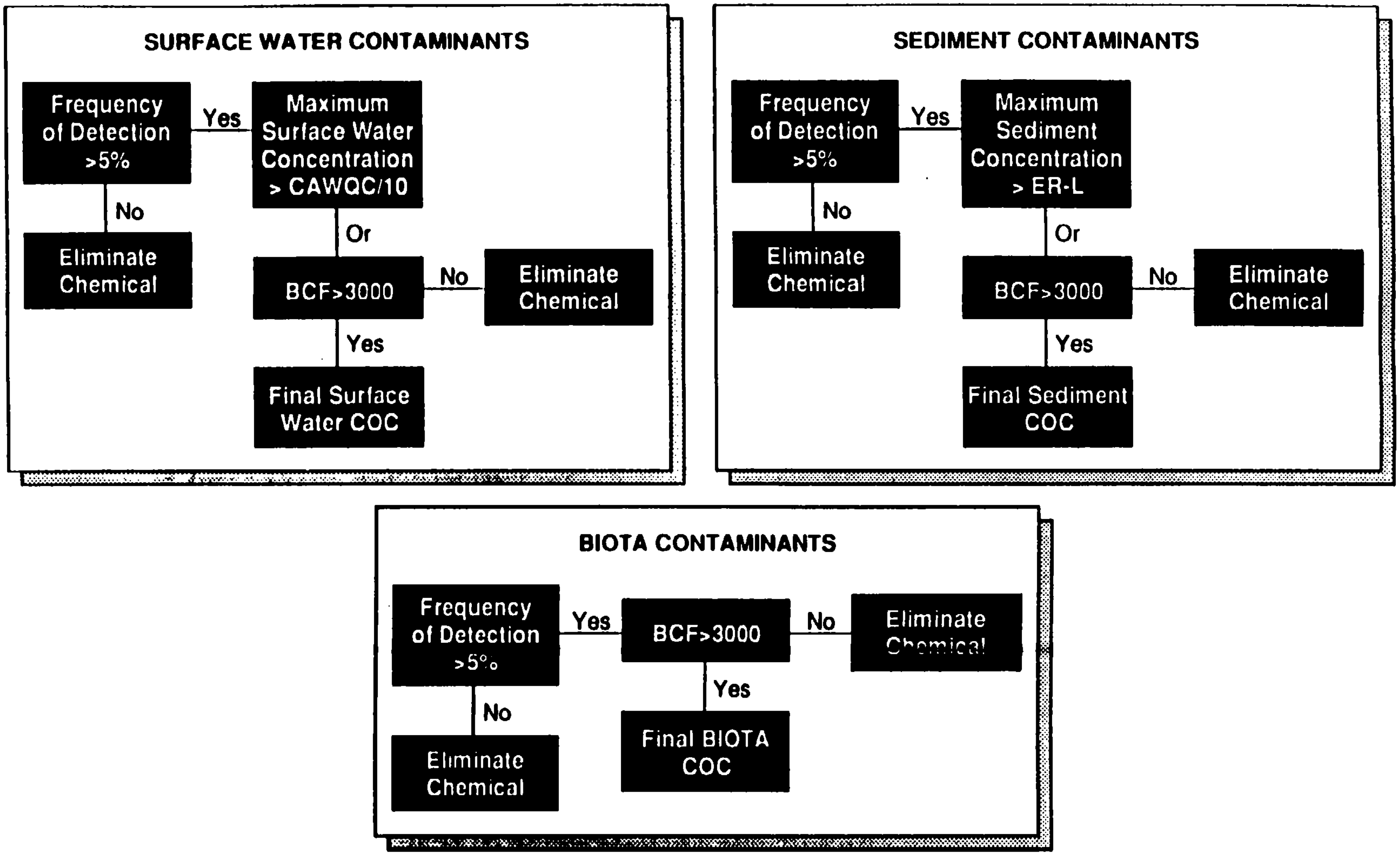
1: SURROGATE VALUE BASED ON AQUEOUS TOXICITY [CAWQC OR (LOEC/10) / 0.0005] (EPA 1980-88)
0.0005 = MEDIAN CAWQC/ER-L FOR ALL CHEMICALS WITH BOTH CAWQC AND ER-L
2: LONG AND MORGAN, 1989. ARSENIC VALUE BASED ON As III, CHROMIUM ON Cr VI.
3: LOWEST PAH ER-L (LONG AND MORGAN, 1989)
4: SURROGATE VALUE BASED ON [(LOWEST ACUTE LC50/ACR) / 0.0005] (EPA 1980-88)
ACR=20 FOR NONPERSISTENT CHEMICALS, 100 FOR PERSISTENT CHEMICALS (EPA 1985I)
5: [(LOWEST ACUTE LC50/ACR) / 0.005)], (LC50, VERSCHUEREN, 1983)
6: AMBIENT WATER QUALITY DOCUMENT (EPA, 1980-86)
7: ACQUIRE DATABASE, 1990
8: SYRACUSE RESEARCH CORPORATION, CHEMFATE DATABASE (SRC, 1990)
9: VERSCHUEREN, 1983
10: NO AVAILABLE BCF, LOG KOW <3.5
11: CALCULATED FROM EQUATION (VEITH AND KOSIAN, 1983)

TABLE 7-4
BIOTA COC
BASED ON FREQUENCY OF DETECTION AND BIOCONCENTRATION POTENTIAL

POTENTIAL BIOTA COC	GEOMETRIC MEAN BCF	BCF REF*	FINAL BIOTA COC
ALUMINUM	82	1	NO
ARSENIC	8	2	NO
CADMIUM	404	1	NO
CHROMIUM	23	1	NO
COPPER	856	1	NO
MERCURY (INORGANIC)	1852	1	NO
SELENIUM	120	1	NO
ZINC	378	1	NO
4,4'-DDD	79439	3	YES
4,4'-DDE	2166	3	NO
4,4'-DDT	93332	3	YES
ACETONE	NA	4	NO
AROCLOR 1254	18803	1	YES
AROCLOR 1260	270000	1	YES
BIS(2-ETHYLHEXYL)PHTHALATE	378	1	NO
CHLORDANE (TOTAL)	7350	3	YES
DIELDRIN	4467	3	YES
DI-N-BUTYLPHTHALATE	748	1	NO
METHYLMERCURY	26919	1	YES
PHENOL	2	2	NO
4-METHYLPHENOL	NA	4	NO

* REFERENCES

1: AMBIENT WATER QUALITY DOCUMENT (EPA, 1980-88). CHROMIUM BCF BASED ON Cr VI.
2: ACQUIRE DATABASE (EPA, 1990). ARSENIC BCF BASED ON As III.
3: SYRACUSE RESEARCH CORPORATION, CHEMFATE DATABASE (SRC, 1990)
4: NO AVAILABLE BCF, LOG KOW <3.5



ER-L - Effects Range-Low (10th percentile)
CAWQC - Chronic Ambient Water Quality Criteria or Surrogate
BCF - Highest Bioconcentration Factor for Fish or Invertebrates

Figure 7-3. Process for Selection of Media-Specific Chemicals of Concern (COCs) the assessment. Rejection of data associated with unfiltered samples was considered inappropriate at this stage, even though unfiltered samples probably overestimate actual exposure concentrations of surface water chemicals. Section 7.4.4 discusses the differences in bioavailability between filtered and unfiltered samples.

The second criterion used for selection of surface water COCs was toxicity. The selected benchmark toxicity value (TV) for screening purposes was one-tenth of the chronic ambient water quality criteria (CAWQC/10). This value was selected as a conservative and appropriate screening criterion. Surrogate values for CAWQC were used for chemicals for which CAWQC are unavailable. Surrogate values for CAWQC include lowest observed effects concentration (LOEC) divided by 10.

LOEC/10 is an estimate of the no-observed-effects concentration (NOEC). The calculation of CAWQC that are hardness dependent were based on a surface water hardness value of 25 mg $CaCO_3$/L.

The final criterion for selection of surface water COCs was bioconcentration potential. In most cases, and specifically if sufficient data were available, the geometric mean freshwater BCF was used to represent the chemical-specific BCF for selecting surface water COCs. If insufficient bioconcentration data using freshwater species were available, BCFs based on saltwater species were included. BCFs were unavailable for a few chemicals, and were estimated by using appropriate Kow/BCF relationships. Surface water chemicals associated with appropriately derived BCFs greater than 3,000 were considered surface water COCs.

Surface water samples were analyzed for inorganic and organic chemicals, which are presented in Section 4.0. The five percent frequency of detection criterion eliminated antimony, beryllium, cadmium, cobalt, selenium, thallium, vanadium, chloromethane, methylethyl ketone, 1,4-dichlorobenzene, 1,2-dichlorobenzene, and gamma-BHC (lindane) from consideration as COCs in surface waters.

After being subjected to the frequency of detection screen, several of the 20 chemicals that remained under consideration as surface water COCs are generally considered to be nontoxic at concentrations present in the Study Area. These chemicals include barium, calcium, iron, magnesium, manganese, potassium, and sodium). Although very high concentrations of some of these chemicals can result in adverse effects to aquatic life (e.g., by upsetting acid-base balance), they were eliminated from further consideration because of their relatively nontoxic nature compared to the large number of potentially toxic chemicals requiring further evaluation.

The 13 chemicals retained for consideration as surface water COCs were subjected to toxicity and bioconcentration screens. To eliminate any of these chemicals from consideration as a surface water COC, the maximum concentration of the chemical measured in surface waters had to be less than the selected benchmark toxicity value (CAWQC/10), and the bioconcentration factor associated with the chemical had to be less than 3,000. Table 7-2 lists the results of the toxicity and bioconcentration screening process for surface water contaminants, and identifies the final nine surface water COCs.

7.3.3 Selection of Sediment COCs

This assessment based the selection of sediment COCs on criteria generally similar to those used for the selection of surface water COCs; these included frequency of detection, toxicity, and bioconcentration potential. Again, a tiered approach was used for the selection of sediment COCs. The first tier consisted of evaluating frequency of detection, and the second tier consisted of evaluating toxicity and bioconcentration potential. Environmental persistence, a common screening criteria, was evaluated separately within the exposure assessment. Persistence is most appropriately associated with exposure duration, and it was considered inappropriate to eliminate chemicals from consideration as sediment COCs based on environmental persistence.

The first tier in screening potential sediment COCs consisted of evaluating sediment source chemicals that were measured above detection limits in five percent or more of total sediment samples analyzed. Chemicals for which the frequency of detection exceeded five percent were considered potential sediment COCs.

The second tier in screening potential sediment COCs consisted of evaluating toxicity and bioconcentration potential. The toxicity evaluation was based on the biological effects data of Long and Morgan (1989), who derived toxicant concentrations in sediments that are associated with observed adverse biological effects.

For toxicants present in sediments, Long and Morgan sorted in ascending order the concentrations of specific toxicants that are associated with observed adverse biological effects, and derived the 10th and 50th percentile concentrations, described as the Effects Range-Low (ER-L) and Effects Range-Median (ER-M), respectively, for each chemical evaluated. ER-L values represent concentrations of a chemical in sediment (dry weight) that is equivalent to the lower 10th percentile of the screened available data. Similarly, ER-M values are equivalent to the median (50th percentile) of the screened available data. Although the database of apparent effects is based predominantly on marine life, freshwater organisms are not expected to exhibit markedly different responses; therefore, the entire database was considered useable for screening purposes.

The ER-L value was selected as the criterion value for selecting sediment COCs. ER-L values were unavailable for several chemicals measured in sediment samples. For such chemicals, surrogate values were used as screening criteria for toxicity. Surrogate values included (1) CAWQC (or surrogate) divided by 0.0005, which is the median value of the ratio of CAWQC/ER-L computed for all chemicals for which ER-L values and CAWQC are available, and (2) ER-L values for closely related chemicals that are expected to exhibit similar toxicities. Chemicals measured in sediments at concentrations above ER-L values (or surrogate values) were considered to be sediment COCs. Table 7-3 lists the ER-L values and the surrogate ER-L values for chemicals for which ER-L values have not been derived.

This ecological risk assessment evaluated bioconcentration potential, the final criterion for selecting sediment COCs, by determining appropriate BCFs for each potential sediment COC. The selection of appropriate BCFs for sediment COCs was based on the same criteria used for determining appropriate BCFs for potential surface water COCs. Chemicals measured in sediment samples above detection limits with BCFs greater than 3,000 (or log Kow >3.5) were considered to be sediment COCs.

Sediment samples were analyzed for inorganic and organic chemicals, which are presented in Section 4.0. The first tier of the screening process for the selection of sediment COCs, which involved the evaluation of the frequency of detection, resulted in the elimination of 11 chemicals (antimony, silver, benzene, tetrachloroethene, toluene, 1,3-dichlorobenzene, diethyl phthalate, di-n-octylphthalate, gamma-chlordane, PCB-1254 or Aroclor 1254, and dimethylmercury).

Nine of the 58 chemicals that remained under consideration as sediment COCs, after being subjected to the frequency of detection screen, are generally considered to be associated with low toxicity. In general, toxicity data are unavailable for these nine chemicals which included barium, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, and vanadium.

These chemicals were eliminated from further consideration because of their relatively low toxicity in comparison to the large number of potentially toxic chemicals requiring further evaluation.

The remaining 11 inorganic and 38 organic chemicals were subjected to toxicity and bioconcentration screens. Table 7-3 lists the results of the toxicity and bioconcentration screens, as well as the 33 final sediment COCs.

7.3.4 Selection of Biota COCs

This assessment based the selection of COCs for biota samples on frequency of detection in fish tissue samples and on bioconcentration potential. Chemicals detected in fish tissue at a frequency of five percent or more were considered potential biota COCs. Eight inorganic and 13 organic chemicals exceeded the 5 percent frequency of detection criterion; therefore, 21 chemicals were considered to be potential biota COCs. Potential biota COCs with BCFs of 3,000 or greater became final biota COCs. Of the 21 potential biota COCs evaluated (Table 7-4), 14 were eliminated due to low bioconcentration potential. The seven organic chemicals remaining were selected as biota COCs; these COCs are listed in Table 7-4.

7.4 Exposure Assessment

The major objective of the exposure assessment is to estimate, as accurately as possible, the media-specific chemical concentrations to which site biota might be exposed. Estimated environmental concentrations (EECs) are based most appropriately on measured site-specific data, and should be based on the bioavailable, or potentially bioavailable, portion of the total media-specific chemical concentration. The bioavailable portion of a chemical is the portion that is in a form that is known or likely to cause adverse effects to biota under likely exposure scenarios. The important components of exposure scenarios include not only EECs, but also frequency and duration of exposure. For aquatic life, exposures are constant or nearly constant for water-column contaminants, while they can vary for sediment-source contaminants, depending on species. For semiaquatic and terrestrial biota and birds, exposure durations and frequencies are likely to vary with season, species, and life stage.

If site-specific data on a chemical are insufficient for predicting chemical fate and transport, appropriate models are often used. The models used in this exposure assessment described the partitioning behavior of contaminants between various media. The relationships between media-specific contaminant concentrations are expressed by partitioning coefficients. Because sufficient site-specific data was available, the use of complex computer modeling for chemical fate and transport was not appropriate with the exception of its use for food chain modeling.

7.4.1 Fate and Transport of COCs

Section 5.0 describes chemical fate and transport mechanisms in detail. Most Site related contaminants probably are transported primarily by sediment transport. Atmospheric transport and deposition is likely for some offsite contaminants, such as some polycyclic aromatic hydrocarbons (PAHs). The uptake of certain chemicals that are likely to biomagnify within food chain organisms is a probable fate process; the transport of such chemicals through food chains via ingestion of contaminated prey by upper level predators is also likely.

Environmental persistence of media-specific COCs is a critical component of exposure duration. Chemicals that are toxic and environmentally persistent probably provide a long-term source of hazard to exposed biota. This assessment determined environmental persistence by evaluating the maximum reported soil or surface water aerobic half-life of a chemical. The categories of persistence are high (half-life > 1 year), moderate (half-life 6 months to 1 year), and low (half-life less than 6 months). These categories are based on generally accepted definitions of high, moderate, and low biodegradation rates (Howard et al., 1991).

Table 7-5 lists environmental half lives for the media-specific organic and organometalic COCs. Of the 39 COCs derived for all media, 12 (all) inorganic and 17 organic COCs are associated with high persistence. Of the remaining 10 COCs, 8 are considered to have low persistence, and the final 2 COCs are designated moderate in persistence. The fact that the majority of COCs are highly persistent is not unexpected. COCs detected in sediments are most often environmentally persistent, and 33 of the 39 total COCs are sediment COCs.

7.4.2 Exposure Pathways

The four major elements of an exposure pathway are (1) contaminant sources and release mechanisms, (2) retention or transport media, (3) points of potential contact, and (4) exposure routes (EPA, 1989a). Figure 7-4 shows these primary exposure pathway elements.

TABLE 7-5
ENVIRONMENTAL PERSISTENCE FOR FINAL COCS (ALL MEDIA)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

CHEMICAL	MEDIA COC	HALF-LIFE (DAYS)	REF*	PERSISTENCE
ALUMINUM	SW/SED	NA		HIGH
ARSENIC	SED	NA		HIGH
BERYLLIUM	SW	NA		HIGH
CADMIUM	SED	NA		HIGH
CHROMIUM	SW/SED	NA		HIGH
COPPER	SW/SED	NA		HIGH
LEAD	SW/SED	NA		HIGH
MERCURY (INORGANIC)	SW/SED	NA		HIGH
NICKEL	SW/SED	NA		HIGH
SELENIUM	SED	NA		HIGH
SILVER	SW	NA		HIGH
ZINC	SW/SED	NA		HIGH
4,4'-DDD	SED/BIOTA	5694	1	HIGH
4,4'-DDE	SED	6	1	LOW
4,4'-DDT	SED/BIOTA	350	1	MOD
ACENAPHTHENE	SED	102	1	LOW
ACENAPHTHYLENE	SED	60	1	LOW
ANTHRACENE	SED	460	1	HIGH
AROCLOR 1254	BIOTA	5475	2	HIGH
AROCLOR 1260	BIOTA	5475	2	HIGH
BENZO(A)ANTHRACENE	SED	679	1	HIGH
BENZO(A)PYRENE	SED	529	1	HIGH
BENZO(B)FLUORANTHENE	SED	610	1	HIGH
BENZO(G,H,I)PERYLENE	SED	650	1	HIGH
BENZO(K)FLUORANTHENE	SED	2139	1	HIGH
BIS(2-ETHYLHEXYL)PHTHALATE	SW/SED	23	1	LOW
CHLORDANE	BIOTA	1387	1	HIGH
CHRYSENE	SED	993	1	HIGH
DIBENZOFURAN	SED	28	1	LOW
DIBENZO(A,H)ANTHRACENE	SED	942	1	HIGH
DIELDRIN	BIOTA	1095	1	HIGH
DI-N-BUTYLPHTHALATE	SED	23	1	LOW
FLUORANTHENE	SED	440	1	HIGH
FLUORENE	SED	60	1	LOW
INDENO(1,2,3-CD)PYRENE	SED	730	1	HIGH
METHYLMERCURY	SED/BIOTA	NA	3	HIGH
NAPHTHALENE	SED	48	1	LOW
PHENANTHRENE	SED	200	1	MOD
PYRENE	SED	1898	1	HIGH

NA: NOT APPLICABLE

* REFERENCES

1. BASED ON MAXIMUM SOIL OR SURFACE WATER AEROBIC HALF-LIFE (HOWARD ET AL., 1991)
2. BASED ON MAXIMUM PCB PERSISTENCE IN SEDIMENTS (USFWS, 1986b)
3: BASED ON INORGANIC MERCURY

PERSISTENCE: HIGH:>1 YR, MOD: 6 MOS – 1 YR, LOW: < 6 MOS (HOWARD ET AL., 1991)

7.4.2.1 Exposure Sources and Release Mechanisms

Exposure sources include the source of the contaminant, such as contaminated sediments. In some cases the exposure source can be the exposure point, and no release mechanism is identified. In other cases, however, release mechanisms can be identified (spills, leaks, leaching, volatilization, etc.).

Exposure sources can be point or nonpoint sources, or a combination of both. Point sources for contaminants include the original site location and adjoining wetlands and creeks.

In addition, present industrial facilities contributing to the contamination of the Sudbury River and its tributaries can be point sources of pollutants. Nonpoint sources can include surface runoff, atmospheric deposition, transported contaminants from upstream waters, and transported sediments.

7.4.2.2 Exposure Points

Exposure points are locations of potential contact between an organism and the chemical agent of concern. Exposure points that require evaluation include locations with the highest levels of potential contamination.

7.4.2.3 Exposure Routes

Exposure routes are ways by which a COC comes in contact with an organism; they can include ingestion, inhalation, and dermal contact. Table 7-6 summarizes the plant and animal exposure pathways considered in the Study Area.

7.4.3 Future Exposures

Present and future land use scenarios often produce similar EECs of COCs. In other cases, however, exposures estimated for future land use scenarios could differ from exposures based on present land uses. Even when land uses remain essentially unchanged, the chemical structure or concentration of a contaminant can change over time due to physical, chemical, or biological processes. For most COCs and under most conditions, the present exposure posed to site organisms will be the most hazardous, with hazards decreasing over time. For other COCs and under other conditions, however, exposures can increase over time.

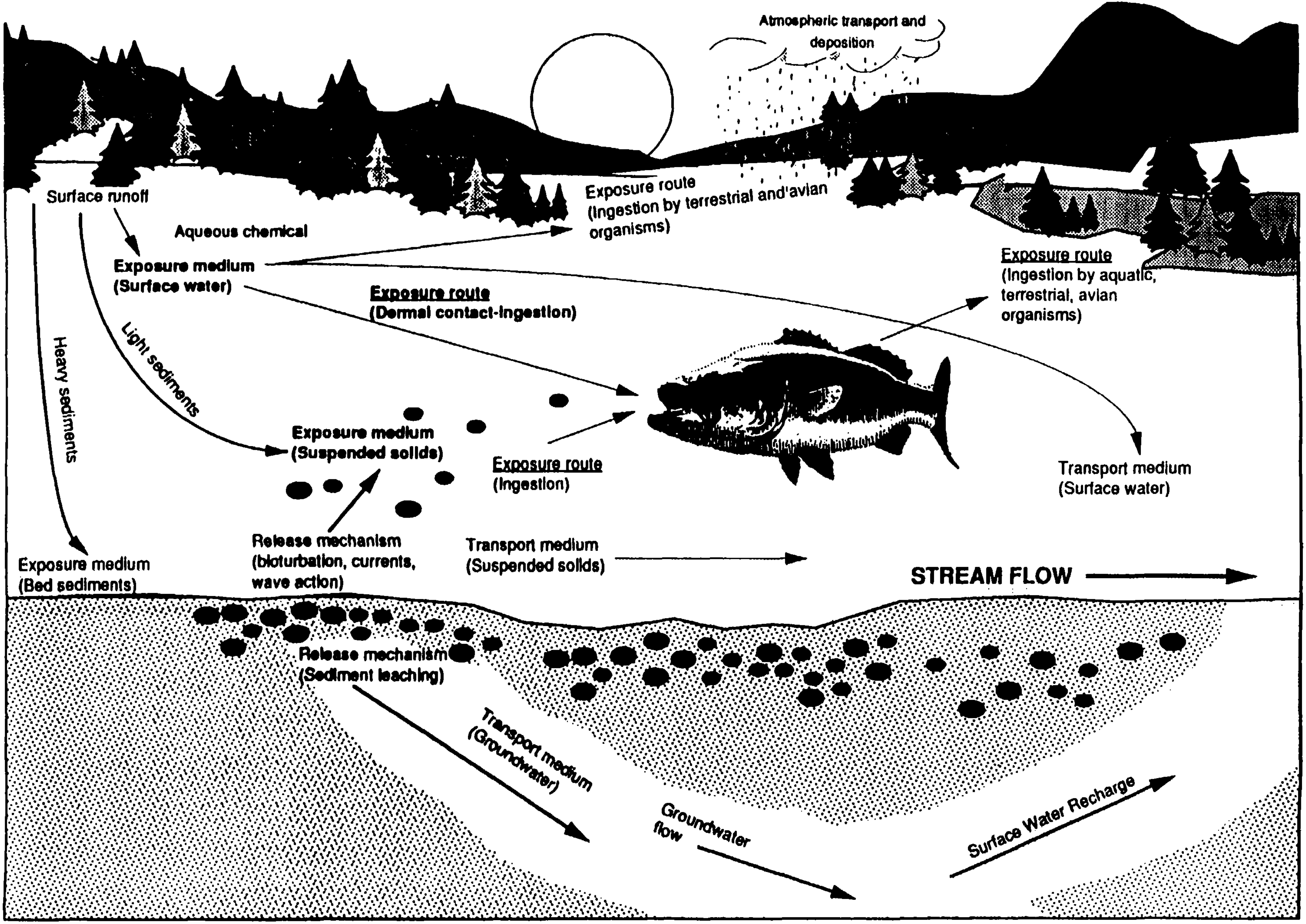


Figure 7-4. Exposure Pathways

Tabl(5. Summary of Exposure Pathways

Potentially Exposed Organisms	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Water-column biota (e.g., phytoplankton, zooplankton, fish)	• Direct contact with aqueous chemicals • Ingestion of aqueous chemicals	Yes Yes	• Toxicity to aquatic life is evaluated based on constant exposure that considers both direct contact and aqueous ingestion
	• Ingestion of contaminated biota	Yes	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
Benthic biota (e.g., insect larvae, crayfish, benthic fish)	• Direct contact with contaminated sediments	No	• Potential for significant exposure via this pathway is low compared to aqueous ingestion
	• Ingestion of contaminated sediments	Yes/No	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
	• Ingestion of contaminated biota	Yes	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
	• Ingestion of aqueous chemicals in interstitial water	Yes	• Actual exposure to benthic organisms is best estimated by interstitial water concentrations
Semi-aquatic biota (e.g., amphibians, turtles, snakes, ducks, beavers)	• Direct contact with aqueous chemicals	Yes	• Toxicity to aquatic life is evaluated based on constant exposure that considers both direct contact and aqueous ingestion
	• Ingestion of contaminated biota	Yes	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
	• Direct contact with contaminated sediments	No	• Potential for significant exposure via this pathway is low compared to other pathways
	• Ingestion of contaminated sediments	Yes/No	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
	• Ingestion of aqueous chemicals	Yes	• Toxicity to aquatic life is evaluated based on constant exposure that considers both direct contact and aqueous ingestion
Terrestrial/avian biota (e.g., invertebrates, reptiles, birds, mammals)	• Ingestion of aqueous chemicals	No	• Potential for significant exposure via this pathway is low for chemicals that tend to bioaccumulate
	• Ingestion of contaminated aquatic biota	Yes/No	• Potential for significant exposure via this pathway is high for chemicals that tend to bioaccumulate
Floating aquatic plants	• Uptake of aqueous chemicals	Yes	• Potential for significant exposure via this pathway is high for water-column source contaminants
Rooted aquatic plants	• Uptake of chemicals from sediments or interstitial water	Yes/No	• Potential for significant exposure via this pathway is evaluated for chemicals that tend to bioaccumulate
Terrestrial plants	• Uptake of chemicals from soils	No	• Potential for significant exposure via this pathway is low for aqueous/sediment contaminants

Examples of situations that can result in increased bioavailable exposures over time include (1) the presence of COCs for which the degradation products are potentially more toxic than the parent chemical, and (2) changes in exposure locations (e.g., increasing sediment deposition and contamination downstream of the source over time). Usually, future changes in exposure scenarios are best predicted using computer-based fate and transport models, but because this particular risk assessment is focused on present land use only, future land uses and future exposure scenarios are not considered.

7.4.4 Surface Water Exposure Assessment

The surface water exposure assessment is based on both the average and maximum concentration of COCs measured in surface waters. The use of the maximum measured value is a conservative approach that estimates maximum likely exposure. In contrast, the use of average concentrations of surface water COCs allows a more realistic estimate of exposure for potentially exposed organisms. The value used to represent the average surface water concentration is based on the average reported concentration of each surface water COC.

In the average reported concentration, COCs measured below detection limits (BDLs), have been considered by using half of the detection limit to represent their actual concentration.

Both filtered and unfiltered samples were used for selecting surface water COCs. The use of unfiltered samples is an appropriate and conservative approach for this selection. However, such an approach is inappropriate for estimating bioavailable, or potentially hazardous, exposure concentrations of surface water COCs. Therefore, the average and maximum concentrations of inorganic COCs presented in the surface water exposure are based on filtered samples only. Filtered samples express concentrations of chemicals dissolved in water, and samples filtered at ambient pH probably best represent potentially hazardous aqueous exposure concentrations. Chemicals bound to particulate matter, which are measured in unfiltered samples, are not generally considered to be bioavailable (US EPA, 1985h). Such chemicals should eventually settle out of the water column and become sediments. Section 7.4.5 discusses the assessment of sediment COC exposures. Table 7-7 lists the average reported and maximum concentrations of the 10 surface water COCs in filtered samples for each location sampled.

TABLE 7-7
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SURFACE WATER COC (FILTERED INORGANICS), BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION:	BACKGROUND		R2	R2	R3	R3	R4	R4	R5	R5
CHEMICAL (ug/L)	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX
ALUMINUM	ND	–	29.28	67.30	80.80	80.80	107.00	107.00	ND	–
BERYLLIUM	ND	–	ND	–	ND	–	ND	–	ND	–
CHROMIUM	ND	–	ND	–	ND	–	ND	–	ND	–
COPPER	ND	–	ND	–	ND	–	ND	–	ND	–
LEAD	ND	–	ND	–	ND	–	1.50	1.50	ND	–
MERCURY	ND	–	ND	–	ND	–	ND	–	ND	–
NICKEL	3.80	7.00	ND	–	ND	–	ND	–	ND	–
SILVER	ND	–	ND	–	ND	–	ND	–	ND	–
ZINC	12.11	21.60	ND	–	18.50	18.50	22.80	22.80	ND	–
BIS-(2-ETHYLHEXYL)PHTHALATE	ND	–	ND	–	NV	1.00	ND	–	ND	–

	R6	R6	R7	R7	EW	EW	OC	OC	CSB	CSB
CHEMICAL (ug/L)	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX
ALUMINUM	110.57	174.00	72.34	155.00	ND	–	67.00	67.00	NS	–
BERYLLIUM	ND	–	ND	–	ND	–	ND	–	NS	–
CHROMIUM	ND	–	ND	–	ND	–	ND	–	NS	–
COPPER	ND	–	ND	–	ND	–	ND	–	NS	–
LEAD	ND	–	ND	–	6.80	8.70	2.40	2.40	NS	–
MERCURY	ND	–	ND	–	0.43	0.49	0.42	0.42	NS	–
NICKEL	ND	–	ND	–	ND	–	ND	–	NS	–
SILVER	ND	–	3.88	8.00	ND	–	ND	–	NS	–
ZINC	ND	–	ND	–	ND	–	46.10	46.10	NS	–
BIS-(2-ETHYLHEXYL)PHTHALATE	ND	–	ND	–	ND	–	1.00	1.00	58.00	58.00

REPORTED MEAN: INCLUDES BELOW DETECTION LIMIT (DL) VALUES SET TO 1/2 DL

LOCATIONS SAMPLED: R=REACH 2-7, EW=EASTERN WETLANDS, OC=OUTFALL CREEK, CSB=COLD SPRING BROOK

ND: NOT DETECTED
NS: NOT SAMPLED
NV: NO VALUE – MEAN EXCEEDS MAXIMUM

7.4.5 Sediment Exposure Assessment

The sediment exposure assessment is based on both the reported average and the maximum concentration of COCs in sediment. An assessment of sediment exposures can present concentrations of COCs in sediment directly as sediment concentrations (ug COC/kg sediment, dry weight), as listed in Table 7-8. As an alternative, sediment COC concentrations can be extrapolated to interstitial water through the use of partitioning coefficients.

Interstitial water concentrations are estimates of actual bioavailable exposure concentrations of chemicals associated with contaminated sediments. Most modeling methods for determining interstitial water concentrations (e.g., equilibrium partitioning, or EP) are limited to organic chemicals, and are not applicable to metals because of their complex partitioning behavior. Metal adsorption-desorption from sediments can depend on ionic strength, pH, Eh, and, for at least some metals, the concentration of acid volatile sulfides (DiToro et al., 1986; DiToro, 1989). Much of the research on metal partitioning behavior is based on laboratory studies in which a specific, well-characterized sediment was spiked with a single contaminant. There have been few field studies investigating complex interactions between multiple contaminants and various sediment types, and the collection of sufficient site-specific information about the partitioning behavior of metals is difficult for large, complex sites such as the subject study area.

Another alternative for evaluating exposures of COCs in sediment is the measurement of COC concentrations in interstitial water samples.

This approach has many limitations, including difficulties obtaining representative samples that provide acceptably accurate and precise analytical results. Analytical data based on COC concentrations in interstitial water were unavailable for this assessment.

This assessment employed a separate and distinct methodology for organic and inorganic sediment COCs. For inorganic sediment COCs, exposures were based on concentrations of COCs in sediment without extrapolation to interstitial water (ug COC/kg sediment). These exposure concentrations of sediment COCs were compared directly to biological effects data, as described in Section 7.6.

Biological effects data are based on concentrations of chemicals in sediments that are associated with known biological effects, including mortality, impaired growth and reproduction, and ecologically significant behavioral changes. Table 7-8 lists the reported average and the maximum concentration of each sediment COC for each reach.

For organic sediment COCs, equilibrium partitioning (EP) was used to extrapolate from concentrations of COCs in sediment (ug/kg sediment, dry weight) to concentrations in interstitial water (ug/L). Location-specific estimates of interstitial water concentrations are based on location-specific concentrations of COCs and organic carbon in sediments. Partitioning coefficients used (Table 7-9) include Foc (fraction organic carbon), Kow (octanol/water partitioning coefficient), Koc (organic carbon/chemical partitioning coefficient), and Kd (sediment/water partitioning coefficient). Section 5.3 presents definitions of, and the relationships between, these input parameters.

EP is appropriate for single non-ionic organic chemicals; however, EP is associated with several assumptions. The primary assumptions are that equilibrium conditions exist between sediment and interstitial waters, and that the process determined for single chemicals are not affected by other chemicals while no single approach appears to be applicable for deriving sediment quality criteria, EPA has selected EP because it "presents the greatest promise for generating defensible natural numerical chemical-specific sediment quality criteria applicable across a broad range of sediment types" (EPA, 1991d,e,f).

The final result of the equilibrium partitioning approach is the derivation of the mean and maximum estimated interstitial water concentrations of organic sediment COCs for each sampled location (Table 7-10). These values were compared directly to aqueous concentrations of sediment COCs that are potentially hazardous to aquatic biota. The comparisons are made and evaluated in the risk characterization section of this assessment.

7.4.6 Biota Exposure Assessment

The assessment of biota exposure consists of two approaches. The first approach evaluated the exposure assessment based on measured tissue concentrations of biota COCs in sampled fish. The second approach used a food chain model to estimate body burdens of biota COCs in various trophic levels.

TABLE 7-8
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SEDIMENT COC, BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION:	BACKG	R1*	R2	R2	R3	R3	R4	R4	R5	R5
CHEMICAL (ug/kg)	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX
ALUMINUM	9200910	2E+07	7608330	2E+07	1E+07	2E+07	1E+07	2E+07	7023330	2E+07
ARSENIC	8740	21100	6950	14900	7610	21500	10680	32300	3830	9200
CADMIUM	ND	–	ND	–	4980	19900	4810	14900	ND	–
CHROMIUM	22400	55200	34000	216000	292620	2620000	71610	224000	17950	60600
COPPER	73020	340400	40190	184000	184470	454000	115850	332000	41670	158000
LEAD	85090	248000	58070	295000	137970	285000	93960	219000	237990	809000
MERCURY (INORGANIC)	270	1590	3810	30600	15980	54600	3380	7300	980	4100
NICKEL	11350	51000	7470	19100	28430	88800	28690	63000	6790	16100
SELENIUM	1040	3100	ND	–	810	4000	1740	4000	NV	440
ZINC	133500	629000	126440	330000	177060	435000	161050	327000	199880	765000
4,4'-DDD	ND	–	NV	26	85	370	ND	–	ND	–
4,4'-DDE	ND	–	17	58	32	60	ND	–	ND	–
4,4'-DDT	ND	–	172	1400	ND	–	ND	–	ND	–
ACENAPHTHENE	ND	–	544	1235	NV	100	ND	–	ND	–
ACENAPHTHYLENE	ND	–	486	500	819	880	ND	–	160	160
ANTHRACENE	ND	–	754	2900	NV	240	NV	140	150	150
BENZO(A)ANTHRACENE	ND	–	1105	4400	1346	4500	NV	110	470	470
BENZO(A)PYRENE	NV	91	1028	3750	1209	4400	140	150	320	320
BENZO(B)FLUORANTHENE	NV	200	1034	3550	1496	4400	275	400	1400	1400
BENZO(G,H,I)PERYLENE	ND	–	594	650	773	1600	NV	92	270	270
BENZO(K)FLUORANTHENE	ND	–	990	3800	1494	3900	NV	150	ND	–
BIS(2-ETHYLHEXYL)PHTHALATE	ND	–	651	2000	791	910	ND	–	330	330
CHRYSENE	NV	180	1092	4200	1737	7700	205	220	700	700
DIBENZOFURAN	ND	–	556	1060	ND	–	ND	–	ND	–
DIBENZO(A,H)ANTHRACENE	ND	–	NV	80	NV	310	ND	–	ND	–
DI-N-BUTYLPHTHALATE	ND	–	ND	–	1645	5200	ND	–	ND	–
FLUORANTHENE	NV	320	2014	9250	2332	12000	260	270	1100	1100
FLUORENE	ND	–	607	1500	NV	200	ND	–	ND	–
INDENO(1,2,3-CD)PYRENE	ND	–	626	900	786	1800	NV	94	240	240
METHYLMERCURY	ND	–	109	312	NV	26	27	79	ND	–
NAPHTHALENE	ND	–	599	1180	NV	120	ND	–	ND	–
PHENANTHRENE	NV	160	1635	10650	1368	7300	NV	170	540	540
PYRENE	NV	270	1669	8900	2461	11000	255	260	1100	1100

TABLE 7-8
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SEDIMENT COC, BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 2

LOCATION	R6	R6	R7	R7	R8	R8	R9	R9	R10	R10
CHEMICAL (ug/kg)	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX
ALUMINUM	1E+07	2E+07	7736900	2E+07	6636000	8310000	9806000	1E+07	6790000	2E+07
ARSENIC	11100	24000	10130	40600	12130	30000	32000	64600	5990	12200
CADMIUM	3830	13600	2210	17900	2080	4300	7050	8600	ND	–
CHROMIUM	66600	281000	47950	209000	22000	36400	50260	78000	11240	17100
COPPER	113500	303000	65940	278000	67610	96600	83330	135000	14115	31000
LEAD	285700	876000	117940	526000	66700	100000	115260	184000	22480	33800
MERCURY (INORGANIC)	3300	17600	1520	5500	1620	2100	3150	3900	161	530
NICKEL	20300	78400	11290	44100	7080	13100	24950	28100	7370	11100
SELENIUM	1370	6100	1180	7200	750	1800	ND	–	ND	–
ZINC	292300	564000	170060	646000	187360	329000	197130	319000	38350	53400
4,4'-DDD	399	700	ND	–	NS	–	NS	–	NS	–
4,4'-DDE	ND	–	ND	–	NS	–	NS	–	NS	–
4,4'-DDT	ND	–	ND	–	NS	–	NS	–	NS	–
ACENAPHTHENE	NV	74	490	110	NS	–	NS	–	NS	–
ACENAPHTHYLENE	ND	–	ND	–	NS	–	NS	–	NS	–
ANTHRACENE	NV	240	521	210	NS	–	NS	–	NS	–
BENZO(A)ANTHRACENE	1018	1500	430	880	NS	–	NS	–	NS	–
BENZO(A)PYRENE	NV	1100	720	880	NS	–	NS	–	NS	–
BENZO(B)FLUORANTHENE	1626	3400	516	910	NS	–	NS	–	NS	–
BENZO(G,H,I)PERYLENE	NV	820	655	610	NS	–	NS	–	NS	–
BENZO(K)FLUORANTHENE	2413	980	446	850	NS	–	NS	–	NS	–
BIS(2-ETHYLHEXYL)PHTHALATE	NV	1900	846	1100	NS	–	NS	–	NS	–
CHRYSENE	NV	1500	640	1200	NS	–	NS	–	NS	–
DIBENZOFURAN	ND	–	ND	–	NS	–	NS	–	NS	–
DIBENZO(A,H)ANTHRACENE	ND	–	ND	–	NS	–	NS	–	NS	–
DI-N-BUTYLPHTHALATE	ND	–	ND	–	NS	–	NS	–	NS	–
FLUORANTHENE	1975	2600	953	1900	NS	–	NS	–	NS	–
FLUORENE	NV	160	496	140	NS	–	NS	–	NS	–
INDENO(1,2,3-CD)PYRENE	NV	740	631	540	NS	–	NS	–	NS	–
METHYLMERCURY	ND	–	ND	–	NS	–	NS	–	NS	–
NAPHTHALENE	ND	–	ND	–	NS	–	NS	–	NS	–
PHENANTHRENE	1171	1600	593	1200	NS	–	NS	–	NS	–
PYRENE	2075	2900	876	1700	NS	–	NS	–	NS	–

TABLE 7-8
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SEDIMENT COC, BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 3

LOCATION: CHEMICAL (ug/kg)	EW MEAN	EW MAX	CBC MEAN	CBC MAX	OC MEAN	OC MAX	RW MEAN	RW MAX	CSB MEAN	CSB MAX
ALUMINUM	7216000	1E+07	3520000	3690000	5876670	1E+07	2E+07	3E+07	9225000	1E+07
ARSENIC	6590	12700	4300	6600	2930	4100	24960	37200	3500	4300
CADMIUM	ND	-	ND	-	ND	-	2280	5600	ND	-
CHROMIUM	123680	462000	82300	135000	341800	988000	155500	208000	15150	16700
COPPER	63730	120000	63350	92500	137830	359000	217750	306000	31500	32900
LEAD	72580	142000	38250	57500	105950	233000	435750	758000	234000	328000
MERCURY (INORGANIC)	35878	152000	6800	7100	35330	99200	710	970	ND	-
NICKEL	10143	40400	ND	-	ND	-	89890	186000	ND	-
SELENIUM	1430	6500	ND	-	ND	-	ND	-	ND	-
ZINC	65393	164000	92950	103000	166300	390000	365880	542000	148000	166000
4,4'-DDD	76	117	ND	-	ND	-	32	108	NS	-
4,4'-DDE	ND	-	ND	-	ND	-	11	21	NS	-
4,4'-DDT	ND	-	ND	-	ND	-	ND	-	NS	-
ACENAPHTHENE	ND	-	ND	-	ND	-	ND	-	NS	-
ACENAPHTHYLENE	ND	-	NV	140	263	310	ND	-	NS	-
ANTHRACENE	ND	-	215	250	NV	185	NV	3100	NS	-
BENZO(A)ANTHRACENE	ND	-	710	810	800	1050	5713	11000	NS	-
BENZO(A)PYRENE	843	860	720	770	900	1200	3888	4700	NS	-
BENZO(B)FLUORANTHENE	NV	2500	820	840	1233	1750	4263	5200	NS	-
BENZO(G,H,I)PERYLENE	ND	-	NV	270	492	730	ND	-	NS	-
BENZO(K)FLUORANTHENE	ND	-	680	780	473	1000	4300	6300	NS	-
BIS(2-ETHYLHEXYL)PHTHALATE	ND	-	150	200	960	2000	NV	2500	NS	-
CHRYSENE	1013	1200	745	760	1077	1400	5975	8600	NS	-
DIBENZOFURAN	ND	-	NV	92	ND	-	ND	-	NS	-
DIBENZO(A,H)ANTHRACENE	ND	-	ND	-	ND	-	ND	-	NS	-
DI-N-BUTYLPHTHALATE	ND	-	ND	-	ND	-	ND	-	NS	-
FLUORANTHENE	1213	1600	1300	1400	1307	1600	14263	20000	NS	-
FLUORENE	ND	-	NV	84	ND	-	NV	2800	NS	-
INDENO(1,2,3-CD)PYRENE	ND	-	NV	330	453	635	ND	-	NS	-
METHYLMERCURY	68	229	ND	-	ND	-	ND	-	NS	-
NAPHTHALENE	1563	2300	565	600	218	340	4081	6700	NS	-
PHENANTHRENE	NV	620	760	790	630	930	12113	16000	NS	-
PYRENE	1263	1700	1200	1200	1800	2500	9400	13000	NS	-

TABLE 7-8
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SEDIMENT COC, BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 4

LOCATION:	BW	BW	HP	HP
CHEMICAL (ug/kg)	MEAN	MAX	MEAN	MAX
ALUMINUM	1E+07	2E+07	1E+07	1E+07
ARSENIC	6220	11900	10850	10850
CADMIUM	ND	–	ND	–
CHROMIUM	24010	101000	40200	40200
COPPER	18013	83400	136000	136000
LEAD	71190	254000	149000	149000
MERCURY (INORGANIC)	1071	7600	3500	3500
NICKEL	7180	21800	11300	11300
SELENIUM	70	1200	ND	–
ZINC	41078	127000	302000	302000
4,4'-DDD	NS	–	NS	–
4,4'-DDE	NS	–	NS	–
4,4'-DDT	NS	–	NS	–
ACENAPHTHENE	NS	–	NS	–
ACENAPHTHYLENE	NS	–	NS	–
ANTHRACENE	NS	–	NS	–
BENZO(A)ANTHRACENE	NS	–	NS	–
BENZO(A)PYRENE	NS	–	NS	–
BENZO(B)FLUORANTHENE	NS	–	NS	–
BENZO(G,H,I)PERYLENE	NS	–	NS	–
BENZO(K)FLUORANTHENE	NS	–	NS	–
BIS(2-ETHYLHEXYL)PHTHALATE	NS	–	NS	–
CHRYSENE	NS	–	NS	–
DIBENZOFURAN	NS	–	NS	–
DIBENZO(A,H)ANTHRACENE	NS	–	NS	–
DI-N-BUTYLPHTHALATE	NS	–	NS	–
FLUORANTHENE	NS	–	NS	–
FLUORENE	NS	–	NS	–
INDENO(1,2,3-CD)PYRENE	NS	–	NS	–
METHYLMERCURY	NS	–	NS	–
NAPHTHALENE	NS	–	NS	–
PHENANTHRENE	NS	–	NS	–
PYRENE	NS	–	NS	–

TABLE 7-8
REPORTED MEAN AND MAXIMUM CONCENTRATIONS OF SEDIMENT COC, BY LOCATION
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 5

REPORTED MEAN: INCLUDES BELOW DETECTION LIMIT (DL) VALUES SET TO 1/2 DL

LOCATIONS SAMPLED: R=REACH 1-10, EW=EASTERN WETLANDS, CBC=CHEMICAL BROOK CULVERT, OC=OUTFALL CREEK
RW=RACEWAY, CSB=COLD SPRING BROOK, BW=BORDERING WETLANDS, HP=HEARD POND

ND: NOT DETECTED
NS: NOT SAMPLED
NV: MEAN EXCEEDS MAXIMUM

TABLE 7-[illegible]

PARTITIONING COEFFICIENTS FOR ORGANIC SEDIMENT COCS
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

			LOCATION	BKD+	R2	R3	R4	R5	R6	R7	R8	R9	R10	EW	CBC	OC	RW	CSB	HP	BW
				MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC	MEAN FOC
				0.03	0.03	0.04	0.05	0.02	0.04	0.04	0.12	0.01	0.01	0.01	0.05	0.02	0.03	0.07	0.16	0.09
ORGANIC SED COCS	LOG KOW	KOW REF*	LOG KOC	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD	KD
4,4'-DDD	6.02	1	4.65	1346	1346	1795	2243	897	1795	1795	5384	449	449	449	2243	897	1346	3141	7178	4038
4,4'-DDE	6.51	2	4.92	2487	2487	3315	4144	1658	3315	3315	9946	829	829	829	4144	1658	2487	5802	13261	7460
4,4'-DDT	6.36	2	4.84	2061	2061	2747	3434	1374	2747	2747	8242	687	687	687	3434	1374	2061	4808	10990	6182
ACENAPHTHENE	3.84	3	3.59	117	117	156	195	78	156	156	468	39	39	39	195	78	117	274	625	352
ACENAPHTHYLENE	4.07	1	3.81	193	193	257	321	128	257	257	771	64	64	64	321	128	193	449	1027	578
ANTHRACENE	4.45	2	4.16	437	437	583	729	292	583	583	1749	146	146	146	729	292	437	1020	2332	1312
BENZO(A)ANTHRACENE	5.61	2	5.25	5342	5342	7123	8904	3562	7123	7123	21369	1781	1781	1781	8904	3562	5342	12465	28492	16027
BENZO(A)PYRENE	6.42	1	6.01	30669	30669	40892	51115	20446	40892	40892	122676	10223	10223	10223	51115	20446	30669	71561	163568	92007
BENZO(B)FLUORANTHENE	6.32	4	5.92	24717	24717	32956	41195	16478	32956	32956	98869	8239	8239	8239	41195	16478	24717	57674	131825	74152
BENZO(G,H,I)PERYLENE	7.05	1	6.60	119403	119403	159204	199004	79602	159204	159204	477611	39801	39801	39801	199004	79602	119403	278606	636814	358208
BENZO(K)FLUORANTHENE	6.85	1	6.41	77556	77556	103407	129259	51704	103407	103407	310222	25852	25852	25852	129259	51704	77556	180963	413629	232667
BIS(2-EH)PHTHALATE	5.11	5	4.16	431	431	574	718	287	574	574	1722	144	144	144	718	287	431	1005	2298	1292
CHRYSENE	5.71	4	5.34	6629	6629	8838	11048	4419	8838	8838	26515	2210	2210	2210	11048	4419	6629	15467	35353	19886
DIBENZOFURAN	4.12	6	3.85	215	215	286	358	143	286	286	858	72	72	72	358	143	215	501	1144	644
DIBENZO(A,H)ANTHRACENE	6.50	1	6.08	36447	36447	48596	60745	24298	48596	48596	145788	12149	12149	12149	60745	24298	36447	85043	194383	109341
DI-N-BUTYLPHTHALATE	5.60	7	4.42	795	795	1060	1326	530	1060	1060	3181	265	265	265	1326	530	795	1856	4242	2386
FLUORANTHENE	5.19	3	4.86	2159	2159	2878	3598	1439	2878	2878	8635	720	720	720	3598	1439	2159	5037	11513	6476
FLUORENE	4.27	4	3.99	297	297	395	494	198	395	395	1186	99	99	99	494	198	297	692	1582	890
INDENO(1,2,3-CD)PYRENE	7.66	1	7.17	445233	445233	593644	742056	296822	593644	593644	1780933	148411	148411	148411	742056	296822	445233	1038878	2374578	1335700
METHYLMERCURY	6.28	8	4.79	1864	1864	2485	3107	1243	2485	2485	7456	621	621	621	3107	1243	1864	4350	9942	5592
NAPHTHALENE	3.36	1	3.20	48	48	64	80	32	64	64	192	16	16	16	80	32	48	112	256	144
PHENANTHRENE	4.36	3	4.08	360	360	480	600	240	480	480	1441	120	120	120	600	240	360	840	1921	1080
PYRENE	4.88	2	4.57	1106	1106	1475	1843	737	1475	1475	4424	368	368	368	1843	737	1106	2580	5898	3318

+ BACKGROUND

* KOW REF REFERENCE FOR LOG KOW
1. EPA [illegible]
2. SCHUURMANN AND KLEIN [illegible]
3. EPA [illegible]d,e,f
4. DUXBURY, [illegible]
5. HOWARD, [illegible]
6. ZAROOGIAN ET AL., [illegible]
7. EPA [illegible]b
8. ESTIMATED BY CALCULATION (LYMAN ET AL. [illegible])

LOCATION R=REACH EW=EASTERN WETLANDS CBC=CHEMICAL BROOK CULVERT, OC=OUTFALL CREEK, RW=RACEWAY
CSB=COLD SPRING BROOK HP=HEARD POND BW=BORDERING WETLANDS

FOC = FRACTION ORGANIC CARBON
LOG KOC = 0.544 LOG KOW + 1.377 (NON-PAHS)
= 0.937 LOG KOW - 0.006 (PAHS)
KD = KOC * FOC

TABLE 7-10

ESTIMATED LOCATION-SPECIFIC INTERSTITIAL WATER (IW) CONCENTRATIONS OF ORGANIC SEDIMENT COC
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

ORGANIC COC IN SEDIMENT	BACKGROUND					R2					R3					R4				
	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L
4,4'-DDD	1346	ND	-	-	-	1346	NV	28	0.00	0.02	1795	65	370	0.05	0.21	2243	ND	-	-	-
4,4'-DDE	2487	ND	-	-	-	2487	17	58	0.01	0.02	3315	32	60	0.01	0.02	4144	ND	-	-	-
4,4'-DDT	2081	ND	-	-	-	2081	172	1400	0.06	0.68	2747	ND	-	-	-	3434	ND	-	-	-
ACENAPHTHENE	117	ND	-	-	-	117	544	1238	4.64	10.83	156	NV	100	-	0.64	185	ND	-	-	-
ACENAPHTHYLENE	103	ND	-	-	-	103	488	500	2.52	2.60	257	819	880	3.19	3.43	321	ND	-	-	-
ANTHRACENE	437	ND	-	-	-	437	754	2900	1.72	6.63	583	NV	240	-	0.41	720	NV	140	-	0.18
BENZO(A)ANTHRACENE	5342	ND	-	-	-	5342	1105	4400	0.21	0.82	7123	1346	4500	0.19	0.63	8904	NV	110	-	0.01
BENZO(A)PYRENE	30669	NV	91	-	0.00	30669	1028	3750	0.03	0.12	40892	1209	4400	0.03	0.11	51115	140	150	0.00	0.00
BENZO(B)FLUORANTHENE	24717	NV	200	-	0.01	24717	1034	3550	0.04	0.14	32956	1498	4400	0.05	0.13	41105	275	400	0.01	0.01
BENZO(G,H,I)PERYLENE	119403	ND	-	-	-	119403	594	650	0.00	0.01	159204	773	1600	0.00	0.01	199004	NV	92	-	0.00
BENZO(K)FLUORANTHENE	77950	ND	-	-	-	77950	900	3800	0.01	0.05	103407	1494	3900	0.01	0.04	129259	NV	150	-	0.00
BIS(2-EH)PHTHALATE	431	ND	-	-	-	431	651	2000	1.51	4.65	574	791	910	1.38	1.59	718	ND	-	-	-
CHRYSENE	6629	NV	180	-	0.03	6629	1082	4200	0.16	0.63	6838	1737	7700	0.20	0.87	11046	205	220	0.02	0.02
DIBENZOFURAN	215	ND	-	-	-	215	550	1060	2.56	4.94	286	ND	-	-	-	358	ND	-	-	-
DIBENZO(A,H)ANTHRACENE	38447	ND	-	-	-	38447	NV	80	-	0.00	48596	NV	310	-	0.01	60745	ND	-	-	-
DI-N-BUTYLPHTHALATE	795	ND	-	-	-	795	ND	-	-	-	1060	1645	5200	1.55	4.90	1326	ND	-	-	-
FLUORANTHENE	2150	NV	320	-	0.15	2150	2014	9250	0.93	4.29	2878	2332	12000	0.81	4.17	3598	260	270	0.07	0.08
FLUORENE	207	ND	-	-	-	207	807	1500	2.05	5.06	395	NV	200	-	0.51	494	ND	-	-	-
INDENO(1,2,3-CD)PYRENE	445233	ND	-	-	-	445233	626	900	0.00	0.00	593644	766	1600	0.00	0.00	742056	NV	84	-	0.00
METHYLMERCURY	1864	ND	-	-	-	1864	109	312	0.06	0.17	2465	NV	28	-	0.01	3107	27	79	0.01	0.03
NAPHTHALENE	46	ND	-	-	-	46	580	1180	12.46	24.54	64	NV	120	-	1.87	80	ND	-	-	-
PHENANTHRENE	360	NV	160	-	0.44	360	1935	10690	4.64	20.57	480	1368	7300	2.85	15.20	600	NV	170	-	0.28
PYRENE	1109	NV	270	-	0.24	1109	1960	8900	1.51	8.05	1475	2461	11000	1.67	7.46	1643	255	260	0.14	0.14

ORGANIC COC IN SEDIMENT	R5					R6					R7					EW				
	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L
4,4'-DDD	807	ND	-	-	-	1795	360	700	0.22	0.39	1795	ND	-	-	-	449	76	117	0.17	0.26
4,4'-DDE	1658	ND	-	-	-	3315	ND	-	-	-	3315	ND	-	-	-	829	ND	-	-	-
4,4'-DDT	1374	ND	-	-	-	2747	ND	-	-	-	2747	ND	-	-	-	687	ND	-	-	-
ACENAPHTHENE	78	ND	-	-	-	156	NV	74	-	0.47	156	490	110	-	0.70	39	ND	-	-	-
ACENAPHTHYLENE	128	180	180	1.28	1.28	257	ND	-	-	-	257	ND	-	-	-	64	ND	-	-	-
ANTHRACENE	292	180	180	0.51	0.51	583	NV	240	-	0.41	583	621	210	-	0.36	146	ND	-	-	-
BENZO(A)ANTHRACENE	3562	470	470	0.13	0.13	7123	1018	1500	0.14	0.21	7123	430	880	0.06	0.12	1781	ND	-	-	-
BENZO(A)PYRENE	20446	320	320	0.02	0.02	40892	NV	1100	-	0.03	40892	720	880	0.02	0.02	10223	843	860	0.08	0.08
BENZO(B)FLUORANTHENE	16478	1400	1400	0.08	0.08	32956	1626	3400	0.05	0.10	32956	516	910	0.02	0.03	8239	NV	2500	0.00	0.30
BENZO(G,H,I)PERYLENE	79602	270	270	0.00	0.00	159204	NV	820	-	0.01	159204	655	610	-	0.00	39801	ND	-	-	-
BENZO(K)FLUORANTHENE	61704	ND	-	-	-	103407	2413	980	-	0.01	103407	446	850	0.00	0.01	25852	ND	-	-	-
BIS(2-EH)PHTHALATE	287	330	330	1.16	1.16	574	NV	1900	-	3.31	574	646	1100	1.47	1.92	144	ND	-	-	-
CHRYSENE	4419	700	700	0.16	0.16	6838	NV	1500	-	0.17	6838	640	1200	0.07	0.14	2210	1013	1200	0.46	0.54
DIBENZOFURAN	143	ND	-	-	-	286	ND	-	-	-	286	ND	-	-	-	72	ND	-	-	-
DIBENZO(A,H)ANTHRACENE	24298	ND	-	-	-	48596	ND	-	-	-	48596	ND	-	-	-	12149	ND	-	-	-
DI-N-BUTYLPHTHALATE	530	ND	-	-	-	1060	ND	-	-	-	1060	ND	-	-	-	265	ND	-	-	-
FLUORANTHENE	1439	1100	1100	0.76	0.76	2878	1078	2600	0.60	0.90	2878	953	1900	0.33	0.66	720	1213	1900	1.69	2.22

TABLE 7-10
ESTIMATED LOCATION-SPECIFIC INTERSTITIAL WATER (IW) CONCENTRATIONS OF ORGANIC SEDIMENT COC
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
PAGE 2

	R5					R6					R7					EW				
ORGANIC COC IN SEDIMENT	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L
FLUORENE	198	ND	-	-	-	395	NV	160	-	0.40	395	496	140	-	0.35	99	ND	-	-	-
INDENO(1,2,3-CD)PYRENE	296822	240	240	0.00	0.00	593644	NV	740	-	0.00	593644	631	540	-	0.00	148411	ND	-	-	-
METHYLMERCURY	1243	ND	-	-	-	2485	ND	-	-	-	2485	ND	-	-	-	621	66	229	0.11	0.37
NAPHTHALENE	32	ND	-	-	-	64	ND	-	-	-	64	ND	-	-	-	16	1563	2300	97.52	143.51
PHENANTHRENE	240	540	540	2.25	2.25	480	1171	1600	2.44	3.33	480	593	1200	1.23	2.50	120	NV	620	-	5.16
PYRENE	737	1100	1100	1.49	1.49	1475	2075	2900	1.41	1.97	1475	876	1700	0.59	1.15	369	1263	1700	3.43	4.61

	CBC					OC					RW				
ORGANIC COC IN SEDIMENT	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L	KD	MEAN SED CONC ug/kg	MAX SED CONC ug/kg	MEAN IW CONC ug/L	MAX IW CONC ug/L
4,4'-DDD	2243	ND	-	-	-	897	ND	-	-	-	1346	32	108	0.02	0.08
4,4'-DDE	4144	ND	-	-	-	1658	ND	-	-	-	2487	11	21	0.00	0.01
4,4'-DDT	3434	ND	-	-	-	1374	ND	-	-	-	2061	ND	-	-	-
ACENAPHTHENE	195	ND	-	-	-	78	ND	-	-	-	117	ND	-	-	-
ACENAPHTHYLENE	321	NV	140	-	0.44	128	263	310	2.05	2.41	193	ND	-	-	-
ANTHRACENE	730	215	250	0.29	0.34	292	NV	185	-	0.63	437	NV	3100	-	7.09
BENZO(A)ANTHRACENE	8905	710	810	0.08	0.09	3562	800	1050	0.22	0.29	5342	5713	11000	1.07	2.06
BENZO(A)PYRENE	51115	720	770	0.01	0.02	20446	800	1200	0.04	0.06	30669	3888	4700	0.13	0.15
BENZO(B)FLUORANTHENE	41195	820	840	0.02	0.02	16478	1233	1750	0.07	0.11	24717	4263	5200	0.17	0.21
BENZO(G,H,I)PERYLENE	199004	NV	270	-	0.00	79602	492	730	0.01	0.01	119403	ND	-	-	-
BENZO(K)FLUORANTHENE	129260	680	700	0.01	0.01	51704	473	1000	-	0.02	77556	4300	6300	0.06	0.08
BIS(2-EH)PHTHALATE	718	150	200	0.21	0.28	287	960	2000	3.34	6.97	431	NV	2500	-	5.80
CHRYSENE	11045	748	790	0.07	0.07	4418	1077	1400	0.24	0.32	6628	5975	8600	0.90	1.30
DIBENZOFURAN	358	NV	92	-	0.26	143	ND	-	-	-	215	ND	-	-	-
DIBENZO(A,H)ANTHRACENE	60746	ND	-	-	-	24298	ND	-	-	-	36447	ND	-	-	-
DI-N-BUTYLPHTHALATE	1326	ND	-	-	-	530	ND	-	-	-	795	ND	-	-	-
FLUORANTHENE	3598	1200	1400	0.33	0.39	1439	1307	1600	0.91	1.11	2159	14263	20000	6.61	9.27
FLUORENE	494	NV	84	-	0.17	198	ND	-	-	-	297	NV	2800	-	9.44
INDENO(1,2,3-CD)PYRENE	742056	NV	330	-	0.00	296822	453	835	0.00	0.00	445233	ND	-	-	-
METHYLMERCURY	3107	ND	-	-	-	1243	ND	-	-	-	1864	ND	-	-	-
NAPHTHALENE	80	566	592	7.08	7.40	32	218	340	6.80	10.61	48	4081	6700	84.88	139.35
PHENANTHRENE	600	760	790	1.27	1.32	240	630	930	2.62	3.87	360	12113	16000	33.63	44.43
PYRENE	1843	1200	1200	0.65	0.65	737	1800	2500	2.44	3.39	1106	9400	13000	8.50	11.76

SAMPLED LOCATIONS R=REACH EW=EASTERN WETLANDS CBC=CHEMICAL BROOK CULVERT, RW=RACEWAY

IW CONC (ug/L) = SED CONC (ug/kg) / KD

ND=NOT DETECTED
NV=NO VALUE - MEAN EXCEEDS MAXIMUM
NS=NOT SAMPLED

7.4.6.1 Measured Biota Exposure Assessment

Except for dieldrin, biota COCs of a closely related nature were combined for evaluating exposures based on measured tissue concentrations in sampled fish. DDD and DDT were combined and evaluated as Total DDT.

Similarly, Aroclor 1254 and 1260 were combined as Total PCBs, alpha and gamma chlordane were combined as Total Chlordane. Mercury in fish was analyzed by cold vapor technique, which measures total mercury; in addition, methylmercury was analyzed be a method specific for methylmercury. Since the cold vapor analysis measures both inorganic and methylmercury, mercury concentrations based on this method were used to represent total mercury. The final biota COCs evaluated for exposure assessment consisted of Total DDT, Total PCBs, Total Chlordane, Total Mercury, and dieldrin.

The fish species sampled for this assessment included largemouth bass (Micropterus salmoides), yellow perch (Perca flavescens), and bullheads (Ictalurus spp.). In addition, caddis fly larvae were collected and analyzed for potential contaminants of concern. The usefulness of the caddis fly data was limited by technical problems associated with sample volume; therefore, these data were not included in the quantitative exposure assessment.

Fish were sampled in two phases. Phase I data were collected from Reaches 1, 3, 4, and 6. Phase II data were collected from Reaches 1, 2, 3, 4, 6, and 9. Phase I fish data consisted of many individual filet samples and relatively few composited viscera or offal samples. Viscera samples are the whole body minus the filet portions. No viscera samples were matched to filet samples for the same fish. Composited viscera samples were assumed to be representative of each particular fish species. The ingestion of only the filet portion of fish is not considered a likely route of exposure for nonhuman predators within food chains; therefore, COC whole-body concentrations were extrapolated from the concentrations measured in both filet and viscera samples.

The mean and maximum tissue concentrations of all biota COCs listed in Table 7-11, except for mercury, are based on estimated whole-body concentrations calculated from the viscera/filet (V/F) ratios derived for each species. Mercury concentrations listed on this table were based on total mercury in filet samples, which were considered to be representative of whole body total mercury. The basis for this assumption is explained below.
V/F ratios were determined for each fish species and for each biota COC other than mercury, and were based on average concentrations of each COC measured in viscera and filet samples taken from each fish species. The following table lists the V/F ratios determined for the three fish species:

T/ 7-11
DETECTED MEAN AND MAXIMUM CONCENTRATION OF BIOTA COCS, BY SPECIES AND REACH
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

LARGEMOUTH BASS

LOCATION CHEMICAL	B MEAN	B MAX	R2 MEAN	R2 MAX	R3 MEAN	R3 MAX	R4 MEAN	R4 MAX	R6 MEAN	R6 MAX	R9 MEAN	R9 MAX
DDT (TOTAL) 1/	91	190	ND	–	116	293	95	114	57	88	73	137
PCBS (TOTAL) 2/	108	152	ND	–	249	709	553	553	177	208	405	750
CHLORDANE (TOTAL) 3/	1.2	1.2	ND	–	2.3	3.4	14.6	14.6	ND	–	0.5	0.5
DIELDRIN	2.8	2.8	ND	–	0.3	0.3	0.9	0.9	ND	–	0.3	0.3
MERCURY (TOTAL)	745	1180	1120	1120	2870	7600	1470	4190	940	1800	1320	3200

YELLOW PERCH

LOCATION CHEMICAL	B MEAN	B MAX	R2 MEAN	R2 MAX	R3 MEAN	R3 MAX	R4 MEAN	R4 MAX	R6 MEAN	R6 MAX	R9 MEAN	R9 MAX
DDT (TOTAL) 1/	NS	–	80	66	63	155	55	66	29	65	34	77
PCBS (TOTAL) 2/	NS	–	450	450	206	704	136	135	68	95	157	297
CHLORDANE (TOTAL) 3/	NS	–	ND	–	1.5	1.9	ND	–	2.1	2.3	2.3	2.3
DIELDRIN	NS	–	ND	–	ND	–	0.6	0.6	2.2	2.6	ND	–
MERCURY (TOTAL) 4/	3330	9600	1430	1980	1560	3640	760	760	700	1400	720	1800

BULLHEAD

LOCATION CHEMICAL	B MEAN	B MAX	R2 MEAN	R2 MAX	R3 MEAN	R3 MAX	R4 MEAN	R4 MAX	R6 MEAN	R6 MAX	R9 MEAN	R9 MAX
DDT (TOTAL) 1/	NS	–	NS	–	32	47	86	170	65	96	NS	–
PCBS (TOTAL) 2/	NS	–	NS	–	127	150	127	216	127	190	NS	–
CHLORDANE (TOTAL) 3/	NS	–	NS	–	4.2	5.2	12	20.8	5.2	502	NS	–
DIELDRIN	NS	–	NS	–	2.6	2.6	ND	–	0	0	NS	–
MERCURY (TOTAL)	NS	–	NS	–	1990	2850	920	1200	740	880	NS	–

B = BACKGROUND (Includes Reach 1)

1/:4,4'-DDD + 4,4'-DDT
2/:AROCLOR 1254 + AROCLOR 1260
3/:ALPHA CHLORDANE + GAMMA CHLORDANE
4/:VALUES FOR YELLOW PERCH, INCLUDES REACH 1 PERCH WITH
ABNORMALLY HIGH MERCURY CONCENTRATIONS
ND:NOT DETECTED
NS:NOT SAMPLED

CONCENTRATIONS (ug/kg, wet wt.) UNADJUSTED FOR FISH AGE, LENGTH, OR WEIGHT
VALUES BASED ON FILET OR VISCERA SAMPLES ADJUSTED TO WHOLE BODY CONCENTRATIONS WITH V/F RATIOS (EXCEPT MERCURY)
MERCURY VALUES BASED ON TOTAL MERCURY IN FILET SAMPLES (V/F RATIO APPROXIMATELY = 1)

	TOTAL TDDT	TOTAL TPCB	TOTAL CHLORDANE	DIELDRIN
Largemouth Bass	6.6	2.2	1.3	10
Yellow Perch	3.4	0.8	0.5	10
Bullhead	5.4	3.0	9.4	10

Because fish samples consisted of either composited viscera samples or individual filet samples, conversion of filet or viscera concentrations to estimated whole body concentrations required a different conversion formula for each sample type. The conversion formulas are based on the following assumption:

Whole-Body (WB) Weight = Filet Weight + Viscera Weight

Individual filet and viscera weights were unavailable. In general, the filet portions of food fish are approximately equal in weight to that of the viscera portions. For this study, filet weight was assumed to equal viscera weight. Based on this assumption, the following conversions were used, as appropriate to estimate whole-body tissue concentrations of biota COCs for all fish species:

$$\frac{\text{WB Conc} = \text{Filet Conc (measured)} + (\text{Filet Conc} * \text{V/F Ratio})}{2}$$

$$\frac{\text{WB Conc} = \text{Viscera Conc (measured)} + (\text{Viscera Conc} / \text{V/F Ratio})}{2}$$

Concentrations of total mercury were evaluated because of potential methylation of inorganic mercury within biological tissues. Methylmercury is generally thought to partition preferentially to lipid (fat), while inorganic mercury is not expected to have a similar affinity for lipids. In addition, most mercury in fish tissues is generally accepted to be in the form of methylmercury. However, the results of this study do not fully support these assumptions.

Largemouth bass and yellow perch were sampled from six locations, and bullhead were sampled from three locations; resulting in 15 total cumulative samples. No single fish was analyzed for whole-body concentrations of total mercury; therefore, the relationships between filet and viscera samples are based on a comparison of the cumulative species- and location-specific mean and maximum values.

Total mercury V/F ratios for yellow perch and largemouth bass averaged approximately 1.0, suggestion that mercury does not differentially partition to lipids. In fact, studies have shown that methylmercury preferentially binds to sulfhydryl groups in proteins (Dr. D. Hinckley, personal communication, 1992). Therefore, similar concentrations of mercury in filet and viscera samples are not expected. In addition, viscera samples were based on relatively few (bass=3, perch=1, bullhead=2) composited samples, while filet samples were based on individual fish. Filet samples were therefore considered to be the most appropriate and most representative samples for estimating total mercury concentrations in individual fish. Table 7-11 lists estimated mean and maximum whole-body total mercury concentrations for each species and each location.

The mean and maximum estimated whole-body mercury concentrations in yellow perch collected from Background locations (Tables 7-11, 7-20, and 7-21) may not be truly representative of that species or location. A filet sample from one individual yellow perch collected from Reach 1 contained extremely elevated concentrations of mercury (9,600 ug/kg) relative to other yellow perch collected from Reach 1. This value is therefore considered to be suspect. Because the source of this apparently non-representative value cannot be determined, the value was retained and evaluated. However, it is likely that this value represents a transcription or laboratory error that can not be identified. Risk estimates (Tables 7-20 and 7-21) associated with this sample (yellow perch, Reach 1) are likely to overestimate actual risks for this species and location.

Phase II data included estimates of fish age and measurements of length and weight; Table 7-12 summarizes these data, while Table 7-21 presents a more thorough analysis of Phase II data, in which estimated whole-body total mercury concentrations are normalized for fish age. The data summarized in Table 12 show no consistent relationships between location and fish age, length, or weight. However, it should be noted that, on average, yellow perch collected from Reach 3 were lighter in weight and shorter in length than yellow perch from other locations. Also, largemouth bass from Reach 3 were heavier and older than largemouth bass from other locations. Simple statistics generally indicate slower growth rates for both species in Reaches 3 and 4 as compared to less contaminated areas.

These relationships were not statistically analyzed for significance.

Length, weight, and age data were not collected during Phase I. Phase II samples consisted only of filet portions. There was some concern that the integrity of some Phase II fish samples might have been compromised after collection and before processing in the laboratory. Some decomposition of sampled fish was observed, and these samples might not have been treated properly to ensure acceptable sample integrity. Contaminants could leach from decomposing muscle tissue (filet), resulting in erroneous muscle concentrations of some contaminants. However, the primary biota

TABLE 7-12

PHASE II SPECIES-SPECIFIC AND LOCATION-SPECIFIC FISH LENGTH, WEIGHT, AND AGE DATA
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

LARGEMOUTH BASS	MEAN LENGTH (mm)	LENGTH PER YEAR OF AGE (mm)	MEAN WEIGHT (g)	WEIGHT PER YEAR OF AGE (g)	MEAN AGE (yr)
BACKGROUND	266	89	366	122	3
REACH 2	325	81	568	142	4
REACH 3	340	68	693	139	5
REACH 4	299	75	418	104	4
REACH 6	313	78	533	133	4
REACH 9	341	85	723	181	4
YELLOW PERCH					
BACKGROUND	NS	NS	NS	NS	NS
REACH 2	233	58	186	46	4
REACH 3	205	51	95	23	4
REACH 4	246	41	169	28	6
REACH 6	246	49	188	38	5
REACH 9	247	49	203	40	5

NS: NOT SAMPLED

LENGTH, WEIGHT, AND AGE DATA UNAVAILABLE FOR BULLHEADS

COCs identified should sorb strongly to organic matter, probably decreasing the potential for contaminant leaching from filet samples.

7.4.6.2 Food Chain Exposure Assessment

A computer-based food chain model was used to estimate body burdens of biota COCs in organisms occupying various trophic levels within the aquatic system. The following paragraphs describe this model.

Because not all trophic levels in a food chain or all organisms occupying a given trophic level in a food chain can be analyzed for tissue chemical concentrations, food chain models have been developed to estimate concentrations of COCs in specific food chain organisms. These models should reasonably predict the biotic concentrations of COCs, given adequate quality and quantity of input data.

One limiting assumption of most food chain models is that the food chain being evaluated is phytoplankton driven; however, many food chains are detritus driven and the Sudbury River is likely to be a detritus-based system. Estimates of tissue concentrations of organisms of a detritus-based food chain can be expected to have greater uncertainty in comparison to estimates based on organisms in a phytoplankton-based food chain. In spite of this limitation, the food chain models that have been the subject of most reviews and are the most accepted are phytoplankton driven. Although cautious interpretation of results is warranted when such models are applied to detrital systems, these models are assumed to provide reasonable estimates of tissue concentrations of detrital-based food chain organisms. This assumption can be validated with actual measured values of tissue chemical concentrations.

The food chain model selected for this assessment is the Bioaccumulation Model of Organic Chemical Distribution in Aquatic Food Chains, developed by R.V. Thomann (1989). This model is based generally on the relationship of chemical octanol/water partitioning coefficients (Kow) and uptake efficiency from water, excretion rate, and chemical assimilation.

As discussed in Section 5.0, bioaccumulation considers chemical uptake from both food and water, while bioconcentration considers uptake from water only. Bioconcentration factors (BCFs) generally approximate bioaccumulation factors (BAFs) for chemicals that do not biomagnify. For chemicals that biomagnify significantly in food chains/webs, such as mercury and DDT, chemical uptake is best expressed in terms of bioaccumulation rather than bioconcentration because food ingestion is considered to be the primary uptake process. However, BAFs are generally unavailable for most chemicals and most organisms, and BCFs are often used as surrogate

BAFs for estimating chemical uptake by aquatic organisms (EPA, 1985h).

The outputs of this model include log BAFs for three trophic levels: Levels 2, 3, and 4. Level 1 is represented by phytoplankton, and at Kow values as high as approximately 6, phytoplankton BAF equals chemical Kow. Level 2 is represented by zooplankton, Level 3 by small fish, and Level 4 by large fish (top aquatic predator). Thomann's use of the terms "small fish" and "large fish" has been retained; however, these terms are considered synonymous with "zooplankton consumers" and "piscivorous fish," respectively. For the purposes of this risk assessment, the estimated log BAFs for Levels 2, 3, and 4 are the critical outputs from this model. Input variables for the model include chemical Kow, organism wet weight, and percent lipids in selected organisms. The model appears to be more sensitive to changes in the lipid content in comparison to the weight of organisms used to represent various trophic levels.

Because this model is based on chemical Kow, Kow must be accurately determined for the COCs. Kow values are readily available for most organic contaminants; however, Kows are not generally applicable to metals and, therefore, there is no readily available Kow for mercury. However, because methylmercury is an organic form of mercury, Kow estimations are possible based on Kow/BCF relationships. This approach is based on generally accepted methods and equations, and is expected to reasonably estimate the partitioning behavior of methylmercury for the purpose intended. Using the equation of Veith (Lyman, Reehl, and Rosenblatt, 1990), the relationship between log Kow and log BCF is described as follows:

$$\log BCF = 0.76 \log Kow - 0.23$$

Solving for log Kow results in the following equation:

$$\log Kow = \frac{\log BCF + 0.23}{0.76}$$

Freshwater whole-body bioconcentration factors for methylmercury range from 11,000 to 85,700 (n=6, EPA, 1984g). Log BCFs for these same values range from 4.04 to 4.93. The calculated geometric mean of the log BCF for methylmercury is 4.54. Using the rearranged equation of Veith, the log Kow for methylmercury is 6.28 (rounded to 6.3), which was the primary input variable to the food chain model selected.

Log Kows for PCBs differ for each specific PCB species. In this study, two PCBs, Aroclor 1254 and Aroclor 1260, dominated fish tissue PCB concentrations. The following table lists the log Kows used in this risk assessment for the two dominant Aroclors, as well as for Chlordane, DDT and its metabolites (DDD, DDE), methylmercury, and dieldrin:

Chemical	Reported Log Kow	Reference	Selected Log Kow
Aroclor 1254	6.03	U.S. EPA, 1979*	6.5
	6.5	Thomann, 1989	
Aroclor 1260	7.14	U.S. EPA, 1979*	6.5
	6.5	Thomann, 1989	
Chlordane	2.78	U.S. EPA, 1979	6.0
	6.0	Thomann, 1989	
DDT	4.88	U.S. EPA, 1979*	6.0
	6.0	Thomann, 1989	
DDD	6.04	U.S. EPA, 1979*	6.0
	6.0	Thomann, 1979	
DDE	5.74	U.S. EPA, 1979*	6.0
	5.7	Thomann, 1989	
Methylmercury	6.28	estimated, see above	6.3
Dieldrin	5.48	Thomann, 1989	5.5

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* mean of reported values

The variability associated with log Kows for most COCs resulted in the decision to use Thomann's values, which are based on recently published values from a variety of sources. With the exception of Chlordane, Thomann's values are similar to values reported by EPA (1979). Reported log BCFs for chlordane (5.98-7.24; Thomann, 1989) suggest that the 1979 Kow value of 2.78 might be too low and insufficiently conservative; therefore, log Kow was set at 6.0 for Chlordane. The log Kow was set at 6.5 for total PCBs, 6.0 for DDT and its metabolites, and 5.5 for dieldrin.

Values for the other input variables (percent lipids and organism wet weight) were specific for organisms representing trophic Levels 1 through 4. Levels 1 and 2 input values remained constant, while weight values for Levels 3 and 4 varied within the ranges indicated below. The values of input variables used in this assessment are listed below:

Level 1 (phytoplankton): Wet weight (g) = N/A
Percent lipid = 10

Level 2 (zooplankton): Wet weight (g) = 0.10
Percent lipid = 10

Level 3 (small fish): Wet weight (g) = 10 and 100
Percent lipid = 4.5

Level 4 (large fish): Wet weight (g) = 500 and 1500
Percent lipid = 4.5

Reported mean percent lipids for fish species ranged from 3.6 (black bullhead) to 4.4 (yellow perch) to approximately 5.5 (freshwater bass, not <u>Micropterus</u>) (Sidwell, 1981). The range associated with the reported mean percent lipid values for the three fish species overlapped considerably, suggesting no significant differences in average percent lipids for these species. Species-specific values for percent lipids were unavailable for largemouth bass. Because of the uncertainty associated with them, the three mean values were averaged for all sampled fish species, resulting in a mean lipid value of 4.5 percent. Because of the extensive overlap in the range of percent lipids for sampled species, intraspecific differences in percent lipids are expected to be as much as the reported interspecific difference. Therefore, the use of a single value for all sampled fish species should not measurably impact the results of the food chain model.

The trophic levels described above (Levels 1-4) are considered to be representative of site biota. Level 1 is assumed to represent detritus as well as phytoplankton. Level 2 is considered to be representative of small aquatic invertebrates (e.g., zooplankton and caddis fly larvae) that might be consumed by Level 3 organisms, which are typically fish weighing 10 to 100g. Finally, Level 4 organisms are considered to be top-level aquatic predators, including large individuals of yellow perch and largemouth bass weighing from 500 to 1,500g. Variability [illegible] fish weights did not produce measurable differences in pr[illegible]ted BAFs modeled; therefore, the fact that the actual weight [illegible] few largemouth bass exceeded the maximum modeled weight shou[illegible]t affect the model results.

Based on the results of the food chain model, Table 7-13 lists predicted BAFs for Levels 1 through 4, cumulative BAFs, and input parameters for biota COCs. Because the model is based predominantly on log Kow, and because the estimated log Kow for both groups of chemicals are the same (6.0), predicted BCFs for total DDT and total chlordane are equal. The results of this model suggest that log Kow provides a reasonable estimate of log BAF between any two trophic levels. For example, log BAFs for mercury (log Kow = 6.3) estimated between any two trophic levels range from 6.3 to 7.2. Similar results are predicted for PCBs, DDT, dieldrin, and chlordane, where all BAFs were estimated within the range of 5.5 to 7.3, while log Kows ranged from 5.5 to 6.5.

TABLE 7–13

PREDICTED BIOACCUMULATION FACTORS (BAFS) FOR FOOD CHAIN ORGANISMS (1)
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

TROPHIC LEVEL	PERCENT LIPID	WEIGHT (g)	BIOACCUMULATION FACTORS				
			MERCURY (2)	PCB (3)	DDT (4)	CHLORDANE (4)	DIELDRIN (5)
1	10	NA	6.3	6.5	6.0	6.0	5.5
2	10	0.1	6.7	6.8	6.4	6.4	6.1
3	4.5	10–100	6.9	7.0	6.4	6.4	5.9
4	4.5	500–1500	7.2	7.3	6.5	6.5	5.9
CUMULATIVE BAF LEVELS 1–4	---	---	2097	2259	1597	1597	1168

(1) PREDICTIONS BASED ON RESULTS OF THOMANN'S MODEL, 1989
(2) LOG KOW = 6.3 (ESTIMATED)
(3) LOG KOW = 6.5 (AVERAGE OF REPORTED VALUES)
(4) LOG KOW = 6.0 (AVERAGE OF REPORTED VALUES)
(5) LOG KOW = 5.5 (THOMANN, 1989)
NA: NOT APPLICABLE

Predicted cumulative AFs, expressing uptake from the source (surface water or interstitial water) to trophic level 4 (top aquatic predators) range from 1,168 (dieldrin) to 2,259 (total PCBs). Cumulative values for total mercury (2,097), total DDT (1,597), and total chlordane (1,597) fall within this range. These predicted cumulative BAF values are evaluated in the risk characterization section of this assessment.

7.4.7 Uncertainty Analysis, Exposure Assessment

The following paragraphs discuss some general areas of potential concern that are expected to contribute to exposure uncertainty. These statements are a means to identify the primary sources of potential uncertainty in the exposure assessment; they describe the methods used to decrease uncertainty that might be associated with the specific area of concern.

1. Sufficient quantities of environmental samples should be collected using appropriate sampling designs; the samples should be properly transported, and accurately and precisely analyzed.

   Sample collection and transport methods generally followed accepted protocols. Possible deviations from standard protocols used for storage and transport of fish samples (Phase II) might have compromised some fish data, but the impacts of the deviations should be minimal for the COCs identified. In-laboratory quality control (QC) and quality assurance (QA) programs are expected to limit uncertainty associated with sample analysis. In general, sufficient quantities of both chemical and biological samples were collected and analyzed for use in this assessment. Additional samples of caddis fly larvae would have produced an increased volume of pooled samples, thereby improving the analytical recovery of contaminants.

2. Methods selected for analyzing environmental samples should be appropriate to the analyte and sufficiently sensitive and specific for the needs of the assessment.

   Under the contract laboratory program (CLP), analytical laboratories must use EPA-recommended methods to analyze specific chemicals or groups of chemicals. All analyses in this assessment were performed using appropriate methods without deviation. Detection limits (DLs) and other QC results obtained in the analytical laboratory generally met predefined criteria. If QC criteria were not met, such data were appropriately qualified and considered to be conditionally acceptable or unacceptable, depending on the type of qualifier. Unacceptable environmental samples or environmental samples associated with unacceptable QC specimens were not used for this assessment.

3. Appropriate and reasonable assumptions should be made concerning exposure pathways (sources, points, routes).

   All major pathways were considered for the ecological resources potentially at risk. Minor pathways were not considered if they were associated with insignificant contributions to overall exposure. For example, organisms occupying the upper trophic levels of the food chains examined (e.g., osprey) were assumed to obtain a relatively small amount of potentially hazardous chemicals through the water ingestion pathway in comparison to the ingestion of contaminated prey items. Therefore, the water ingestion pathway was not considered in this case.

4. Selection of COCs for each media should not eliminate potentially hazardous chemicals from consideration for full assessment.

   Chemicals that were eliminated from further consideration included those that were relatively less toxic than retained chemicals, those that occurred in concentrations considered to be not toxic, and those that were detected in less than 5 percent of media-specific samples.

5. Appropriate and accepted sources of physical and chemical data should be used for evaluating fate and transport of COCs.

   Physical and chemical data used in this assessment were obtained primarily from the U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (FWS). Other sources included peer-reviewed journals and books in the specific subject areas.

6. Relationships between COC concentrations in viscera and filet samples should not overestimate or underestimate actual values.

   Filet samples were not correlated to viscera samples for any single fish. However, the composited viscera samples and individual filet samples offer sufficient information to establish reasonable relationships. Greater uncertainty is associated with relationships based on derived rather than measured values, but the consistent application of such relationships should not affect comparisons of relative differences in body burdens between species or between locations.

Sources of uncertainty in the exposure assessment fall into three major divisions: (1) analytical, (2) sampling, and (3) assumptions. The estimate of analytical uncertainty was relatively low due to stringent QA and QC procedures in CLP laboratories. In contrast, uncertainty associated with sampling procedures and especially sampling design, was expected to contribute significantly to overall uncertainty. This assumption was based on the fact that chemicals are not evenly distributed throughout any environmental study area, and even the best sampling design might not result in data that accurately describe the actual environmental concentrations or distributions of contaminants. Probably the greatest levels of uncertainty in the exposure assessment arise from the uncertainty associated with exposure assumptions. Assumptions are usually "best guess estimates," and certain levels of uncertainty are inherent in any assumption.

While potentially important areas of concern regarding exposure uncertainty have been identified, all efforts were made to limit the uncertainty as much as possible. For example, exposure assumptions were based on reasonable and accepted exposure scenarios where possible. If guidance was unavailable, reasonable assumptions describing "upper-bound likely" conditions were made. Analytical laboratories that were considered appropriate for the tasks assigned were used throughout the risk assessment process, ensuring that data quality objectives would be met. The sampling design, even though constrained by time and cost, was developed to provide site characterization that was as accurate as possible with respect to contaminant concentrations and distributions.

7.5 Hazard Assessment

Hazard assessment weighs evidence about the potential for COCs to cause adverse effects to exposed populations. Commonly assessed adverse effects include toxic effects (toxicity assessment) and food chain effects (effects due to bioconcentration/ biomagnification of chemicals). In addition, hazard assessment attempts to estimate the relationship between the duration and frequency of exposure to a chemical and the increased likelihood or severity of adverse effects (EPA, 1989a).

Duration of exposure is commonly expressed in terms of either acute or chronic toxicity. Acute exposures are relatively short-term duration exposures, often resulting in lethal or serious adverse effects to exposed organisms. Chronic exposures are considered long-term exposures, resulting in lethal or sublethal adverse effects to exposed organisms. Sublethal adverse effects include decreased growth and reproduction, teratogenic effects, and ecologically significant behavioral effects. No clear distinction exists between acute and chronic exposures in most cases, and exposure duration should be clearly defined. While most environmental exposures are considered to be chronic, exposures such as oil spills or runoff from the season's first rain event can pose an acute hazard to biota. Duration of exposure can be based on spatial and temporal components of a contaminated site or may be based on the behavior of affected organisms. For example, a "hot spot" of contaminated sediments can pose a continuous hazard to sessile benthic organisms. In contrast, mobile organisms are more likely to be exposed intermittently because contact is unlikely to be continuous, or because they might avoid the site.

Although evaluations of exposure and toxicity of <u>individual</u> chemicals are most often performed in risk assessments, chemicals rarely exist individually in the environment. In general, the toxicity of contaminant mixtures and the interactions of the contaminants making up the mixtures are poorly understood. Toxicant interactions can include synergism, antagonism, and additivity. In general, additivity best describes the type of interaction expected in toxicant mixtures, and it is assumed to be the predominant interaction in this risk assessment.

Benchmark Toxicity Values

For comparing estimated exposure concentrations to potentially hazardous concentrations of COCs, benchmark toxicity values were established. Benchmark toxicity values are defined as concentrations of media-specific COCs that are known or likely to be hazardous to species of concern. Such concentrations are intended for the protection of sensitive species from sublethal effects. For this reason, benchmark toxicity values are most appropriately based on data derived from chronic toxicity tests utilizing sublethal endpoints, such as chronic ambient water quality criteria.

Actual COC exposures to study area organisms are assumed to be primarily long-term exposures, usually at sublethal concentrations. However, chronic toxicity data are not uniformly available and, in some cases, chronic values were estimated from acute toxicity data. The acute toxicity database is much larger than the chronic toxicity database for most chemicals and most organisms; if acute toxicity data were the only data available, they were used for estimating critical chronic toxicity values. Appropriate chronic toxicity values include chronic ambient water quality criteria (CAWQC), lowest observed effect concentration (LOEC), or no observed effect concentration (NOEC) values. The preferred chronic toxicity value for surface water evaluations is the CAWQC value.

However, CAWQC values are unavailable for many chemicals, and toxicity values such as the lowest median lethal concentration, 50 percent (LC50)/100 or LOEC/10 were used as surrogate values.

Table 7-14 lists specific benchmark toxicity values used, and references the individual values.

The use of LC50/100 is based on laboratory data used to derive ambient water quality criteria for a variety of inorganic and organic chemicals. These data suggest that an LC50 for a standard sensitive test species divided by 100 provides a reasonable and adequate level of protection for sensitive untested species. Similarly, the use of LOEC/10 provides an estimate of NOEC, and LOEC/10 was selected as an appropriate chronic benchmark toxicity value for some chemicals.

Assumptions about the relationships between LOEC and NOEC values can be summarized as follows:

LOEC > NOEC and LOEC/10 **approximates** NOEC

The relationship between LOEC/10 and NOEC is based on a conservative approach. The NOEC is probably estimated more accurately by LOEC/2 than by LOEC/10, based on experimentally derived toxicity data. For example, results of chronic toxicity tests with hexavalent chromium and rainbow trout (EPA, 1985c) revealed an LOEC of 105 ug/L and an NOEC of 51 ug/L. In another example, in which sheepshead minnows were tested with acenaphthene (EPA, 1980a), the LOEC and NOEC equalled 970 and 520 ug/L, respectively, supporting the general LOEC/2 approximation of NOEC relationship. Because chronic data are limited for most chemicals and most species, a conservative approach was considered to be appropriate for the protection of untested species that might not follow the general relationships illustrated by these examples; therefore, LOEC/10 was used to estimate NOEC conservatively.

Data Sources

Sources of toxicity data used in this risk assessment include EPA Ambient Water Quality Criteria Documents (EPA, 1980-1988), EPA AQUIRE database for aquatic organisms (ACQUIRE, 1990), Syracuse Research Corporation's Chemfate database (SRC, 1990), U.S. Fish and Wildlife Service Hazard Review Documents (FWS, 1986-1990), and recent peer-reviewed scientific literature. The determination of acceptable versus unacceptable data was based on the appropriateness of endpoints, test design, and test species. EPA national guidelines contain appropriate criteria for data used in aquatic evaluations (EPA, 1985h).

7.5.1 Benchmark Toxicity Values - Surface Water COCs

This assessment evaluated surface water COCs for potential impacts to freshwater aquatic animals, freshwater aquatic plants, and avian/terrestrial organisms. Benchmark toxicity values were derived for each group of organisms based on chronic effects data from the most sensitive tested species. For freshwater aquatic animals, the benchmark toxicity values for all surface water COCs, except Bis-(2-ethylhexyl)phthalate, were based on chronic ambient water quality criteria, adjusted to a water hardness of 25 mg $CaCO_3$/L where appropriate. Because a CAWQC value has not been derived for Bis-(2-ethylhexyl)phthalate, a surrogate value was used. The surrogate value was based on the lowest of all reported lowest observed effect concentrations for freshwater fish and invertebrates divided by a safety factor of 10 (LOEC/10). LOEC/10 estimates the no observed effect concentration (NOEL).

Although plant toxicity data are sparse compared to toxicity data on animals, sufficient data exist for some chemicals to predict the potential impacts associated with contamination. In general, plant toxicity data consist of concentrations estimated to produce significant growth reduction or mortality. Potential toxicity of surface water COCs posed to freshwater aquatic plants were evaluated by establishing the lowest concentration affecting 50 percent of tested organisms (effect concentration, 50 percent or EC50). For aquatic plants such as algae, EC50s are available for some chemicals. Because such data were unavailable for some surface water COCs, LOEC/10 was used to estimate NOEC.

Avian and terrestrial animals are exposed to surface waters primarily through drinking. Concentrations of surface water COCs that are considered safe for ingestion by birds or other wildlife have not been established; therefore, ambient water quality criteria for the protection of human health, adjusted for drinking water only, were used as benchmark toxicity values for avian and terrestrial biota. The use of values intended for the protection of humans is associated with uncertainty; however, this uncertainty is expected to primarily overestimate rather than underestimate the toxicity of surface water COCs.

Table 7-14 lists the benchmark toxicity values for the COCs for aquatic animals, aquatic plants, and avian and terrestrial biota based on the ingestion of surface water.

7.5.2 Benchmark Toxicity Values - Sediment COCs

This assessment used a separate approach for estimating exposure concentrations of inorganic and organics sediment COCs. The

TABLE 7-14

BENCHMARK TOXICITY VALUES FOR SURFACE WATER CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

[illegible]	FRESHWATER AQUATIC ANIMAL TOXICITY VALUE ug/L	REF*	FRESHWATER AQUATIC PLANT TOXICITY VALUE ug/L	REF*	AVIAN/ [illegible]RRESTRIAL ANIMAL TOXICITY VALUE ug/L	REF*
Al [illegible]	87	1	4.6	3	–	5
[illegible]	11	1	0.2	4	50	6
[illegible]	3.6	1	0.1	4	1.0	6
LEAD	0.5	1	50	4	50	6
MERCURY (INORGANIC)	0.2	1	0.5	4	10	6
NICKEL	49	1	0.5	4	15.4	6
SILVER	0.1	1	3	4	50	6
ZINC	33	1	3	4	5	6
BIS-(2-ETHYLHEXYL) PHTHALATE	0.3	2	856	3	21000	6

* REFERENCES

1: CHRONIC AMBIENT WATER QUALITY CRITERIA (EPA, 1980-88)
ADJUSTED FOR HARDNESS = 25 mg $CaCO_3$ (Cu, Pb, Ni, Zn)
2: LOWEST OBSERVED EFFECT CONCENTRATION (LOEC) FOR INVERTEBRATES OR FISH / 10 (EPA, 1980-1988)
LOEC/10 = ESTIMATED NO OBSERVED EFFECT CONCENTRATION (NOEC)
3: LOWEST EFFECT CONCENTRATION, 50% (EC50) FOR AQUATIC PLANTS / 100 (EPA, 1980-1988)
EC50/100 = ESTIMATED NO OBSERVED EFFECT CONCENTRATION (NOEC)
4: LOWEST LOEC FOR AQUATIC PLANTS / 10 (EPA, 1980-1988)
LOEC/10 = ESTIMATED NO OBSERVED EFFECT CONCENTRATION (NOEC)
5: TOXICITY DATA FOR WATER INGESTION FOR TERRESTRIAL/AVIAN SPECIES UNAVAILABLE
6: AMBIENT WATER QUALITY CRITERIA FOR THE PROTECTION OF HUMAN HEALTH (EPA, 1986d)
ADJUSTED FOR DRINKING WATER ONLY

separate exposure approaches required distinct methods for establishing benchmark toxicity values for these COCs.

For inorganic COCs in sediment, biological effects data, based on ug chemical/kg sediment, dry weight, were used to establish benchmark toxicity values. At this time, sediment quality criteria values have been established for only a few organic chemicals. Therefore, sediment COC concentrations cannot be compared directly to criteria values. In a manner similar to that used for the selection of sediment COCs, biological effects data from Long and Morgan (1989) were used as surrogate criteria values for sediment COCs.

Long and Morgan derived toxicant concentrations in sediments that are associated with observed adverse biological effects, and sorted, in ascending order, the concentrations in sediment of a specific toxicant associated with observed adverse biological effects. The 10th and 50th percentile concentrations, described as the Effects Range-Low and Effects Range-Median, respectively, were derived for each chemical evaluated. ER-L values represent concentrations of a chemical in sediment (dry weight) that is equivalent to the lower 10th percentile of the screened available data. Similarly, ER-M values are equivalent to the median (50th percentile) of the screened available data.

Because both ER-L and ER-M values were expected to provide valuable information about the range of potentially toxic concentrations, both values were selected as benchmark toxicity values for inorganic sediment COCs. ER-L values were unavailable for two inorganic sediment COCs, aluminum and selenium. For these two COCs, surrogate values were used as benchmark toxicity values. To derive the surrogate values, the relationship between CAWQC and ER-L values was investigated. The median value of the ratio of CAWQC/ER-L computed for all chemicals for which ER-L values and CAWQC are available equals approximately 0.0005.

That is, dividing the chemical-specific CAWQC value by 0.0005 provides a reasonable estimate of ER-L for that chemical. Similarly, for aluminum and selenium, the estimated ER-M value was based on the relationship between ER-L and ER-M for all chemicals for which both values have been derived. This relationship can be described generally as

ER-M is approximately equal to ER-L * 3

This relationship was used to estimate ER-M values for both aluminum and selenium.

Organic COCs in sediment were partitioned to interstitial water using equilibrium partitioning in the exposure assessment.

Concentrations of sediment COCs in interstitial water are most appropriately compared to aqueous toxicity values. CAWQC or surrogate values were selected to represent the aqueous benchmark toxicity values for organic sediment COCs. In contrast to what was done with inorganic COCs in sediment, only a single benchmark toxicity value was established for each chemical. Surrogate values were used for organic COCs in sediment for which CAWQC have not been derived; these values include final chronic values (FCVs), LC50/100, and EC50/10.

Toxicity data are unavailable for an assessment of potential adverse effects of contaminated sediments on terrestrial or avian species. The potential for contaminated sediments to produce toxic adverse effects on terrestrial and avian species is considered minimal compared to potential food chain effects on terrestrial and avian species due to biomagnifiable COCs in sediment. Section 7.5.3 describes potential food chain effects.

Table 7-15 lists ER-L and ER-M values for inorganic sediment COCs and CAWQC (and surrogate values) for organic COCs in sediment.

7.5.3 Benchmark Toxicity Values - Biota COCs

The hazard assessment component of an ecological risk assessment is commonly referred to as a "toxicity assessment". Although this terminology is appropriate for many assessments, certain situations exist for which the term "hazard assessment" is more appropriate. This risk assessment considers the risk of biomagnification of certain COCs (e.g., mercury, DDT, chlordane) in food chains to be a critical component requiring assessment beyond that associated with acute or chronic toxicity. Therefore, the selection of biota COCs was based on bioconcentration potential, which is directly related to biomagnification, rather than on toxicity.

Chemicals that tend to biomagnify within food chains can produce severe adverse effects in top-level predators, while organisms occupying lower trophic levels exhibit little or no adverse effects even though their tissues contain measurable chemical residues. Clearly, potential risks associated with biomagnifiable COCs are best evaluated by considering both toxicity and bioconcentration/biomagnification potential.

Benchmark toxicity values for biota COCs were based on the maximum permissible tissue concentration (MPTC) for fish. The MPTC is the most sensitive (lowest value) of either the Food and Drug Administration (FDA) Action Level or the lowest value derived from an appropriate dietary intake study (EPA, 1985h). Although FDA Action Levels are not applicable to criteria which are protective of the ecology, the number is utilized as a reference point due to the lack of other relevant data. MPTC values are expressed as

TABLE 7-15

BENCHMARK TOXICITY VALUES FOR SEDIMENT CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

INORGANIC COC IN SEDIMENT	ER-L VALUE ug/kg	REF*	ER-M VALUE ug/kg	REF*	ORGANIC COC IN SEDIMENT	TOXICITY VALUE ug/L	REF*
ALUMINUM	174000	1	522000	3	4,4'-DDD	0.001	5
ARSENIC (III)	33000	2	85000	4	4,4'-DDE	0.001	5
CADMIUM	5000	2	9000	4	4,4'-DDT	0.001	5
CHROMIUM (VI)	80000	2	145000	4	ACENAPHTHENE	23	6
COPPER	70000	2	390000	4	ACENAPHTHYLENE	15	7
LEAD	35000	2	110000	4	ANTHRACENE	15	7
MERCURY (II)	150	2	1300	4	BENZO(A)ANTHRACENE	10	8
NICKEL	30000	2	50000	4	BENZO(A)PYRENE	10	9
SELENIUM	6000	1	18000	3	BENZO(B)FLUORANTHENE	15	7
ZINC	120000	2	270000	4	BENZO(G,H,I)PERYLENE	15	7
					BENZO(K)FLUORANTHENE	15	7
					BIS(2-EH)PHTHALATE	0.3	10
					CHRYSENE	10	9
					DIBENZOFURAN	15	7
					DIBENZO(A,H)ANTHRACEN	10	7
					DI-N-BUTYLPHTHALATE	0.3	11
					FLUORANTHENE	8.1	6
					FLUORENE	3.2	9
					INDENO(1,2,3-CD)PYRENE	15	7
					METHYLMERCURY	0.012	5
					NAPHTHALENE	20	9
					PHENANTHRENE	6.3	6
					PYRENE	15	7

INORGANIC TOXICITY VALUES: ug/kg sediment, dry wt.
ORGANIC TOXICITY VALUES: ug/L surface or interstitial water

* REFERENCES

1: (CAWQC / 0.0005) (EPA 1980-88)
  0.0005 = MEDIAN CAWQC/ER-L FOR ALL CHEMICALS WITH BOTH CAWQC AND ER-L
2: EFFECTS RANGE-LOW (ER-L) (LONG AND MORGAN, 1989)
3: ESTIMATED ER-L * 3 (LONG AND MORGAN, 1989)
  3 = APPROXIMATE MEAN RATIO OF ER-M/ER-L VALUES FOR INORGANIC CHEMICALS
4: EFFECTS RANGE-MEDIAN (ER-M) (LONG AND MORGAN, 1989)
5: CAWQC (EPA, 1980-1988)
6: FINAL CHRONIC VALUE (FCV) (EPA, 1991d,e,f)
7: LOWEST ACUTE 96H LC50 FOR PAHS / 100 (USFWS, 1987b)
8: LC87/100 (USFWS, 1987b)
9: LOWEST ACUTE 96H LC50 / 100 (USFWS, 1987b)
10: LOWEST CHRONIC EC50/10 (EPA, 1980i)
11: LOWEST CHRONIC EC50 FOR PHTHALATE ESTERS / 10 (EPA, 1980i)

ug/kg fish tissue, wet weight. The endpoint of appropriate dietary intake studies can vary with each study, but in general any ecologically significant endpoint is considered to be critical. Such endpoints can include adverse reproductive effects or decreased survival of sensitive species. MPTC values are generally available for classes of chemicals, and a single MPTC value can represent the MPTC for several closely related chemicals.

Therefore, to establish benchmark toxicity values for biota COCs, fish tissue concentrations of some biota COCs were combined. DDD and DDT were assessed as total DDT, Aroclor 1254 and 1260 were assessed as total PCBS, alpha and gamma chlordane were assessed as total chlordane, and inorganic mercury and methylmercury were assessed as total mercury. Table 7-16 lists the benchmark toxicity values for biota COCs.

7.5.4 Uncertainty Analysis, Hazard Assessment

Because complete toxicological databases do not exist for the vast majority of chemicals, there are many opportunities for uncertainty to impact the hazard assessment. Specific areas of concern that can indicate sources of potential uncertainty include the following:

1. Species tested should be representative of site species.

   EPA (1985h) considers tested aquatic species used to derive water quality criteria to be representative of species found throughout the nation. Site-specific species are not expected to be more or less sensitive to contaminants than those comprising the national aquatic database.

2. Laboratory toxicity tests should be representative of the Study Area environment.

   In general, laboratory-to-field extrapolations of toxicity data are considered to be acceptable under most conditions. Recent microcosm studies appear to confirm the general acceptability of laboratory-to-field extrapolations for toxicity testing. While laboratory conditions allow more control over test variables, field studies depict actual conditions more accurately. Unfortunately, acceptable field studies are rare for most organisms and most chemicals, and the majority of accepted toxicity data are based on laboratory studies.

3. Extrapolations (acute-to-chronic, species-to-species, chemical-to-chemical) should be reasonable and appropriate for the chemicals and species selected.

TABLE 7-16

BENCHMARK TOXICITY VALUES FOR BIOTA CHEMICALS OF CONCERN
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

BIOTA COC	ASSESSED AS	MPTC ug/kg wet wt.	REF*	ACTION LEVEL OR MOST SENSITIVE ECOLOGICALLY SIGNIFICANT EFFECT
4,4'-DDD	TOTAL DDT			
4,4'-DDT	TOTAL DDT	150	1	REDUCED REPRODUCTION IN BROWN PELICANS
AROCLOR 1254	TOTAL PCB			
AROCLOR 1260	TOTAL PCB	640	2	REDUCED SURVIVAL AND REPRODUCTION IN MINK
CHLORDANE (TOTAL)	TOTAL CHLORDANE	300	3	U.S. FDA GUIDELINE FOR HUMAN CONSUMPTION OF FISH AND SHELLFISH
DIELDRIN	DIELDRIN	300	4	U.S. FDA GUIDELINE FOR HUMAN CONSUMPTION OF FISH AND SHELLFISH
METHYLMERCURY	TOTAL MERCURY	100	5	REPRODUCTIVE EFFECTS, SENSITIVE AVIAN SPECIES

MPTC: MAXIMUM PERMISSIBLE TISSUE CONCENTRATION, FISH
BASED ON LOWEST OF FDA ACTION LEVEL OR VALUE FROM APPROPRIATE DIETARY INTAKE STUDY

* REFERENCES

1: EPA, 1980d
2: EPA, 1980g
3: USFWS, 1990
4: EPA, 1980b
5: USFWS, 1987a

Direct testing with local species and site-specific COCs is the best approach for defining potential toxicities of COCs at a given site. However, such data are generally unavailable, and the use of appropriate extrapolations is a reasonable approach. Extrapolations from tested to untested species and chemicals should be based on reasonable, tested relationships between species or chemicals. This document provides equations or other support for expressing such relationships where appropriate.

Deriving appropriate toxicity values for species or chemicals for which toxicity data are limited often requires the use of interspecies correlations for species-to-species extrapolations and chemical QSARs for chemical-to-chemical extrapolations. Interspecies correlations (e.g., Doherty, 1983; Suter and Rosen, 1986) and quantitative structure-activity relationships (QSARs) (e.g., Borman, 1990; Protic and Sabljic, 1989), are commonly used to extrapolate toxicity data from species to species or from chemical to chemical. Such extrapolations were used in a limited manner for this assessment because toxicity data, although often limited, existed for most COCs. The major exception was the lack of toxicity data for some sediment COCs (e.g., some PAHs). For limited toxicity data, chemical relationships were utilized to estimate toxicity, or the toxicity of the most hazardous chemical in a class of chemicals (e.g., PAHs) was used to estimate toxicity for related nontested chemicals.

4. Single-point toxicity values such as LC50s, compared to dose/response relationships (e.g., describing the entire toxicity curve), might or might not adequately depict potential toxicity.

   The description of an entire dose/response or concentration/response curve is potentially more informative than a single value, such as an LC50. However, such data are rarely reported; most often a single value such as an LC50; median lethal dose, 50 percent (LD50), or LOEC, is reported. Although this is considered to be a limitation, the use of single-point toxicity values is still expected to provide an adequate description of the relative toxicity between chemicals and between test species.

5. Accepted toxicity data should be based on standardized, accepted test protocols.

> All aquatic toxicity data used throughout this assessment were based on tests that followed acceptable experimental designs, conditions, and endpoints as defined by EPA (1985h). Terrestrial and avian toxicity test results were considered to be acceptable if selected endpoints were ecologically significant and if toxicant dosing and exposure durations and frequencies followed accepted protocols.

The decision to accept or reject toxicity data for use in the ecological risk assessment was based on best professional judgment in some cases. The justification for accepting or rejecting data was deemed to be critical, and the use of appropriate safety factors and other extrapolation factors were intended to be reasonable and scientifically defensible. Best professional judgment was used only if specific guidance or accepted procedures were unavailable. For example, safety factors were applied to toxicity values using best professional judgment if no specific guidance was available.

Various ecological risk assessment methodologies have been developed to limit the variability and uncertainty associated with toxicological data; however, ecotoxicology is in its infancy in comparison to related disciplines. The number of species and chemicals tested is only a small fraction of species and chemicals that might be of concern. Although there is a continuing effort by aquatic toxicologists, ecotoxicologists, risk assessment specialists, regulatory agencies, and others to establish standardized methodologies for performing ecological risk assessments, this goal has not yet been achieved. There has been measurable success in standardizing toxicity test protocols and in increasing both the quality and quantity of the data for toxicity and exposure assessments. At this time, however, ecological risk assessments are generally based on limited available data and on extrapolations from measured to unmeasured species and chemicals. It is often necessary to draw on experience and best professional judgment, even though confidence and reliability in the resulting judgments can be less than desired. Therefore, ecological risk assessment methodologies will be associated with a degree of uncertainty for both exposure and hazard assessments for some time. In this assessment, efforts have been made to limit the level of uncertainty as much as possible by using appropriate toxicity values that were considered to be adequately protective of biota. If an uncertainty could not be quantified or limited, efforts were made to err on the side of conservatism, or overprotection. While EPA has stated that neither overprotection nor underprotection is desirable (EPA, 1985h), erring on the side of overprotection of biotic resources seems prudent.

7.6 Risk Characterization

Risk characterization relates exposure concentrations of COCs to concentrations of COCs that potentially cause adverse effects; it is based primarily on the integration of exposure and hazard assessments. This section compares the media-s[ecofoc and reach-specific exposures (representative organisms) from Site and Study Area contaminants and potentially toxic concentrations of these contaminants.

7.6.1 General Approach

The quotient method was selected to characterize risk for the toxicity portion of this ecological risk assessment. In a manner similar to that used in the initial selection of COCs, the average and the maximum estimated environmental concentrations for each media and each reach were divided by the appropriate benchmark toxicity value. The average and maximum exposure concentrations for each media-specific COC were based on the values presented in Section 7.4. Toxicity values used to derive the exposure/toxicity ratios followed the guidelines described in Section 7.5.

The quotient method is probably the most common and most accepted method used for risk characterization in ecological risk assessments. However, it is associated with inherent limitations. One primary limitation is that the quotient method is a "yes/no" method for relating toxicity to exposure. That is, it utilizes single values for exposure concentrations and toxicity values, and does not account for incremental or cumulative toxicity. This limitation is addressed specifically by summing the quotients for all COCs, including those that are less than 1.0. In general, an exposure/toxicity quotient less than 1.0 is considered to be associated with insignificant risk. However, the cumulative toxicity of several COCs with exposure/toxicity quotients that approach, but are less than, 1.0 can be significant; this issue is addressed in this section. Section 7.6.5 discusses other limitations of the quotient method.

Advantages of the quotient method, according to Barnthouse et al. (1986), include the following:

1. The quotient method is relatively easy to implement, is generally accepted, and can be applied to any data.

2. The quotient method is useful when a large number of chemicals must be screened.

The following sections present estimated risks to aquatic and terrestrial biota, based on media-specific mean and maximum exposure concentrations. The individual numeric risk values do not represent risk probability values in themselves, but are representative of the relative probability of risk; that is, the greater the estimated environmental concentration/ toxicity value quotient (EEC/TV), the greater the probability of risk.

7.6.2 Cumulative Toxicity

Although risk assessments generally evaluate the potential for adverse ecological effects due to individual chemicals, they should also address potential hazards associated with the cumulative effects of toxicant mixtures. Bioassays are the preferred means to determine the toxicity of complex chemical mixtures or to identify the actual toxicity of samples for which analytical methodologies are unavailable. In general, however, site-specific bioassay data are unavailable; estimates of the hazards to site biota from complex chemical mixtures can be assessed through various methods designed to address cumulative risk.

The method used in this risk assessment to evaluate cumulative risk is based generally on the method of Barnthouse et al. (1986). This method, which is based on the principle of toxicant additivity, simply sums the individual EEC/TV quotients for a given exposure. Toxicant additivity best describes the majority of toxicant interactions, and this fact supports this methodology for estimating cumulative toxicity. Other types of interactions, including synergistic and antagonistic interactions, have been insufficiently documented for most of the chemical mixtures studied.

Because this method utilizes chronic ambient water quality criteria or surrogate values, its application is intended only for aquatic systems. At present, no method exists for estimating cumulative toxicity for terrestrial or avian biota. The toxicity associated with most sites results from one primary toxicant or a few critical toxicants. Therefore, in most cases, adverse ecological impacts should not result from cumulative low toxicities associated with many toxicants.

7.6.3 Risk from Surface Water COCs

This assessment divided average and maximum concentrations of each surface water COC within each reach by benchmark toxicity values. Each individual COC-specific quotient resulting from these calculations is directly comparable to the other COC-specific quotients. Therefore, the relative toxicity associated with each COC in each reach can be assessed. In addition, individual quotients for all COCs in each reach were summed, and the cumulative risk due to all surface water COCs was calculated for each reach. Table 7-17 lists the results of risk calculations based on surface water COCs.

The data listed in Table 7-17 suggest that overall risk posed to avian and terrestrial organisms that drink site surface waters is minimal. For all surface water COCs, the ingestion of site water poses little risk to terrestrial and avian life when compared to other exposure pathways; concentrations of COCs in surface waters are well below those expected to pose measurable risks to such biota.

Aluminum in surface waters appears to be the primary source of risk to aquatic plants in most reaches. For Reach 1, zinc and nickel pose the primary risk to aquatic plants. Over all reaches, the risks for aquatic plants that are associated with zinc are generally less than the risks associated with aluminum. For both of these COCs, risk to aquatic plants can be somewhat overestimated because of potential complexation with organic acids. Aluminum complexed to organic (fulvic and humic) acids can be analytically indistinguishable from bioavailable forms of dissolved aluminum. Therefore, risk estimates based on aluminum and, to a lesser extent, zinc can be overestimated for waters with significant organic acid concentrations, such as swamps, bogs, marshes, and wetlands.

Risks posed to aquatic animals vary significantly from reach to reach, with the exception of aluminum. In general, aluminum contributes similarly to overall risk in Reaches 2 through 7, and in the Outfall Creek (OC) and Cold Spring Brook (CSB) locations. Reaches 1 to 6 are associated with relatively low risk estimates compared to Reach 7, Eastern Wetlands (EW), OC, and CSB. The primary surface water COCs associated with these locations are silver (R7), lead (EW and OC), and bis(2-ethylyhexyl)phthalate (OC and CSB). The risk estimate for CSB, which is based entirely on bis(2-ethylyhexyl) phthalate, greatly exceeds all other risk estimates for surface water COCs.

7.6.4 Risk from Sediment COCs

This assessment divided average and maximum concentrations of each sediment COC in each reach by benchmark toxicity values. As in the surface water risk characterization, each individual COC-specific quotient is directly comparable to the other COC-specific quotients. Again, the relative toxicity associated with each COC in each reach can be assessed. Individual quotients for all sediment COCs in each reach were added together, and the cumulative risk from all sediment COCs was calculated for each reach.

TABLE 7-17

RISK ESTIMATES – SURFACE WATER COC
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS

				FRESHWATER AQUATIC ANIMAL			FRESHWATER AQUATIC PLANT			AVIAN/TERRESTRIAL ANIMAL		
LOCATION	CHEMICAL	MEAN SW CONC (ug/L)	MAX SW CONC (ug/L)	TOXICITY VALUE 1/ (ug/L)	MEAN RISK VALUE	MAX RISK VALUE	TOXICITY VALUE 1/ (ug/L)	MEAN RISK VALUE	MAX RISK VALUE	TOXICITY VALUE 1/ (ug/L)	MEAN RISK VALUE	MAX RISK VALUE
BACKGROUND	NICKEL	3 8	7	49	0 1	0 1	0.5	7.6	14.0	15.4	0.2	0.5
BACKGROUND	ZINC	12 11	21.6	33	0.4	0 7	3	4.0	7.2	5	2.4	4.3
BACKGROUND	SUM RISK				0.4	0.8		11.6	21.2		2.7	4.8
R2	ALUMINUM	29 26	67 3	87	0 3	0.8	4.6	6.4	14.6	NA		
R2	SUM RISK				0.3	0 8		6.4	14.6		0.0	0.0
R3	ALUMINUM	80 8	80 8	87	0.9	0 9	4.6	17.6	17.6	NA		
R3	ZINC	18 5	18 5	33	0 6	0.6	3	6.2	6.2	5	3.7	3.7
R3	BIS(2-EH)PHTH	NV	1	0 3		3 3	856		0.0	21000		0.0
R3	SUM RISK				1.5	4.8		23.7	23.7		3.7	3.7
R4	ALUMINUM	107	107	87	1.2	1.2	4.6	23.3	23.3	NA		
	LEAD	1 5	1 5	0 5	3 0	3 0	50	0.0	0.0	50	0.0	0.0
R4	ZINC	22 6	22 6	33	0 7	0.7	3	7.6	7.6	5	4.6	4.6
R4	SUM RISK				4.9	4.9		30.9	30.9		4.6	4.6
R6	ALUMINUM	110 57	174	87	1.3	2.0	4.6	24.0	37.8	NA		
R6	SUM RISK				1.3	2.0		24.0	37.8		0.0	0.0
R7	ALUMINUM	72 34	155	87	0.8	1 8	4.6	15.7	33.7	NA		
R7	SILVER	3 88	8	0 1	38 8	80.0	3	1.3	2.7	50	0.1	0.2
R7	SUM RISK				39 6	81 8		17.0	36.4		0.1	0.2

TABLE 7-17
RISK ESTIMATES - SURFACE WATER COC
NYANZA OPERABLE UNIT 3
MIDDLESEX COUNTY, MASSACHUSETTS
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LOCATION	CHEMICAL	MEAN SW CONC (ug/L)	MAX SW CONC (ug/L)	FRESHWATER AQUATIC ANIMAL TOXICITY VALUE 1/ (ug/L)	FRESHWATER AQUATIC ANIMAL MEAN RISK VALUE	FRESHWATER AQUATIC ANIMAL MAX RISK VALUE	FRESHWATER AQUATIC PLANT TOXICITY VALUE 1/ (ug/L)	FRESHWATER AQUATIC PLANT MEAN RISK VALUE	FRESHWATER AQUATIC PLANT MAX RISK VALUE	AVIAN/TERRESTRIAL ANIMAL TOXICITY VALUE 1/ (ug/L)	AVIAN/TERRESTRIAL ANIMAL MEAN RISK VALUE	AVIAN/TERRESTRIAL ANIMAL MAX RISK VALUE
EW	LEAD	6.8	8.7	0.5	13.6	17.4	50	0.1	0.2	50		
EW	MERCURY	0.43	0.49	0.2	2.2	2.5	0.5	0.9	1.0	10	0.0	0.0
EW	SUM RISK				15.8	19.9		1.0	1.2		0.0	0.0
OC	ALUMINUM	67	67	87	0.8	0.8	4.6	14.6	14.6	NA		
OC	LEAD	2.4	2.4	0.5	4.8	4.8	50	0.0	0.0	50		
OC	MERCURY	0.42	0.42	0.2	2.1	2.1	0.5	0.8	0.8	10	0.0	0.0
OC	ZINC	46.1	46.1	33	1.4	1.4	3	15.4	15.4	5	9.2	9.2
OC	BIS(2-EH)PHTH	1	1	0.3	3.3	3.3	3	0.3	0.3	5	0.2	0.2
OC	SUM RISK				12.4	12.4		31.2	31.2		9.5	9.5
CSB	BIS(2-EH)PHTH	58	58	0.3	193.3	193.3	3	19.3	19.3	5	11.6	11.6
CSB	SUM RISK				193.3	193.3		19.3	19.3		11.6	11.6

1/ BENCHMARK TOXICITY VALUE FROM TABLE 7-14

SAMPLED LOCATIONS: R=REACH, EW=EASTERN WETLANDS, OC=OUTFALL CREEK, CSB=COLD SPRING BROOK

NV: NO VALUE - MEAN EXCEEDS MAXIMUM
NA: TOXICITY VALUE NOT AVAILABLE

The ingestion of highly contaminated sediments can pose a real hazard to organisms that routinely ingest significant amounts of sediment. Such large-scale ingestion, which is unlikely for most biota, is best evaluated using food chain modeling that accounts for bioaccumulation. Toxic effects to individual organisms associated with significant sediment ingestion has not been fully evaluated because supporting toxicity data are lacking. However, such risks are likely to be minimal because of the low probability of significant sediment ingestion by most terrestrial and avian biota. Herons and some duck species might be exceptions; they are considered to be among the organisms at significant risk due to the ingestion of contaminated sediments.

The risk estimates for inorganic sediment COCs listed in Table 7-18 indicate that aluminum is a primary inorganic sediment contaminant for nearly all locations, including Background areas. As stated above, aluminum concentrations that form the basis for the risk estimates might not be totally bioavailable, resulting in overestimations of risk.

Based on the similar risk values for aluminum over all reaches, including Reach 1 (background), much of the aluminum measured in sediments is assumed to be naturally occurring, complexed aluminum that is generally considered to be nontoxic.

However, the presence of elevated concentrations of aluminum in surface waters in most reaches suggests that sediment-source aluminum is releasing aluminum to surface waters in concentrations that can be toxic to aquatic life. The other inorganic sediment COCs associated with significantly higher risk estimates than the other COCs are mercury and, to a lesser degree, chromium, copper, and lead. Sediment chromium probably consists primarily of trivalent chromium (Section 4.0), which is considered to have lower bioavailability and toxicity than hexavalent chromium. Sediment copper and lead might or might not be bioavailable and toxic, depending on specific sediment conditions. In contrast to aluminum, mercury is considered potentially bioavailable because the uptake and methylation of inorganic mercury by benthic biota are likely, resulting in biomagnification in the food chain.

Table 7-19 lists risk estimates for organic COCs in sediment. The primary contributors to overall risk include DDT and its metabolites, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and methylmercury. Cumulative maximum risk estimates range from 0.1 (Reach 1) to 762.3 (Reach 2, primarily due to DDT).

TABLE 7-18
RISK ESTIMATES – INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
B*	ALUMINUM	9200910	16600000	174000	52.9	95.4	522000	17.6	31.8
B	ARSENIC	8740	21100	33000	0.3	0.6	85000	0.1	0.2
B	CHROMIUM	22400	55200	80000	0.3	0.7	145000	0.2	0.4
B	COPPER	73020	340400	7000	10.4	48.6	390000	0.2	0.9
B	LEAD	85090	248000	35000	2.4	7.1	110000	0.8	2.3
B	MERCURY	270	1590	150	1.8	10.6	1300	0.2	1.2
B	NICKEL	11350	51000	30000	0.4	1.7	50000	0.2	1.0
B	SELENIUM	1040	3100	6000	0.2	0.5	18000	0.1	0.2
B	ZINC	133500	62900	120000	1.1	0.5	270000	0.5	0.2
B	SUM RISK VALUES 1/				69.8	165.8		19.8	38.2
B	SUM RISK VALUES 2/				4.8	19.0		1.2	4.1
R2	ALUMINUM	7608330	16800000	174000	43.7	96.6	522000	14.6	32.2
R2	ARSENIC	6950	14900	33000	0.2	0.5	85000	0.1	0.2
R2	CHROMIUM	34000	216000	80000	0.4	2.7	145000	0.2	1.5
R2	COPPER	40190	184000	7000	5.7	26.3	390000	0.1	0.5
R2	LEAD	58070	295000	35000	1.7	8.4	110000	0.5	2.7
R2	MERCURY	3810	30600	150	25.4	204.0	1300	2.9	23.5
R2	NICKEL	7470	19100	30000	0.2	0.6	50000	0.1	0.4
R2	ZINC	126440	330000	120000	1.1	2.8	270000	0.5	1.2
R2	SUM RISK VALUES 1/				78.5	341.8		19.1	62.1
R2	SUM RISK VALUES 2/				27.7	215.6		3.8	27.9
R3	ALUMINUM	12210000	21500000	174000	70.2	123.6	522000	23.4	41.2
R3	ARSENIC	7610	21500	33000	0.2	0.7	85000	0.1	0.3
R3	CADMIUM	4890	19900	5000	1.0	4.0	9000	0.5	2.2
R3	CHROMIUM	292620	2620000	80000	3.7	32.8	145000	2.0	18.1
R3	COPPER	184470	454000	7000	26.4	64.9	390000	0.5	1.2
R3	LEAD	137970	285000	35000	3.9	8.1	110000	1.3	2.6
R3	MERCURY	15960	54600	150	106.5	364.0	1300	12.3	42.0
R3	NICKEL	28430	88800	30000	0.9	3.0	50000	0.6	1.8
R3	SELENIUM	810	4000	6000	0.1	0.7	18000	0.0	0.2
R3	ZINC	177060	435000	120000	1.5	3.6	270000	0.7	1.6
R3	SUM RISK VALUES 1/				214.4	605.2		41.3	111.1
R3	SUM RISK VALUES 2/				115.3	409.5		16.2	65.1

TABLE 7-18 (continued)
RISK ESTIMATES – INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS
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				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
R4	ALUMINUM	12821540	22900000	174000	73.7	131.6	522000	24.6	43.9
R4	ARSENIC	10680	32300	33000	0.3	1.0	85000	0.1	0.4
R4	CADMIUM	4810	14900	5000	1.0	3.0	9000	0.5	1.7
R4	CHROMIUM	71610	224000	80000	0.9	2.8	145000	0.5	1.5
R4	COPPER	115850	332000	7000	16.6	47.4	390000	0.3	0.9
R4	LEAD	93960	219000	35000	2.7	6.3	110000	0.9	2.0
R4	MERCURY	3380	7300	150	22.5	48.7	1300	2.6	5.6
R4	NICKEL	28690	63000	30000	1.0	2.1	50000	0.6	1.3
R4	SELENIUM	1740	4000	6000	0.3	0.7	18000	0.1	0.2
R4	ZINC	161050	327000	120000	1.3	2.7	270000	0.6	1.2
R4	SUM RISK VALUES 1/				120.2	246.2		30.7	58.6
R4	SUM RISK VALUES 2/				27.4	61.7		4.6	11.2
R5	ALUMINUM	7023330	20700000	174000	40.4	119.0	522000	13.5	39.7
R5	ARSENIC	3830	9200	33000	0.1	0.3	85000	0.0	0.1
R5	CHROMIUM	17950	60600	80000	0.2	0.8	145000	0.1	0.4
R5	COPPER	41670	158000	7000	6.0	22.6	390000	0.1	0.4
R5	LEAD	237990	809000	35000	6.8	23.1	110000	2.2	7.4
R5	MERCURY	980	4100	150	6.5	27.3	1300	0.8	3.2
R5	NICKEL	6790	16100	30000	0.2	0.5	50000	0.1	0.3
R5	SELENIUM	NV	440	6000	0.0	0.1	18000	0.0	0.0
R5	ZINC	199880	765000	120000	1.7	6.4	270000	0.7	2.8
R5	SUM RISK VALUES 1/				61.9	200.0		17.5	54.3
R5	SUM RISK VALUES 2/				13.7	51.5		3.1	11.0
R6	ALUMINUM	11636400	19300000	174000	66.9	110.9	522000	22.3	37.0
R6	ARSENIC	11100	24000	33000	0.3	0.7	85000	0.1	0.3
R6	CADMIUM	3830	13600	5000	0.8	2.7	9000	0.4	1.5
R6	CHROMIUM	66600	281000	80000	0.8	3.5	145000	0.5	1.9
R6	COPPER	113500	303000	7000	16.2	43.3	390000	0.3	0.8
R6	LEAD	285700	876000	35000	8.2	25.0	110000	2.6	8.0
R6	MERCURY	3300	17600	150	22.0	117.3	1300	2.5	13.5
R6	NICKEL	20300	78400	30000	0.7	2.6	50000	0.4	1.6
R6	SELENIUM	1370	6100	6000	0.2	1.0	18000	0.1	0.3
R6	ZINC	292300	564000	120000	2.4	4.7	270000	1.1	2.1
R6	SUM RISK VALUES 1/				118.5	311.9		30.3	67.0
R6	SUM RISK VALUES 2/				32.1	149.3		6.2	25.2

TABLE 7-18 (continued)
RISK ESTIMATES - INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS
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				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
R7	ALUMINUM	7736900	16500000	174000	44.5	94.8	522000	14.8	31.6
R7	ARSENIC	10130	40600	33000	0.3	1.2	85000	0.1	0.5
R7	CADMIUM	2210	17900	5000	0.4	3.6	9000	0.2	2.0
R7	CHROMIUM	47950	209000	80000	0.6	2.6	145000	0.3	1.4
R7	COPPER	65940	278000	7000	9.4	39.7	390000	0.2	0.7
R7	LEAD	117940	526000	35000	3.4	15.0	110000	1.1	4.8
R7	MERCURY	1520	5500	150	10.1	36.7	1300	1.2	4.2
R7	NICKEL	11290	44100	30000	0.4	1.5	50000	0.2	0.9
R7	SELENIUM	1180	7200	6000	0.2	1.2	18000	0.1	0.4
R7	ZINC	170080	646000	120000	1.4	5.4	270000	0.6	2.4
R7	SUM RISK VALUES 1/				70.7	201.7		18.8	48.9
R7	SUM RISK VALUES 2/				14.9	59.1		2.9	12.9
R8	ALUMINUM	6636000	8310000	174000	38.1	47.8	522000	12.7	15.9
R8	ARSENIC	12130	30000	33000	0.4	0.9	85000	0.1	0.4
R8	CADMIUM	2080	4300	5000	0.4	0.9	9000	0.2	0.5
R8	CHROMIUM	22000	36400	80000	0.3	0.5	145000	0.2	0.3
R8	COPPER	67610	96600	7000	9.7	13.8	390000	0.2	0.2
R8	LEAD	66700	100000	35000	1.9	2.9	110000	0.6	0.9
R8	MERCURY	1620	2100	150	10.8	14.0	1300	1.2	1.6
R8	NICKEL	7080	13100	30000	0.2	0.4	50000	0.1	0.3
R8	SELENIUM	750	1800	6000	0.1	0.3	18000	0.0	0.1
R8	ZINC	167360	329000	120000	1.6	2.7	270000	0.7	1.2
R8	SUM RISK VALUES 1/				63.5	84.1		16.1	21.4
R8	SUM RISK VALUES 2/				13.8	19.1		2.4	3.6
R9	ALUMINUM	9806000	11700000	174000	56.4	67.2	522000	18.8	22.4
R9	ARSENIC	32000	64600	33000	1.0	2.0	85000	0.4	0.8
R9	CADMIUM	7050	8600	5000	1.4	1.7	9000	0.8	1.0
R9	CHROMIUM	50260	78000	80000	0.6	1.0	145000	0.3	0.5
R9	COPPER	83330	135000	7000	11.9	19.3	390000	0.2	0.3
R9	LEAD	115260	184000	35000	3.3	5.3	110000	1.0	1.7
R9	MERCURY	3150	3900	150	21.0	26.0	1300	2.4	3.0
R9	NICKEL	24950	28100	30000	0.8	0.9	50000	0.5	0.6
R9	ZINC	197130	319000	120000	1.6	2.7	270000	0.7	1.2
R9	SUM RISK VALUES 1/				98.0	126.0		25.2	31.4
R9	SUM RISK VALUES 2/				27.3	35.9		5.0	6.9

TABLE 7-18 (continued)
RISK ESTIMATES – INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS
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				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
R10	ALUMINUM	6790000	17600000	174000	39.0	101.1	522000	13.0	33.7
R10	ARSENIC	5990	12200	33000	0.2	0.4	85000	0.1	0.1
R10	CHROMIUM	11240	17100	80000	0.1	0.2	145000	0.1	0.1
R10	COPPER	14115	31000	7000	2.0	4.4	390000	0.0	0.1
R10	LEAD	22480	33800	35000	0.6	1.0	110000	0.2	0.3
R10	MERCURY	161	530	150	1.1	3.5	1300	0.1	0.4
R10	NICKEL	7370	11100	30000	0.2	0.4	50000	0.1	0.2
R10	ZINC	38350	53400	120000	0.3	0.4	270000	0.1	0.2
R10	SUM RISK VALUES 1/				43.6	111.5		13.8	35.2
R10	SUM RISK VALUES 2/				2.0	5.1		0.5	1.0
EW	ALUMINUM	7216000	11050000	174000	41.5	63.5	522000	13.8	21.2
EW	ARSENIC	6590	12700	33000	0.2	0.4	85000	0.1	0.1
EW	CHROMIUM	123680	462000	80000	1.5	5.8	145000	0.9	3.2
EW	COPPER	63730	120000	7000	9.1	17.1	390000	0.2	0.3
EW	LEAD	72580	142000	35000	2.1	4.1	110000	0.7	1.3
EW	MERCURY	35878	152000	150	239.2	1013.3	1300	27.6	116.9
EW	NICKEL	10143	40400	30000	0.3	1.3	50000	0.2	0.8
EW	SELENIUM	1430	6500	6000	0.2	1.1	18000	0.1	0.4
EW	ZINC	65393	164000	120000	0.5	1.4	270000	0.2	0.6
EW	SUM RISK VALUES 1/				294.7	1108.0		43.7	144.8
EW	SUM RISK VALUES 2/				243.0	1023.6		29.2	121.5
CBC	ALUMINUM	3520000	3690000	174000	20.2	21.2	522000	6.7	7.1
CBC	ARSENIC	4300	6600	33000	0.1	0.2	85000	0.1	0.1
CBC	CHROMIUM	82300	135000	80000	1.0	1.7	145000	0.6	0.9
CBC	COPPER	63350	92500	7000	9.1	13.2	390000	0.2	0.2
CBC	LEAD	38250	57500	35000	1.1	1.6	110000	0.3	0.5
CBC	MERCURY	6800	7100	150	45.3	47.3	1300	5.2	5.5
CBC	ZINC	92950	103000	120000	0.8	0.9	270000	0.3	0.4
CBC	SUM RISK VALUES 1/				77.6	86.1		13.4	14.7
CBC	SUM RISK VALUES 2/				47.6	50.9		6.2	7.0

TABLE 7-18 (continued)
RISK ESTIMATES – INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS
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				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
OC	ALUMINUM	5876670	11500000	174000	33.8	66.1	522000	11.3	22.0
OC	ARSENIC	2930	4100	33000	0.1	0.1	85000	0.0	0.0
OC	CHROMIUM	341600	988000	80000	4.3	12.4	145000	2.4	6.8
OC	COPPER	137830	359000	7000	19.7	51.3	390000	0.4	0.9
OC	LEAD	105950	233000	35000	3.0	6.7	110000	1.0	2.1
OC	MERCURY	35330	99200	150	235.5	661.3	1300	27.2	76.3
OC	ZINC	166300	390000	120000	1.4	3.3	270000	0.6	1.4
OC	SUM RISK VALUES 1/				297.8	801.1		42.8	109.7
OC	SUM RISK VALUES 2/				242.9	680.5		30.5	85.3
RW	ALUMINUM	22850000	29200000	174000	131.3	167.8	522000	43.8	55.9
RW	ARSENIC	24960	37200	33000	0.8	1.1	85000	0.3	0.4
RW	CADMIUM	2280	5600	5000	0.5	1.1	9000	0.3	0.6
RW	CHROMIUM	155500	208000	80000	1.9	2.6	145000	1.1	1.4
RW	COPPER	217750	306000	7000	22.2	29.7	390000	0.4	0.5
RW	LEAD	435750	758000	35000	6.2	8.7	110000	2.0	2.8
RW	MERCURY	710	970	150	4.7	6.5	1300	0.5	0.7
RW	NICKEL	89890	186000	30000	3.0	6.2	50000	1.8	3.7
RW	ZINC	365880	542000	120000	3.0	4.5	270000	1.4	2.0
RW	SUM RISK VALUES 1/				173.7	228.3		51.5	68.2
RW	SUM RISK VALUES 2/				14.1	20.1		4.1	6.0
CSB	ALUMINUM	9225000	10700000	174000	53.0	61.5	522000	17.7	20.5
CSB	ARSENIC	3500	4300	33000	0.1	0.1	85000	0.0	0.1
CSB	CHROMIUM	15100	16700	80000	0.2	0.2	145000	0.1	0.1
CSB	COPPER	31500	32900	7000	4.5	4.7	390000	0.1	0.1
CSB	LEAD	234000	328000	35000	6.7	9.4	110000	2.1	3.0
CSB	ZINC	148000	166000	120000	1.2	1.4	270000	0.5	0.6
CSB	SUM RISK VALUES 1/				65.7	77.3		20.6	24.3
CSB	SUM RISK VALUES 2/				7.0	9.7		2.3	3.1

TABLE 7-18 (continued)
RISK ESTIMATES – INORGANIC COCS IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS
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				EFFECTS RANGE-LOW			EFFECTS RANGE-MEDIAN		
LOCATION	CHEMICAL	MEAN SED CONC (ug/kg)	MAX SED CONC (ug/kg)	ER-L TOXICITY VALUE (ug/kg)	MEAN ER-L RISK VALUE	MAX ER-L RISK VALUE	ER-M TOXICITY VALUE (ug/kg)	MEAN ER-M RISK VALUE	MAX ER-M RISK VALUE
BW	ALUMINUM	12474000	19300000	174000	71.7	110.9	522000	23.9	37.0
BW	ARSENIC	6220	11900	33000	0.2	0.4	85000	0.1	0.1
BW	CHROMIUM	24010	101000	80000	0.3	1.3	145000	0.2	0.7
BW	COPPER	18013	83400	7000	2.6	11.9	390000	0.0	0.2
BW	LEAD	71190	254000	35000	2.0	7.3	110000	0.6	2.3
BW	MERCURY	1071	7600	150	7.1	50.7	1300	0.8	5.8
BW	NICKEL	7180	21800	30000	0.2	0.7	50000	0.1	0.4
BW	SELENIUM	70	1200	6000	0.0	0.2	18000	0.0	0.1
BW	ZINC	41078	127000	120000	0.3	1.1	270000	0.2	0.5
BW	SUM RISK VALUES 1/				84.5	184.4		26.0	47.2
BW	SUM RISK VALUES 2/				9.7	59.5		1.7	9.0
HP	ALUMINUM	10580000	10580000	174000	60.8	60.8	522000	20.3	20.3
HP	ARSENIC	10850	10850	33000	0.3	0.3	85000	0.1	0.1
HP	CHROMIUM	40200	40200	80000	0.5	0.5	145000	0.3	0.3
HP	COPPER	136000	136000	7000	19.4	19.4	390000	0.3	0.3
HP	LEAD	149000	149000	35000	4.3	4.3	110000	1.4	1.4
HP	MERCURY	3500	3500	150	23.3	23.3	1300	2.7	2.7
HP	NICKEL	11300	11300	30000	0.4	0.4	50000	0.2	0.2
HP	ZINC	302000	302000	120000	2.5	2.5	270000	1.1	1.1
HP	SUM RISK VALUES 1/				111.5	111.5		26.4	26.4
HP	SUM RISK VALUES 2/				28.4	28.4		4.5	4.5

* B = BACKGROUND (INCLUDES REACH 1)

SAMPLED LOCATIONS: R=REACH, EW=EASTERN WETLANDS, CBC=CHEMICAL BROOK CULVERT, OC=OUTFALL CREEK,
RW=RACEWAY, CSB=COLD SPRING BROOK, BW=BORDERING WETLAND, HP=HEARD POND

1/ SUM INCLUDES SITE-RELATED AND NON-SITE-RELATED CONTAMINANTS
2/ SUM INCLUDES SITE-RELATED CONTAMINANTS ONLY (As, Cd, Cr, Pb, Hg)

TABLE 7–19
RISK ESTIMATES–ORGANIC COC IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION	CHEMICAL	MEAN IW+ CONC (ug/L)	MAX IW+ CONC (ug/L)	BENCHMARK TOXICITY VALUE (ug/L)	MEAN RISK VALUE	MAXIMUM RISK VALUE
B*	BENZO(A)PYRENE	NV	0.00	10	–	0.0
B	BENZO(B)FLUORANTHENE	NV	0.01	15	–	0.0
B	CHRYSENE	NV	0.03	10	–	0.0
B	FLUORANTHENE	NV	0.15	8.1	–	0.0
B	PHENANTHRENE	NV	0.44	6.3	–	0.1
B	PYRENE	NV	0.24	15	–	0.0
B	SUM RISK					0.1
R2	4,4'–DDD	0.00	0.02	0.001	0.0	20.0
R2	4,4'–DDE	0.01	0.02	0.001	13.7	23.3
R2	4,4'–DDT	0.08	0.68	0.001	80.0	679.4
R2	ACENAPHTHENE	4.64	10.53	23	0.2	0.5
R2	ACENAPHTHYLENE	2.52	2.60	15	0.2	0.2
R2	ANTHRACENE	1.72	6.63	15	0.1	0.4
R2	BENZO(A)ANTHRACENE	0.21	0.82	10	0.0	0.1
R2	BENZO(A)PYRENE	0.03	0.12	10	0.0	0.0
R2	BENZO(B)FLUORANTHENE	0.04	0.14	15	0.0	0.0
R2	BENZO(G,H,I)PERYLENE	0.00	0.01	15	0.0	0.0
R2	BENZO(K)FLUORANTHENE	0.01	0.05	15	0.0	0.0
R2	BIS(2–EH)PHTHALATE	0.51	4.65	0.3	1.7	15.5
R2	CHRYSENE	0.16	0.63	10	0.0	0.1
R2	DIBENZOFURAN	2.59	4.94	15	0.2	0.3
R2	DIBENZO(A.H)ANTHRACENE	NV	0.00	10	–	0.0
R2	FLUORANTHENE	0.93	4.29	8.1	0.1	0.5
R2	FLUORENE	2.05	5.06	3.2	0.6	1.6
R2	INDENO(1,2,3–CD)PYRENE	0.00	0.00	15	0.0	0.0
R2	METHYLMERCURY	0.06	0.17	0.012	4.9	13.9
R2	NAPHTHALENE #	12.46	24.54	20	0.6	1.2
R2	PHENANTHRENE	4.54	29.57	6.3	0.7	4.7
R2	PYRENE	1.51	8.05	15	0.1	0.5
R2	SUM RISK				103.1	762.3
R3	4,4'–DDD	0.05	0.21	0.001	50.0	206.2
R3	4,4'–DDE	0.01	0.02	0.001	10.6	18.1
R3	ACENAPHTHENE	NV	0.64	23	–	0.0
R3	ACENAPHTHYLENE	3.19	3.43	15	0.2	0.2
R3	ANTHRACENE	NV	0.41	15	–	0.0
R3	BENZO(A)ANTHRACENE	0.19	0.63	10	0.0	0.1
R3	BENZO(A)PYRENE	0.03	0.11	10	0.0	0.0
R3	BENZO(B)FLUORANTHENE	0.05	0.13	15	0.0	0.0
R3	BENZO(G.H.I)PERYLENE	0.00	0.01	15	0.0	0.0
R3	BENZO(K)FLUORANTHENE	0.01	0.04	15	0.0	0.0
R3	BIS(2–EH)PHTHALATE	1.38	1.59	0.3	4.6	5.3
R3	CHRYSENE	0.20	0.87	10	0.0	0.1
R3	DIBENZO(A.H)ANTHRACENE	NV	0.01	10	–	0.0
R3	DI–N–BUTYLPHTHALATE	1.55	4.90	0.3	5.2	16.3
R3	FLUORANTHENE	0.81	4.17	8.1	0.1	0.5
R3	FLUORENE	NV	0.51	3.2	–	0.2
R3	INDENO(1,2,3–CD)PYRENE	0.00	0.00	15	0.0	0.0
R3	METHYLMERCURY	NV	0.01	0.012	–	0.9
R3	NAPHTHALENE #	NV	1.87	20	–	0.1
R3	PHENANTHRENE	2.85	15.20	6.3	0.5	2.4
R3	PYRENE	1.67	7.46	15	0.1	0.5
R3	SUM RISK				71.2	250.9

TABLE 7–19 (continued)
RISK ESTIMATES–ORGANIC COC IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX, MASSACHUSETTS
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LOCATION	CHEMICAL	MEAN IW CONC (ug/L)	MAX IW CONC (ug/L)	BENCHMARK TOXICITY VALUE (ug/L)	MEAN RISK VALUE	MAXIMUM RISK VALUE
R4	ANTHRACENE	NV	0.19	15	–	0.0
R4	BENZO(A)ANTHRACENE	NV	0.01	10	–	0.0
R4	BENZO(A)PYRENE	0.00	0.00	10	0.0	0.0
R4	BENZO(B)FLUORANTHENE	0.01	0.01	15	0.0	0.0
R4	BENZO(G,H,I)PERYLENE	NV	0.00	15	–	0.0
R4	BENZO(K)FLUORANTHENE	NV	0.00	15	–	0.0
R4	CHRYSENE	0.02	0.02	10	0.0	0.0
R4	FLUORANTHENE	0.07	0.08	8.1	0.0	0.0
R4	INDENO(1,2,3–CD)PYRENE	NV	0.00	15	–	0.0
R4	METHYLMERCURY	0.01	0.03	0.012	0.7	2.1
R4	PHENANTHRENE	NV	0.28	6.3	–	0.0
R4	PYRENE	0.14	0.14	15	0.0	0.0
R4	SUM RISK				0.7	2.2
R5	ACENAPHTHYLENE	1.25	1.25	15	0.1	0.1
R5	ANTHRACENE	0.51	0.51	15	0.0	0.0
R5	BENZO(A)ANTHRACENE	0.13	0.13	10	0.0	0.0
R5	BENZO(A)PYRENE	0.02	0.02	10	0.0	0.0
R5	BENZO(B)FLUORANTHENE	0.08	0.08	15	0.0	0.0
R5	BENZO(G,H,I)PERYLENE	0.00	0.00	15	0.0	0.0
R5	BIS(2–EH)PHTHALATE	1.15	1.15	0.3	3.8	3.8
R5	CHRYSENE	0.16	0.16	10	0.0	0.0
R5	FLUORANTHENE	0.76	0.76	8.1	0.1	0.1
R5	INDENO(1,2,3–CD)PYRENE	0.00	0.00	15	0.0	0.0
R5	PHENANTHRENE	2.25	2.25	6.3	0.4	0.4
R5	PYRENE	1.49	1.49	15	0.1	0.1
R5	SUM RISK				4.5	4.5
R6	4,4'–DDD	0.22	0.39	0.001	222.3	390.1
R6	ACENAPHTHENE	NV	0.47	23	–	0.0
R6	ANTHRACENE	NV	0.41	15	–	0.0
R6	BENZO(A)ANTHRACENE	0.14	0.21	10	0.0	0.0
R6	BENZO(A)PYRENE	NV	0.03	10	–	0.0
R6	BENZO(B)FLUORANTHENE	0.05	0.10	15	0.0	0.0
R6	BENZO(G,H,I)PERYLENE	NV	0.01	15	–	0.0
R6	BENZO(K)FLUORANTHENE	NV	0.01	15	–	0.0
R6	BIS(2–EH)PHTHALATE	NV	3.31	0.3	–	11.0
R6	CHRYSENE	NV	0.17	10	–	0.0
R6	FLUORANTHENE	0.69	0.90	8.1	0.1	0.1
R6	FLUORENE	NV	0.40	3.2	–	0.1
R6	INDENO(1,2,3–CD)PYRENE	NV	0.00	15	–	0.0
R6	PHENANTHRENE	2.44	3.33	6.3	0.4	0.5
R6	PYRENE	1.41	1.97	15	0.1	0.1
R6	SUM RISK				222.9	402.1
R7	ACENAPHTHENE	NV	0.7	23	–	0.0
R7	ANTHRACENE	NV	0.36	15	–	0.0
R7	BENZO(A)ANTHRACENE	0.6	0.12	10	0.1	0.0
R7	BENZO(A)PYRENE	0.02	0.02	10	0.0	0.0
R7	BENZO(B)FLUORANTHENE	0.02	0.03	15	0.0	0.0
R7	BENZO(G,H,I)PERYLENE	NV	0.00	15	–	0.0
R7	BENZO(K)FLUORANTHENE	0.00	0.01	15	0.0	0.0
R7	BIS(2–EH)PHTHALATE	1.47	1.92	0.3	4.9	6.4
R7	CHRYSENE	0.07	0.14	10	0.0	0.0

TABLE 7-19 (continued)
RISK ESTIMATES-ORGANIC COC IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX, MASSACHUSETTS
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LOCATION	CHEMICAL	MEAN IW CONC (ug/L)	MAX IW CONC (ug/L)	BENCHMARK TOXICITY VALUE (ug/L)	MEAN RISK VALUE	MAXIMUM RISK VALUE
R7	FLUORANTHENE	0.33	0.66	8.1	0.0	0.1
R7	FLUORENE	NV	0.35	3.2	–	0.1
R7	INDENO(1,2,3-CD)PYRENE	NV	0.00	15	–	0.0
R7	PHENANTHRENE	1.23	2.50	6.3	0.2	0.4
R7	PYRENE	0.59	1.15	15	0.0	0.1
R7	SUM RISK				5.2	7.1
EW	4,4'-DDD	0.17	0.26	0.001	169.4	260.8
EW	BENZO(A)PYRENE	0.08	0.08	10	0.0	0.0
EW	BENZO(B)FLUORANTHENE	0.00	0.30	15	0.0	0.0
EW	CHRYSENE	0.46	0.54	10	0.0	0.1
EW	FLUORANTHENE	1.69	2.22	8.1	0.2	0.3
EW	METHYLMERCURY	0.29	0.37	0.012	24.0	30.7
EW	NAPHTHALENE #	97.46	143.51	20	4.9	7.2
EW	PHENANTHRENE	NV	5.16	6.3	–	0.8
EW	PYRENE	3.43	4.61	15	0.2	0.3
EW	SUM RISK				198.8	300.2
CBC	ACENAPHTHYLENE	NV	0.44	15	–	0.0
CBC	ANTHRACENE	0.29	0.34	15	0.0	0.0
CBC	BENZO(A)ANTHRACENE	0.08	0.09	10	0.0	0.0
CBC	BENZO(A)PYRENE	0.01	0.02	10	0.0	0.0
CBC	BENZO(B)FLUORANTHENE	0.02	0.02	15	0.0	0.0
CBC	BENZO(G,H,I)PERYLENE	NV	0.00	15	0.0	0.0
CBC	BENZO(K)FLUORANTHENE	0.01	0.01	15	–	0.0
CBC	BIS(2-EH)PHTHALATE	0.21	0.28	0.3	0.7	0.9
CBC	CHRYSENE	0.07	0.07	10	0.0	0.0
CBC	DIBENZOFURAN	NV	0.26	15	–	0.0
CBC	FLUORANTHENE	0.36	0.39	8.1	0.0	0.0
CBC	FLUORENE	NV	0.17	3.2	–	0.1
CBC	INDENO(1,2,3-CD)PYRENE	NV	0.00	15	–	0.0
CBC	NAPHTHALENE #	7.05	7.49	20	0.4	0.4
CBC	PHENANTHRENE	1.27	1.32	6.3	0.2	0.2
CBC	PYRENE	0.65	0.65	15	0.0	0.0
CBC	SUM RISK				1.4	1.8
OC	ACENAPHTHYLENE	2.05	2.41	15	0.1	0.2
OC	ANTHRACENE	NV	0.63	15	–	0.0
OC	BENZO(A)ANTHRACENE	0.22	0.29	10	0.0	0.0
OC	BENZO(A)PYRENE	0.04	0.06	10	0.0	0.0
OC	BENZO(B)FLUORANTHENE	0.07	0.11	15	0.0	0.0
OC	BENZO(G,H,I)PERYLENE	0.01	0.01	15	0.0	0.0
OC	BENZO(K)FLUORANTHENE	NV	0.02	15	–	0.0
OC	BIS(2-EH)PHTHALATE	3.34	6.97	0.3	11.1	23.2
OC	CHRYSENE	0.24	0.32	10	0.0	0.0
OC	FLUORANTHENE	0.91	1.11	8.1	0.1	0.1
OC	INDENO(1,2,3-CD)PYRENE	0.00	0.00	15	0.0	0.0
OC	NAPHTHALENE #	6.80	10.61	20	0.3	0.5
OC	PHENANTHRENE	2.62	3.87	6.3	0.4	0.6
OC	PYRENE	2.44	3.39	15	0.2	0.2
OC	SUM RISK				12.4	25.0

TABLE 7-19 (continued)
RISK ESTIMATES-ORGANIC COC IN SEDIMENT
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX, MASSACHUSETTS
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LOCATION	CHEMICAL	MEAN IW CONC (ug/L)	MAX IW CONC (ug/L)	BENCHMARK TOXICITY VALUE (ug/L)	MEAN RISK VALUE	MAXIMUM RISK VALUE
RW	4,4'-DDD	0.02	0.08	0.001	20.0	80.0
RW	4,4'-DDE	0.00	0.01	0.001	0.0	10.0
RW	ANTHRACENE	NV	7.09	15	-	0.5
RW	BENZO(A)ANTHRACENE	1.07	2.06	10	0.1	0.2
RW	BENZO(A)PYRENE	0.13	0.15	10	0.0	0.0
RW	BENZO(B)FLUORANTHENE	0.17	0.21	15	0.0	0.0
RW	BENZO(K)FLUORANTHENE	0.06	0.08	15	0.0	0.0
RW	BIS(2-EH)PHTHALATE	NV	5.81	0.3	-	19.4
RW	CHRYSENE	0.90	1.30	10	0.1	0.1
RW	FLUORANTHENE	6.61	9.27	8.1	0.8	1.1
RW	FLUORENE	NV	9.44	3.2	-	3.0
RW	NAPHTHALENE #	84.88	139.35	20	4.2	7.0
RW	PHENANTHRENE	33.63	44.43	6.3	5.3	7.1
RW	PYRENE	8.50	11.76	15	0.6	0.8
RW	SUM RISK				31.2	129.1

* B = BACKGROUND (INCLUDES BACKGROUND)

+ IW = INTERSTITIAL WATER
# SITE-RELATED CONTAMINANT (SRC) - (NAPHTHALENE = ONLY ORGANIC SRC IN SEDIMENTS)
SUM RISK = INCLUDES SITE-RELATED AND NON-SITE-RELATED CONTAMINANTS
NV: NO VALUE - MEAN EXCEEDS MAXIMUM
SAMPLED LOCATIONS: R=REACH, EW=EASTERN WETLANDS, CBC=CHEMICAL BROOK CULVERT,
OC=OUTFALL CREEK, RW=RACEWAY

The high risk estimates for these primary toxicants generally result from the combination of extremely low benchmark toxicity values and slightly to moderately elevated estimated interstitial water concentrations.

7.6.5 Risk from Biota COCs

The ingestion of contaminated biota is considered to be a critical exposure pathway for aquatic, avian, and terrestrial biota that consume fish. Terrestrial and avian organisms are not limited to specific reaches of aquatic habitat, and the entire study area should be considered a single unit for the purpose of defining actual exposures for these organisms. However, individual reaches are assessed in this section so relative hazards posed to aquatic, terrestrial, and avian biota can be assessed on a location-specific basis.

This assessment divided average and maximum fish tissue concentrations of each biota COC within each reach by benchmark toxicity values. As in the surface water and sediment risk characterizations, each individual COC-specific quotient is directly comparable to the other COC-specific quotients. Again, the relative toxicity associated with each COC in each reach can be assessed. Individual quotients for all biota COCs in each reach were added together, and the cumulative risk from all biota COCs was calculated for each reach. Table 7-20 lists the results of risk calculations based on biota COCs.

As listed in Table 7-20, the biota COCs chlordane and dieldrin appear to present little or no risk to species that consume Study Area fish. DDT and its metabolites and total PCBs appear to present relatively small, yet measurable, risks to piscivorous consumers. By far, the primary risk posed to predators of Study Area fish results from the ingestion of mercury-contaminated fish.

Total mercury accounts for nearly all of the measurable risk for all locations sampled. In some cases, however, the maximum risk values associated with mercury can be overestimated. For example, estimated whole-body mercury concentrations for yellow perch in Background areas are probably overestimated because of the single suspect sample described above. This sample was associated with extremely high mercury concentrations relative to all others from Background areas. Most likely, this value is questionable, and probably not representative of yellow perch contamination in Background areas.

For other species and other locations, both mean and maximum risk values appear to be representative of true values, based on the distribution of values for each species and each reach; that is, no extreme outliers are associated with other reaches and other species. Maximum total mercury risk estimates, not including Background yellow perch, ranged from 11.2 (Reach 2 largemouth bass) to 76.0 (Reach 3 largemouth bass).

The values listed in Table 7-20 are based on Phase I and Phase II tissue concentrations unadjusted for fish length, weight, or age. Phase II fish data included fish length, weight, and age. All three parameters were correlated positively to tissue concentration of mercury. The correlation was slightly stronger for fish age ($r^2 = 0.67$) than for length ($r^2 = 0.65$) or weight ($r^2 = 0.64$). Therefore, Phase II fish tissue concentrations of mercury were normalized to fish age. Table 7-21 lists the results of normalization for mercury concentration in Phase II fish samples.

Again, the normalized data for Background yellow perch might be adversely affected by the outlier value described previously. Disregarding Reach 1 yellow perch, maximum age-normalized total mercury concentrations ranged from 155 ug/kg/yr (Reach 6 yellow perch). Normalization of fish data decreased the differences in average and maximum tissue concentrations of mercury between fish species. Largemouth bass, because they were generally older and larger, are expected to have greater exposure duration than yellow perch or bullheads; non-normalized data support this assumption.

This assessment compared mean and maximum age-normalized total mercury concentrations in largemouth bass, based on whole-body estimates, to mean and maximum total mercury concentrations in sediment. The comparisons were limited to largemouth bass because the Phase II data used to investigate the effects of age-normalization were more complete for that species. Figure 7-5 shows the results of these comparisons. In general, the relationship between age-normalized concentrations of total mercury in fish and total mercury concentrations in sediment is not strong. However, these data suggest that, in general, fish with the highest mercury concentrations are associated with reaches that contain the most contaminated sediments. Figure 7-6 shows similar data, based on fish concentrations that were not nomalized for age.

This risk assessment derived sediment/fish ratios (ug/kg Hg in sediment / ug/kg/yr in fish) for each reach and for both nomalized (Figure 7-5) and non-normalized data (Figur 7-6). These ratios are based on both mean and maximum concentrations in largemouth bass and in sediments. In general, higher sediment/fish ratios were associated with the most contaminated reaches, and mercury concentrations in largemouth bass were less variable than concentrations in sediments.

TABLE 7-20
RISK ESTIMATES-BIOTA COCS
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION	SPECIES	CHEMICAL	MEAN WHOLE BODY CONC (ug/kg)	MAX WHOLE BODY CONC (ug/kg)	BENCHMARK TOXICITY VALUE (ug/kg)	MEAN RISK VALUE	MAX RISK VALUE
B	LM	T. DDT	91	190	150	0.6	1.3
B	LM	T. PCB	108	152	640	0.2	0.2
B	LM	T. CHLORDANE	1.2	1.2	300	0.0	0.0
B	LM	DIELDRIN	2.8	2.8	300	0.0	0.0
B	LM	T. MERCURY	745	1180	100	7.5	11.8
B	LM	SUM RISK				8.2	13.3
B	YP	T. DDT	NS	–	150	–	–
B	YP	T. PCB	NS	–	640	–	–
B	YP	T. CHLORDANE	NS	–	300	–	–
B	YP	DIELDRIN	NS	–	300	–	–
B	YP	T. MERCURY #	3330	9600	100	33.3	96.0
B	YP	SUM RISK				33.3	96.0
R2	LM	T. DDT	ND	–	150	–	–
R2	LM	T. PCB	ND	–	640	–	–
R2	LM	T. CHLORDANE	ND	–	300	–	–
R2	LM	DIELDRIN	ND	–	300	–	–
R2	LM	T. MERCURY	1120	1120	100	11.2	11.2
R2	LM	SUM RISK				11.2	11.2
R2	YP	T. DDT	60	66	150	0.4	0.4
R2	YP	T. PCB	450	450	640	0.7	0.7
R2	YP	T. CHLORDANE	ND	–	300	–	–
R2	YP	DIELDRIN	ND	–	300	–	–
R2	YP	T. MERCURY	1430	1980	100	14.3	19.8
R2	YP	SUM RISK				15.4	20.9
R3	LM	T. DDT	116	293	150	0.8	2.0
R3	LM	T. PCB	249	708	640	0.4	1.1
R3	LM	T. CHLORDANE	2.3	3.4	300	0.0	0.0
R3	LM	DIELDRIN	0.3	0.3	300	0.0	0.0
R3	LM	T. MERCURY	2870	7600	100	28.7	76.0
R3	LM	SUM RISK				29.9	79.1
R3	YP	T. DDT	63	155	150	0.4	1.0
R3	YP	T. PCB	206	704	640	0.3	1.1
R3	YP	T. CHLORDANE	1.5	1.9	300	0.0	0.0
R3	YP	DIELDRIN	ND	–	300	–	–
R3	YP	T. MERCURY	1560	3640	100	15.6	36.4
R3	YP	SUM RISK				16.3	38.5
R3	BH	T. DDT	32	47	150	0.2	0.3
R3	BH	T. PCB	127	150	640	0.2	0.2
R3	BH	T. CHLORDANE	4.2	5.2	300	0.0	0.0
R3	BH	DIELDRIN	2.8	2.8	300	0.0	0.0
R3	BH	T. MERCURY	1990	2850	100	19.9	28.5
R3	BH	SUM RISK				20.3	29.1
R4	LM	T. DDT	95	114	150	0.6	0.8
R4	LM	T. PCB	553	553	640	0.9	0.9
R4	LM	T. CHLORDANE	14.6	14.6	300	0.0	0.0
R4	LM	DIELDRIN	0.9	0.9	300	0.0	0.0
R4	LM	T. MERCURY	1470	4190	100	14.7	41.9
R4	LM	SUM RISK				1.5	1.7

TABLE 7-20 (continued)
RISK ESTIMATES-BIOTA COCS
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LOCATION	SPECIES	CHEMICAL	MEAN WHOLE BODY CONC (ug/kg)	MAX WHOLE BODY CONC (ug/kg)	BENCHMARK TOXICITY VALUE (ug/kg)	MEAN RISK VALUE	MAX RISK VALUE
R4	YP	T. DDT	55	66	150	0.4	0.4
R4	YP	T. PCB	135	135	640	0.2	0.2
R4	YP	T. CHLORDANE	ND	–	300	–	–
R4	YP	DIELDRIN	0.6	0.6	300	0.0	0.0
R4	YP	T. MERCURY	760	760	100	7.6	7.6
R4	YP	SUM RISK				8.2	8.3
R4	BH	T. DDT	86	170	150	0.6	1.1
R4	BH	T. PCB	127	216	640	0.2	0.3
R4	BH	T. CHLORDANE	12	20.8	300	0.0	0.1
R4	BH	DIELDRIN	ND	–	300	–	–
R4	BH	T. MERCURY	920	1200	100	9.2	12.0
R4	BH	SUM RISK				10.0	13.5
R6	LM	T. DDT	57	88	150	0.4	0.6
R6	LM	T. PCB	177	208	640	0.3	0.3
R6	LM	T. CHLORDANE	ND	–	300	–	–
R6	LM	DIELDRIN	ND	–	300	–	–
R6	LM	T. MERCURY	940	1800	100	9.4	18.0
R6	LM	SUM RISK				10.1	18.9
R6	YP	T. DDT	29	65	150	0.2	0.4
R6	YP	T. PCB	68	95	640	0.1	0.1
R6	YP	T. CHLORDANE	2.1	2.3	300	0.0	0.0
R6	YP	DIELDRIN	2.2	2.8	300	0.0	0.0
R6	YP	T. MERCURY	700	1400	100	7.0	14.0
R6	YP	SUM RISK				7.3	14.6
R6	BH	T. DDT	65	96	150	0.4	0.6
R6	BH	T. PCB	127	190	640	0.2	0.3
R6	BH	T. CHLORDANE	5.2	502	300	0 0	1.7
R6	BH	DIELDRIN	0	0	300	0.0	0.0
R6	BH	T. MERCURY	740	880	100	7.4	8.8
R6	BH	SUM RISK				8.0	11.4
R9	LM	T. DDT	73	137	150	0.5	0.9
R9	LM	T. PCB	405	780	640	0.6	1.2
R9	LM	T. CHLORDANE	0.5	0.5	300	0.0	0.0
R9	LM	DIELDRIN	0.3	0.3	300	0.0	0.0
R9	LM	T. MERCURY	1320	3200	100	13.2	32.0
R9	LM	SUM RISK				14.3	34 1
R9	YP	T. DDT	34	77	150	0.2	0.5
R9	YP	T PCB	157	297	640	0.2	0.5
R9	YP	T CHLORDANE	2.3	2.3	300	0.0	0.0
R9	YP	DIELDRIN	ND	–	300	–	–
R9	YP	T. MERCURY	720	1800	100	7.2	18.0
R9	YP	SUM RISK				7 7	19 0

LOCATION: R=REACH
SPECIES: LM=LARGEMOUTH BASS, YP=YELLOW PERCH, BH=BULLHEAD
* B = BACKGROUND
ND = NOT DETECTED
NS = NOT SAMPLED
VALUES INCLUDE QUESTIONABLE SAMPLE

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TABLE 7-21
TOTAL MERCURY CONCENTRATIONS IN WHOLE BODY FISH, NORMALIZED FOR FISH AGE
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MIDDLESEX COUNTY, MASSACHUSETTS

LOCATION	SPECIES	INORG. MERCURY CONC. 1/ (ug/kg)	REF#	METHYL MERCURY CONC. (ug/kg)	REF#	EST. TOTAL MERCURY CONC. (ug/kg)	FISH AGE (years)	NORM. TOTAL MERCURY CONC. (ug/kg/yr)	MEAN NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MAX NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MEAN NON-NORM T.MERC. CONC. BY SP/LOC (ug/kg)	MAX NON-NORM. T.MERC. CONC. BY SP/LOC (ug/kg)
B*	YP	360				360	4	90				
B	YP	590				590	4	148				
B	YP	9600	2/			9600	3	3200	1146	3200	3517	9600
B	LM	280				280	2	140				
B	LM	610				610	5	122				
B	LM	890				890	5	178				
B	LM	410				410	4	103	136	178	548	890
R2	YP	730				730	5	146				
R2	YP	370				370	7	53				
R2	YP	1981				1981	4	495				
R2	YP	881				881	5	176	218	495	991	1981
R2	LM	1123				1123	4	281				
R2	LM	685	3/	420		685	3	228				
R2	LM	1076	3/	660		1076	6	179	229	281	961	1123
R3	LM	918				918	5	184				
R3	LM	1042				1042	4	261				
R3	LM	1394				1394	5	279				
R3	LM	1549				1549	5	310				
R3	LM	1786				1786	4	447				
R3	LM	1739				1739	4	435				
R3	LM	2570				2570	5	514				
R3	LM	1943				1943	4	486				
R3	LM	2831				2831	5	566				
R3	LM	2785				2785	6	464				
R3	LM	4463				4463	9	496				
R3	LM	2292				2292	6	382				
R3	LM	3962				3962	5	792				
R3	LM	1899				1899	7	271				
R3	LM	3524				3524	8	441				
R3	LM	1214				1214	4	304				
R3	LM	1228				1228	4	307				
R3	LM	2745				2745	9	305				
R3	LM	5775				5775	10	578				
R3	LM	6132				6132	9	681				
R3	LM	3468				3468	10	347				
R3	LM	3521	3/	2160		3521	3	1174				
R3	LM	2853	3/	1750		2853	5	571				
R3	LM	1842	3/	1130		1842	5	368				
R3	LM	2478	3/	1520		2478	2	1239				
R3	LM	5591	3/	3430		5591	5	1118				
R3	LM	4792	3/	2940		4792	6	799				
R3	LM	4515	3/	2770		4515	6	753				
R3	LM	3651	3/	2240		3651	6	609				
R3	LM	2364	3/	1450		2364	3	788				
R3	LM	4385	3/	2690		4385	7	626				
R3	LM	1092	3/	670		1092	2	546				
R3	LM	2103	3/	1290		2103	2	1051				
R3	LM	1402	3/	860		1402	2	701				
R3	LM	3537	3/	2170		3537	5	707				
R3	LM	1940	3/	1190		1940	4	485				
R3	LM	2673	3/	1640		2673	2	1337	587	1337	2811	6132
R3	YP	1167				1167	5	233				
R3	YP	993				993	4	248				
R3	YP	990				990	4	248				
R3	YP	680				680	4	170				
R3	YP	882				882	4	221				
R3	YP	1114				1114	5	223				
R3	YP	784				784	3	261				
R3	YP	3948	3/	2350		3948	3	1316				
R3	YP	3545	3/	2110		3545	4	886				
R3	YP	5359	3/	3190		5359	3	1786				
R3	YP	2386	3/	1420		2386	4	596				

TABLE 7-21
TOTAL MERCURY CONCENTRATIONS IN WHOLE BODY FISH, NORMALIZED FOR FISH AGE
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LOCATION	SPECIES	INORG. MERCURY CONC. 1/ (ug/kg)	REF#	METHYL MERCURY CONC. (ug/kg)	REF#	EST. TOTAL MERCURY CONC. (ug/kg)	FISH AGE (years)	NORM. TOTAL MERCURY CONC. (ug/kg/yr)	MEAN NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MAX NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MEAN NON-NORM T.MERC. CONC. BY SP/LOC (ug/kg)	MAX NON-NORM. T.MERC. CONC. BY SP/LOC (ug/kg)
R3	YP	958	3/	570		958	3	319				
R3	YP	1075	3/	640		1075	3	358				
R3	YP	3175	3/	1890		3175	3	1058				
R3	YP	2738	3/	1630		2738	4	685				
R3	YP	874	3/	520		874	4	218				
R3	YP	2150	3/	1280		2150	4	538	550	6132	785	6132
R4	LM	303				303	2	152				
R4	LM	888				888	3	296				
R4	LM	539				539	2	270				
R4	LM	1826				1826	5	365				
R4	LM	797				797	2	399				
R4	LM	1308				1308	3	436				
R4	LM	1277				1277	5	255				
R4	LM	1313				1313	6	219				
R4	LM	1144				1144	3	381				
R4	LM	1164				1164	6	194				
R4	LM	1561				1561	7	223				
R4	LM	1211				1211	8	151				
R4	LM	1099				1099	6	183				
R4	LM	1378				1378	7	197				
R4	LM	1660				1660	5	332				
R4	LM	473	3/	290		473	4	118				
R4	LM	2201	3/	1350		2201	6	367				
R4	LM	1744	3/	1070		1744	5	349				
R4	LM	2217	3/	1360		2217	4	554				
R4	LM	1011	3/	620		1011	4	253				
R4	LM	1679	3/	1030		1679	3	560				
R4	LM	1532	3/	940		1532	3	511				
R4	LM	359	3/	220		359	3	120				
R4	LM	2787	3/	1710		2787	3	929				
R4	LM	3032	3/	1860		3032	5	606				
R4	LM	2315	3/	1420		2315	4	579				
R4	LM	994	3/	610		994	3	331				
R4	LM	1451	3/	890		1451	3	484				
R4	LM	2347	3/	1440		2347	3	782				
R4	LM	2282	3/	1400		2282	3	761				
R4	LM	1043	3/	640		1043	3	348				
R4	LM	1174	3/	720		1174	4	293				
R4	LM	1076	3/	660		1076	3	359				
R4	LM	2168	3/	1330		2168	3	723				
R4	LM	3749	3/	2300		3749	5	750	683	2277	2443	6049
R4	YP	1798	3/	1070		1798	6	300				
R4	YP	2218	3/	1320		2218	6	370				
R4	YP	1394	3/	830		1394	5	279				
R4	YP	806	3/	480		806	8	101				
R4	YP	521	3/	310		521	5	104				
R4	YP	1210	3/	720		1210	5	242				
R4	YP	924	3/	550		924	5	185				
R4	YP	823	3/	490		823	5	165				
R4	YP	1075	3/	640		1075	5	215				
R4	YP	1109	3/	660		1109	8	139	210	370	1188	2218
R6	LM	1600				1600	10	160				
R6	LM	1500				1500	10	150				
R6	LM	200				200	7	29				
R6	LM	1200				1200	4	300				
R6	LM	760				760	8	95				
R6	LM	1500				1500	5	300				
R6	LM	1800				1800	4	450				
R6	LM	200				200	6	33				
R6	LM	840				840	5	168				
R6	LM	460				460	3	153				
R6	LM	660				660	3	220				
R6	LM	710				710	3	237				
R6	LM	610				610	3	203				

TABLE 7-21
TOTAL MERCURY CONCENTRATIONS IN WHOLE BODY FISH, NORMALIZED FOR FISH AGE
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LOCATION	SPECIES	INORG. MERCURY CONC. 1/ (ug/kg)	REF#	METHYL MERCURY CONC. (ug/kg)	REF#	EST. TOTAL MERCURY CONC. (ug/kg)	FISH AGE (years)	NORM. TOTAL MERCURY CONC. (ug/kg/yr)	MEAN NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MAX NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MEAN NON-NORM T.MERC. CONC. BY SP/LOC (ug/kg)	MAX NON-NORM. T.MERC. CONC. BY SP/LOC (ug/kg)
R6	LM	640				640	3	213				
R6	LM	554	3/	340		554	3	185				
R6	LM	782	3/	480		782	3	261				
R6	LM	685	3/	420		685	4	171				
R6	LM	766	3/	470		766	4	192	414	6132	563	6132
R6	YP	590				590	7	84				
R6	YP	200				200	3	67				
R6	YP	740				740	5	148				
R6	YP	220				220	4	55				
R6	YP	1000				1000	7	143				
R6	YP	700				700	6	117				
R6	YP	620				620	4	155				
R6	YP	200				200	5	40				
R6	YP	504	3/	300		504	5	101				
R6	YP	538	3/	320		538	5	108				
R6	YP	672	3/	400		672	6	112	103	155	544	1000
R9	LM	3200				3200	9	356				
R9	LM	2700				2700	10	270				
R9	LM	900				900	6	150				
R9	LM	2100				2100	6	350				
R9	LM	1200				1200	7	171				
R9	LM	2900				2900	6	483				
R9	LM	2500				2500	9	278				
R9	LM	2700				2700	8	338				
R9	LM	2700				2700	9	300				
R9	LM	970				970	7	139				
R9	LM	250				250	2	125				
R9	LM	840				840	2	420				
R9	LM	250				250	2	125				
R9	LM	310				310	2	155				
R9	LM	280				280	2	140				
R9	LM	320				320	2	160				
R9	LM	200				200	2	100				
R9	LM	550				550	1	550				
R9	LM	250				250	2	125				
R9	LM	1320	3/	810		1320	4	330				
R9	LM	1271	3/	780		1271	5	254				
R9	LM	1956	3/	1200		1956	4	489				
R9	LM	1320	3/	810		1320	5	264				
R9	LM	1271	3/	780		1271	5	254				
R9	LM	1239	3/	760		1239	4	310				
R9	LM	1614	3/	990		1614	3	538				
R9	LM	1320	3/	810		1320	5	264				
R9	LM	1076	3/	660		1076	4	269				
R9	LM	1108	3/	680		1108	4	277				
R9	LM	962	3/	590		962	5	192				
R9	LM	1076	3/	660		1076	3	359				
R9	LM	782	3/	480		782	2	391				
R9	LM	1011	3/	620		1011	4	253				
R9	LM	1011	3/	620		1011	4	253				
R9	LM	701	3/	430		701	3	234				
R9	LM	750	3/	460		750	4	187				
R9	LM	734	3/	450		734	3	245				
R9	LM	734	3/	450		734	4	183	271	550	1220	6132
R9	YP	739	3/	440		739	4	185				
R9	YP	638	3/	380		638	4	160				
R9	YP	706	3/	420		706	6	118				
R9	YP	790	3/	470		790	5	158				
R9	YP	706	3/	420		706	5	141				
R9	YP	806	3/	480		806	5	161				
R9	YP	554	3/	330		554	5	111				
R9	YP	340				340	5	68				
R9	YP	480				480	5	96				
R9	YP	510				510	6	85				

TABLE 7-21
TOTAL MERCURY CONCENTRATIONS IN WHOLE BODY FISH, NORMALIZED FOR FISH AGE
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LOCATION	SPECIES	INORG. MERCURY CONC. 1/ (ug/kg)	REF#	METHYL MERCURY CONC. (ug/kg)	REF#	EST. TOTAL MERCURY CONC. (ug/kg)	FISH AGE (years)	NORM. TOTAL MERCURY CONC. (ug/kg/yr)	MEAN NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MAX NORM. T.MERC. CONC. BY SP/LOC (ug/kg/yr)	MEAN NON-NORM T.MERC. CONC. BY SP/LOC (ug/kg)	MAX NON-NORM. T.MERC. CONC. BY SP/LOC (ug/kg)
R9	YP	660				660	5	132				
R9	YP	710				710	6	118				
R9	YP	740				740	5	148				
R9	YP	180				180	6	30				
R9	YP	330				330	5	66				
R9	YP	920				920	5	184	347	6132	462	6132

 # REFERENCE

1/ ANALYTICAL METHOD MEASURES INORGANIC MERCURY AND METHYLMERCURY
2/ VALUE BASED ON QUESTIONABLE SAMPLE - MAY NOT BE REPRESENTATIVE
3/ ESTIMATED FROM MEASURED METHYLMERCURY CONCENTRATION * (MEAN INORG MERCURY/MEAN METHYLMERCURY RATIO)

*** B = BACKGROUND**

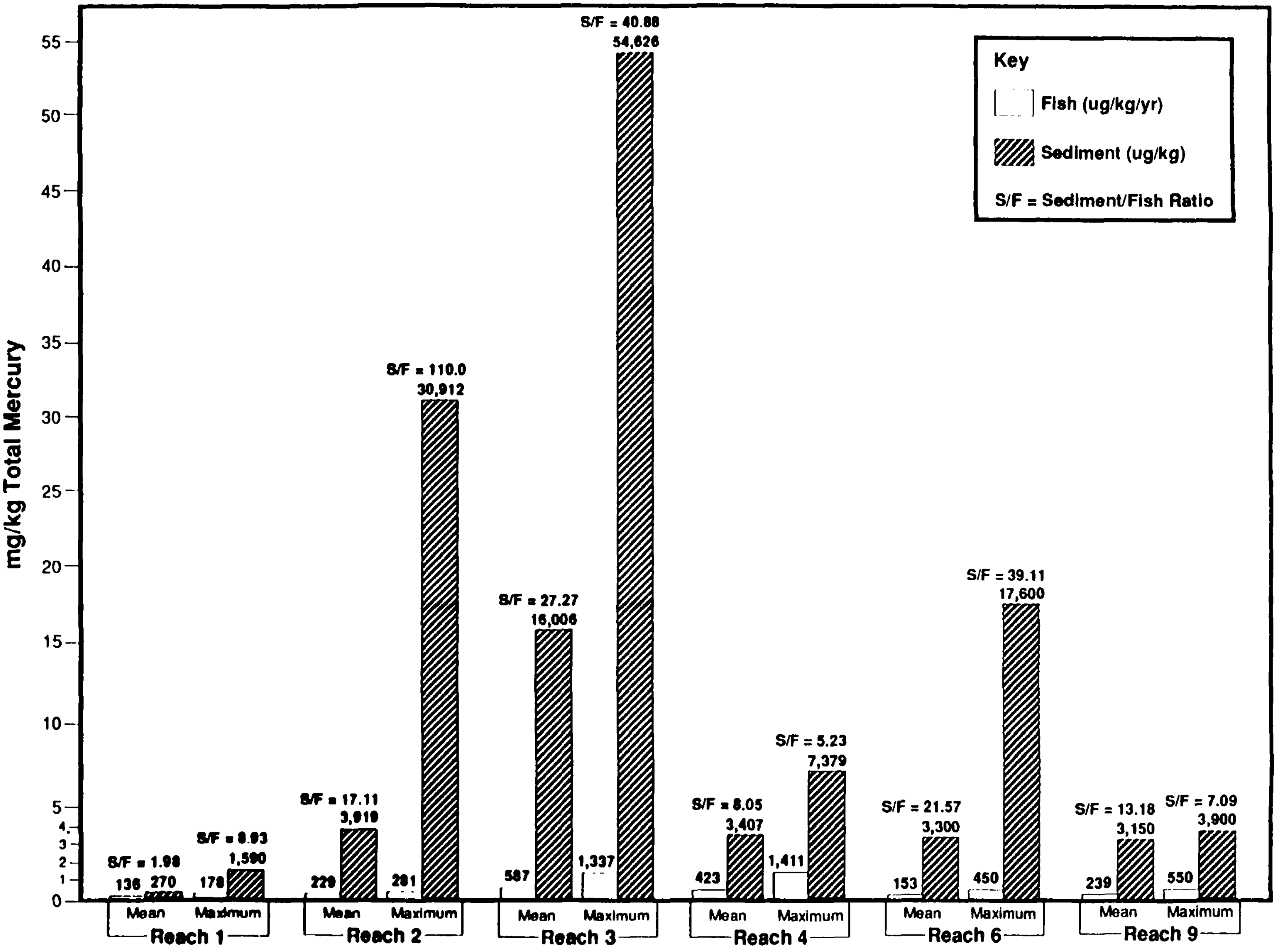

Figure 7-5. Mean and Maximum Total Mercury Concentrations in Sediment and Largemouth Bass (Normalized for Age)

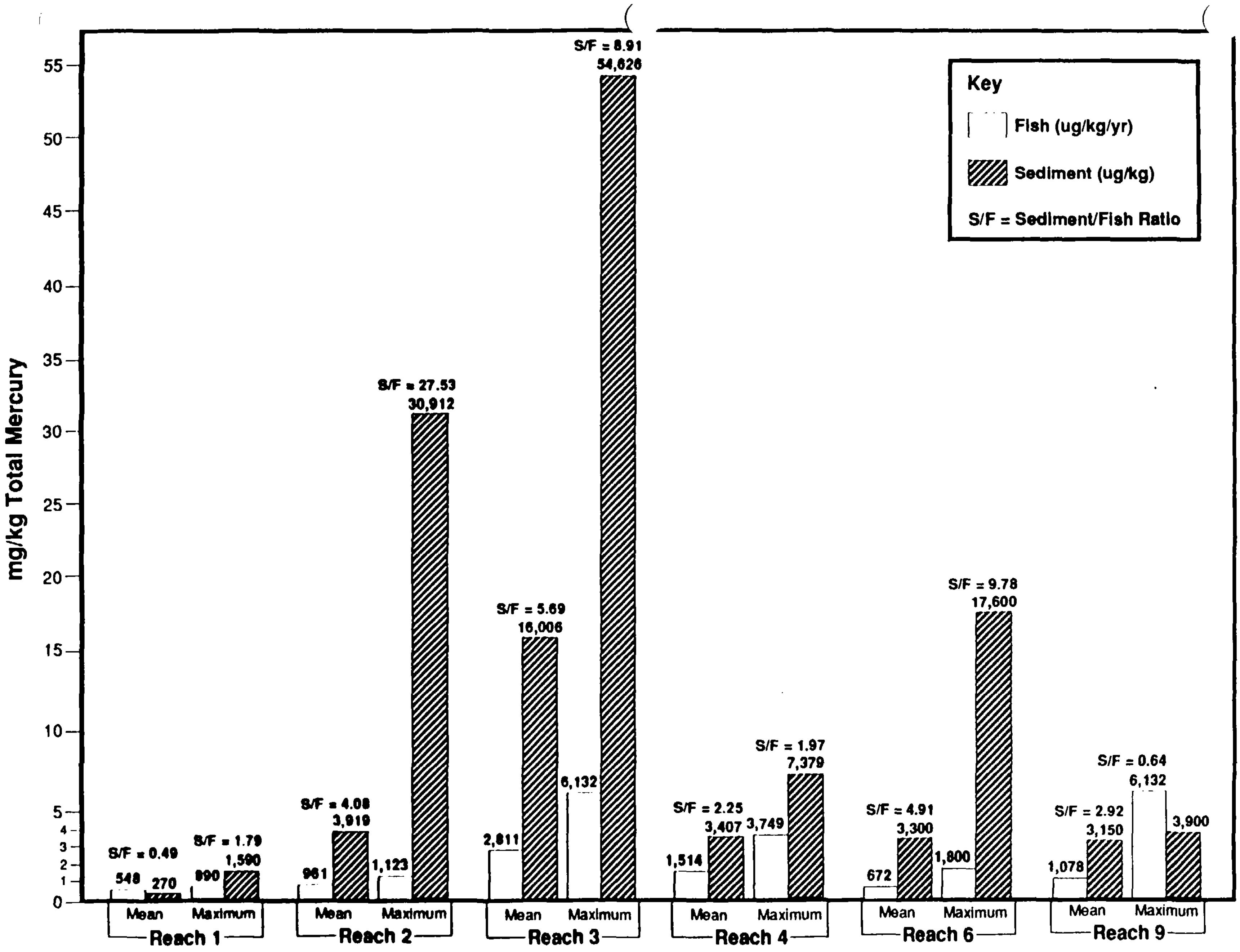

Figure 7-6. Mean and Maximum Total Mercury Concentrations in Sediment and Largemouth Bass

Based on the data presented in Figures 7-5 and 7-6, total mercury concentrations in fish cannot be predicted accurately from total mercury concentrations in sediments. This finding is not unexpected; total mercury in sediments is not equally bioavailable from reach to reach, and bioavailability probably depends on the site-specific characteristics of sediments and surface waters.

7.6.5.1 Risks to Food Chain Organisms

Of the five biota COCs, chlordane and dieldrin were considered to be insignificant contributors to overall risk. Therefore, chlordane and dieldrin were not evaluated for food chain effects; total DDT, total PCB, and total mercury were evaluated.

Risks were evaluated for the three selected food chain predators (blue heron, raccoon, and osprey) that occupy upper trophic levels in aquatic-based food chains. The food chain model was used to estimate tissue burdens of the three selected biota COCs in organisms that occupy lower aquatic trophic levels. In summary, the food chain model and measured COC concentrations in fish were used to assess impacts down the food chain, while measured tissue concentrations in fish tissue and estimated exposure (consumption) scenarios were used to assess impacts up the food chain.

The evaluation of the proposed site-specific food chain, shown in Figure 7-2, requires the explicit statement of assumptions used for food chain analysis.

A major assumption is that the organisms selected to represent the various trophic levels in the site food chain adequately represent other organisms within each trophic level. Although the determination of risks to specific economically or ecologically important organisms due to the ingestion of contaminated prey might be of interest, the intended goal should include estimations of risks to all organisms in the food chain. Therefore, the selection of organisms used for food chain evaluations should be based on three criteria, if possible: (1) organisms that are ecologically or economically important, (2) organisms that are appropriate and representative for the trophic level assigned to them, and (3) organisms selected include those for which sufficient toxicity data exist.

It is inappropriate to select a representative food chain organism based solely on its economic value or human interest, especially if the organism's role (Table 7-20) in the food chain is difficult to assess or if species specific toxicity data are sparse. The organisms selected for assessing upper trophic level impacts include osprey, raccoon, and blue heron.

The following sections evaluate tissue concentrations of total mercury, total DDT, and total PCB in the three trophic levels below Level 4 fish. This assessment is based on a reach-specific basis, using largemouth bass data to represent Level 4 fish for all locations. Concentrations of the same COCs in the tissues of the three representative predators that consume Level 4 fish were estimated, using both measured fish tissue concentrations and estimates of consumption. This portion of the evaluation was not based on reach-specific data; reach-specific estimates were considered to be inappropriate because top-level predators (osprey, raccoon, and heron) are not restricted to single reaches or locations for foraging.

The impacts of home range, seasonal migrations, or seasonal dietary adjustments were not evaluated; however, their inclusion would likely decrease actual risks. Therefore, the risks discussed below, which assume limited home range and restricted diet (fish), are probably overestimates for most predators.

Total Mercury

Lower Trophic Levels, Aquatic Food Chain

Non-normalized mercury concentrations in Level 4 fish (largemouth bass), adjusted for whole-body total mercury (ug/kg, wet weight), were used to estimate BAFs using the food chain model. Table 7-22 lists mean and maximum tissue concentrations of mercury in Level 1, 2, and 3 organisms. These estimated values were compared to the benchmark toxicity values for biota COCs, which are listed in Table 7-16. Of the three biota COCs assessed in this process, only mercury exceeded benchmark toxicity values; this occurred for concentrations of total mercury in tissues of Level 3 organisms (all reaches) and Level 2 organisms (Reaches 3, 4, and 9). Although the benchmark toxicity values established were intended for chemical concentrations in fish, the assessment assumed that ingestion of other organisms, such as Level 2 organisms, can result in similar risks to predators.

TABLE 7-22
ESTIMATED TISSUE CONCENTRATIONS OF BIOTA COCS FOR LEVEL 1, 2, AND 3 TROPHIC LEVELS BASED ON MEAN AND MAXIMUM MEASURED TISSUE CONCENTRATIONS IN LARGEMOUTH BASS
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

REACH	CHEMICAL	MEASURED LEVEL 4 FISH MEAN CONC. (ug/kg)	MEASURED LEVEL 4 FISH MAX CONC. (ug/kg)	MEAN EST. LEVEL 1 CONC. (ug/kg)	MAX EST. LEVEL 1 CONC. (ug/kg)	MEAN EST. LEVEL 2 CONC. (ug/kg)	MAX EST. LEVEL 2 CONC. (ug/kg)	MEAN EST. LEVEL 3 CONC. (ug/kg)	MAX EST. LEVEL 3 CONC. (ug/kg)
1	TOTAL MERCURY	745	1180	2.6	4.1	16.2	25.7	108.0	171.0
1	TOTAL DDT	91	190	0.4	0.8	2.2	4.6	14.0	29.2
1	TOTAL PCB	108	152	0.3	0.5	2.3	3.2	15.4	21.7
2	TOTAL MERCURY	1120	1120	3.8	3.8	24.3	24.3	162.3	162.3
3	TOTAL MERCURY	2870	7600	9.9	26.1	62.4	165.2	415.9	1101.4
3	TOTAL DDT	116	293	0.5	1.2	2.8	7.1	17.8	45.1
3	TOTAL PCB	249	708	0.8	2.3	5.2	14.8	35.6	101.1
4	TOTAL MERCURY	1470	4190	5.1	14.4	32.0	91.1	213.0	607.2
4	TOTAL DDT	9	114	0.0	0.5	0.2	2.8	1.4	17.5
4	TOTAL PCB	553	553	1.8	1.8	11.5	11.5	79.0	79.0
6	TOTAL MERCURY	940	1800	3.2	6.2	20.4	39.1	136.2	260.9
6	TOTAL DDT	57	88	0.2	0.4	1.4	2.1	8.8	13.5
6	TOTAL PCB	177	208	0.6	0.7	3.7	4.3	25.3	29.7
9	TOTAL MERCURY	1320	3200	4.5	11.0	28.7	69.6	191.3	463.8
9	TOTAL DDT	73	137	0.3	0.6	1.8	3.3	11.2	21.1
9	TOTAL PCB	405	780	1.3	2.5	8.4	16.3	57.9	111.4

BOXED VALUES EXCEED BENCHMARK TOXICITY VALUES FOR BIOTA COCS

Mercury concentrations in caddis fly larvae, which were collected as part of the benthic macroinvertebrate sampling plan, were not considered sufficiently reliable for a quantitative evaluation due to sample quantity limitations. However, such data can be used to evaluate the relative differences in tissue mercury concentrations between fish and invertebrate samples. Such data can be used, with caution, to validate the food chain model. Therefore, caddis fly larvae data were considered to be acceptable for rough estimates of actual tissue concentrations of mercury for these invertebrates.

Caddis fly larvae are primarily detrital feeders; therefore, they are assumed to occupy trophic level 2, represented by zooplankton, in the food chain model. Although uptake and depuration rates are unknown for caddis fly larvae, values associated with such rates are assumed to be similar to those of other Level 2 biota. Estimated mean mercury concentrations in Level 2 biota for the food chain model are approximately 16 to 62 ug/kg, wet weight, depending on location. Similar maximum values are predicted to range from approximately 24 to 165 ug/kg, depending on location.

Mercury tissue concentrations in caddis fly larvae, which should be interpreted cautiously, ranged from 100 to 1,000 ug/kg (0.10 to 1.0 mg/kg) dry weight. Based on the average percent solids (22.2%) for sampled caddis fly larvae, wet weight mercury tissue concentrations ranged from approximately 20 to 220 ug/kg, which compare closely with predicted concentrations.

In summary, the data suggest that mercury poses a potentially significant threat at several trophic levels to aquatic predators that prey on aquatic organisms.

Upper Trophic Levels, Representative Organisms

To assess risks to piscivorous terrestrial and avian biota, the mean and maximum measured or estimated whole body COC concentration for largemouth bass was used as the representative dietary source of COCs. Because most terrestrial and avian predators are not confined to reaches, assessing reach-specific risks was considered inappropriate, and the mean and maximum concentrations in largemouth bass from all reaches were used. Using the maximum COC concentration for assessing risk is likely to overestimate the actual risk associated with ingestion of contaminated fish; however, one focus of this assessment is to determine upper bound risk estimates based on possible exposures to food chain biota. The use of mean COC concentrations measured in fish tissue should provide a reasonable estimate of average risk to piscivorous predators.

Table 7-23 lists the mean and maximum estimated daily intake for each of the three potentially hazardous biota COCs.

TABLE 7-23
ESTIMATED DIETARY CONCENTRATIONS OF BIOTA COCS FOR REPRESENTATIVE PREDATORS
NYANZA III REMEDIAL INVESTIGATION
MIDDLESEX COUNTY, MASSACHUSETTS

CHEMICAL	SPECIES	MEAN CONC. (mg/kg)	MAX CONC. (mg/kg)	ESTIMATED INGESTION (kg fish/day)	MEAN ESTIMATED DAILY INTAKE (mg/kg/day)	MAX ESTIMATED DAILY INTAKE (mg/kg/day)
MERCURY	RACCOON	1.411	3.182	0.45	0.63	1.43
DDT	RACCOON	0.086	0.164	0.45	0.04	0.07
PCB	RACCOON	0.298	0.48	0.45	0.13	0.22
MERCURY	HERON	1.411	3.182	0.25	0.35	0.80
DDT	HERON	0.086	0.164	0.25	0.02	0.04
PCB	HERON	0.298	0.48	0.25	0.07	0.12
MERCURY	OSPREY	1.411	3.182	0.40	0.56	1.27
DDT	OSPREY	0.086	0.164	0.40	0.03	0.07
PCB	OSPREY	0.298	0.48	0.40	0.12	0.19

MEAN CONC. BASED ON MEAN LARGEMOUTH BASS CONCENTRATION FOR ALL REACHES
MAX CONC. BASED ON MAXIMUM LARGEMOUTH BASS CONCENTRATION FOR ALL REACHES

Much of the available data on mercury contamination in fish has been compiled by the U.S. Fish and Wildlife Service (FWS, 1987a). An evaluation of those data indicates that the maximum estimated whole-body concentrations from fish at this site (7.6 mg/kg, not including the questionable yellow perch value from Reach 1) generally exceed most other reported values. Using combined muscle, viscera, and whole-body data from freshwater fish from various species and sites (polluted and unpolluted) throughout the United States and Canada, mercury concentrations in fish tissue are reported to range from 0.03 (muscle, largemouth bass, Illinois) to 23.7 mg/kg (liver, striped bass, Nevada). However, of the 60 values included in this compilation, only the 23.7 mg/kg value exceeded the maximum value measured in the present study.

The maximum value determined in this study is based on an actual measured concentration of total mercury in a filet sample, which is considered to be representative of the whole-body concentration of this individual fish. As stated above, this assumption is based on the derived V/F ratio of approximately 1.0 for both largemouth bass and yellow perch.

Potential adverse effects associated with high levels of mercury contamination on fish-eating predators can be assessed by basing estimates of the dietary intake of contaminated prey on fish ingestion rates that may result in adverse effects to predators. This approach was investigated; Table 7-23 lists the results.

Estimates of daily consumption rates for large adults of each of the three representative top-level predators are based on a synthesis of information obtained from FWS (1991) for ospreys, South Carolina Department of Wildlife and Marine Resources (1991) for ospreys, great blue herons, and raccoons, and from Webster (1985) for raccoons.

The FWS recommends that total mercury concentrations in fish should probably not exceed 100 ug/kg for protection of sensitive avian species (FWS, 1987a). Sensitive avian species include chickens, mallard ducks, American black ducks, and others. Fish collected and analyzed at this site, not including the questionable yellow perch collected in Reach 1, were estimated to contain mercury at concentrations up to nearly 80 times the recommended value, suggesting serious potential for adversely affecting avian predators.

An investigation of potential impacts to terrestrial predators (e.g., raccoons) reveals similarly high potential risks for mammalian predators that ingest mercury-contaminated fish. The FWS recommendation for maximum mercury concentrations in fish for the protection of small mammalian predators is 1,100 ug/kg wet weight.

This value is exceeded more than 7-fold by the maximum estimated whole-body concentration in fish collected in this study.

Analysis of estimated dietary intakes suggests that serious concerns for the health of top-level predators are warranted. Some representative top-level predators, such as raccoons and herons, do not eat fish exclusively. However, such predators eat other aquatic vertebrates and invertebrates (e.g., frogs and crayfish) regularly. Because mercury contamination data are lacking for such potential prey items as frogs and crayfish, tissue concentrations of mercury in these organisms were assumed to be similar to those measured in fish. The assumption of a diet consisting exclusively of fish should not underestimate risks to raccoons, ospreys, or blue herons because fish are likely to bioaccumulate mercury in greater concentrations than organisms occupying lower trophic levels, such as crayfish.

Based on daily consumption rates for periods of two to five weeks, mallard ducks fed 0.1 mg mercury/kg wet weight in the diet experienced adverse reproductive behavior; juvenile starlings developed kidney lesions at 1.1 mg/kg total mercury; and pigeons exhibited behavioral alterations at 3.0 mg inorganic mercury/kg and 1.0 mg methylmercury/kg body weight (FWS, 1987a). These dietary intakes are based on daily consumption rates for periods of 2-5 weeks.

The maximum estimated daily intake of mercury from ingestion of contaminated fish for the representative top avian predators (1.27 mg Hg/kg, osprey) exceeds the reported values that produce adverse effects in tested avian species (0.1 to 1.1). These results suggest that estimated daily intakes can produce ecologically significant effects in representative species.

Terrestrial mammals are also sensitive to mercury poisoning from diet or oral administration. Cats fed 0.25 mg Hg/kg daily for 48 days (oral route) experienced increased incidence of abnormal fetuses; rats fed 0.5 mg Hg/kg daily (oral route) experienced reduced fertility; and mink exposed to dietary concentrations of 1.1 mg mercury/kg (exposure duration unavailable) showed signs of mercury poisoning (FWS, 1987a). The results of these studies suggest that daily ingestion prey associated with the calculated maximum mercury concentrations (1.43 mg Hg/kg) is likely to produce significant adverse effects in terrestrial mammals, represented by raccoons.

In summary, concentrations of mercury measured in Study Area fish should pose a significant hazard to aquatic, terrestrial, and avian biota in the Study Area.

Total DDT

Lower Trophic Levels, Aquatic Food Chain

Non-normalized total DDT concentrations in Level 4 fish, represented by largemouth bass, adjusted for whole-body total mercury (ug/kg, wet weight), were employed to estimate BAFs using the food chain model. Table 7-22 lists mean and maximum tissue concentrations of total DDT in Level 1, 2, and 3 organisms. These estimated values were compared to the benchmark toxicity values for biota COCs, which are presented in Table 7-16. Estimated total DDT concentrations in Level 1 to 3 organisms did not exceed the benchmark toxicity value for DDT in any reach. Therefore, total DDT does not appear to present a significant risk to predators ingesting organisms represented by Levels 1 to 3 in the food chain model.

Upper Trophic Levels, Representative Organisms

To assess risks to fish-eating terrestrial and avian biota, the mean and maximum measured or estimated whole-body COC concentration for largemouth bass was used to represent the primary dietary source of COCs. As stated above, assessing reach-specific risks was considered to be inappropriate, and the mean and maximum concentrations in largemouth bass from all reaches were used in this evaluation.

Table 7-23 lists the mean and maximum estimated daily intake for each of the three potentially hazardous biota COCs. These values are comparable to values presented in the scientific literature. An evaluation of estimated DDT intakes that produced sublethal effects to birds or mammals consuming DDT-contaminated fish reveals relatively little recent data. Data on sublethal effects of DDT exposure to mammals and birds reveal behavioral effects observed in young mice when mothers were exposed to 2.5 mg/kg DDT (exposure type and duration unavailable), while liver DDT concentrations of 1.2 mg/kg resulted in adverse reproductive effects in mice (Stickel, 1975). Thinning of egg shells in various bird species (mallards, black ducks, American kestrels, and screech owls) has been demonstrated at dietary concentrations of 3 mg DDE/kg/day, wet weight, and pelican embryos die if eggs contain more than 2.5 mg DDE/kg (Stickel, 1975). Bats and possibly other mammals or birds appear most sensitive to DDT or DDE when they have limited fat reserves (Stickel, 1975).

This finding suggests that DDT or DDE sensitivity can vary according to nutritional state or season. Based on the limited data available, it appears reasonable to assume that DDT or DDE dietary concentrations exceeding approximately 2 to 3 mg/kg can adversely affect behavior or reproduction in at least some mammals and birds. The maximum dietary DDT concentrations expected f- representative mammals and birds, which follow, are estimated to be well below concentrations that are expected to produce adverse effects.

If 2.5 mg/kg or greater dietary DDT is considered potentially hazardous for tested species, and a safety factor of 10 is applied for the protection of untested species, the estimated lowest effect dietary concentration is approximately 0.25 mg/kg. Maximum estimated dietary concentrations of DDT in representative organisms ranged from 0.04 to 0.07 mg/kg/day; comparable mean values ranged from 0.02 to 0.04 mg/kg/day. Because a safety factor of 10 might not be fully protective of all species, DDT contamination in site fish can pose a measurable hazard to fish-eating predators that are especially sensitive.

Total PCBs

Lower Trophic Levels, Aquatic Food Chain

Total PCB concentrations in Level 4 fish, represented by largemouth bass, adjusted for whole-body total mercury (ug/kg, wet weight), were used to estimate BAFs and tissue concentrations of Level 1 to 3 organisms. Table 7-22 lists mean and maximum tissue concentrations of total PCBs in Level 1, 2, and 3 organisms. These estimated values were compared to the benchmark toxicity values for biota COCs, presented in Table 7-16. Estimated total PCB concentrations in Level 1 to 3 organisms did not exceed the benchmark toxicity value for PCBs in any reach. Therefore, total PCBs do not appear to present a significant risk to predators ingesting Level 1 to 3 organisms.

Upper Trophic Levels, Representative Organisms

The maximum whole-body PCB concentration measured or estimated in sampled fish equalled 780 ug/kg. Studies investigating ecologically significant sublethal effects (impaired reproduction, growth, or behavior) in sensitive mammals and birds were used to derive recommended maximum acceptable PCB concentrations in diet for birds and mammals (FWS, 1986b). Depending on the study source, the recommended maximum dietary PCB value ranges from 100 to 640 ug/kg diet for mammals (mink), while the maximum value for birds is 3,000 ug/kg (FWS, 1986b). These recommended FWS values can be compared to estimated PCB intakes by representative birds and mammals in the Study Area based on fish ingestion.

Multiplying estimated daily dietary fish intakes (kg fish/day) for representative mammalian species by mean and maximum whole-body PCB burdens in fish (mg PCB/kg fish), reveals that representative mammals (racoon) can consume approximately 0.1 to 0.2 mg PCB/kg/day, depending on species. The estimated mean and maximum daily intake of PCBs due to fish ingestion (130 to 220 ug/kg) from mammals are below FWS recommendations (100-640 ug/kg) for some mammalian species.

The estimated maximum daily PCB intake for representative bird species (190 ug/kg/day, oprey; 120 ug/kg/day, herons) are much less than the value recommended by FWS (3,000 ug/kg), suggesting reasonably safe levels for birds. Based on FWS recommendations, it appears reasonable to assume that while birds might not be at serious risk from ingesting PCB-contaminated fish taken from study area waters, significant risks may be posed to some sensitive mammalian species, such as mink.

7.6.6 Uncertainty Analysis, Risk Characterization

Because risk characterization is essentially the integration of the exposure assessment and hazard assessment, sources of uncertainty associated with either of these elements should also contribute to uncertainty in risk characterization. In addition, the risk characterization procedure itself should contribute to overall uncertainty. Except for the food chain evaluation, the quotient method was selected as the risk characterization method of choice for this assessment. The advantages of this method, and one of the primary limitations associated with this method, were previously addressed.

Additional limitations of the quotient method, according to EPA (1989b), include the following:

1. EPA-reviewed toxicity data are available for only a limited number of chemicals.
2. Chronic toxicity endpoint data can be inconsistent.
3. Toxicant interactions are not addressed.
4. Toxicity data are sparse for media other than surface waters.
5. Analytical detection limits commonly exceed toxicity benchmark values (i.e., criteria).
6. No means for estimating severity of impacts if benchmark toxicity values are exceeded.

Decreasing the level of uncertainty associated with each of the limitations described above was accomplished using a variety of processes. A brief response to each of these limitations follows:

1. The use of acceptable chemical quantitative structure activity relationships should provide reasonable estimates of toxicity data for untested chemicals.

2. Selecting chronic toxicity test results based only on appropriate endpoints (e.g., effects on mortality, growth, and reproduction), test design, and test durations should decrease the uncertainty associated with chronic test results.

3. The method of Barnthouse et al. (1986), which simply sums quotients and addresses cumulative toxicity, addresses toxicant interactions in a reasonable and consistent manner, based on the generally accepted principle of chemical additivity.

4. Sufficient toxicity data for media other than surface water generally exist; when combined with extrapolations based on chemical structure activity relationships or interspecies correlations, reasonable estimates of required data are possible.

5. A reasonable, conservative, and protective approach for dealing with relatively high detection limits and low "safe" chemical concentrations includes setting the environmental concentration of the chemical to one half the detection limit. This procedure probably results in overestimations of actual environmental concentrations of chemicals of concern, but is reasonable in view of analytical limitations.

6. The severity of ecological impacts expected from exceedences of toxicity benchmark values (e.g., chronic ambient water quality criteria) can be estimated using the cumulative method of assessing toxicant additivity.

Several sources can contribute to total uncertainty associated with the food chain evaluation. Major and specific categories of potential uncertainty can include the following:

1. Fish sample data
    a. Collection of appropriate organisms
    b. Collection and analysis of sufficient quantity of organisms
    c. Adherence to approved sample handling and storage protocols
    d. Accurate analysis of samples

2. Food chain model
    a. Use of appropriate chemical-specific Kow values
    b. Use of appropriate biota weights and lipid content
    c. Identification of appropriate trophic levels
    d. Application of appropriate model for this study site

3. Representative species
    a. Use of appropriate representative species
    b. Use of reasonable estimates of fish ingestion
    c. Applicability of limited toxicity data to representative species

Every effort was taken to ensure that fish sampling, food chain modeling, and the selection of appropriate representative species were performed in the most appropriate manner for this risk assessment. Although all of the above-mentioned categories probably contribute to total uncertainty to some extent, items relating to fish sample data are potentially the most significant. Because this particular study area encompassed a large geographical area, relatively limited fish sampling was performed; and none of the analyses consisted whole-body analysis for any given fish. However, the species selected and the quantity of each species collected appear to be adequate for site characterization. With the possible exception of compromise to the integrity of some Phase II samples, which was discussed previously, the level of uncertainty was considered acceptable for this phase of the ecological risk assessment.

Data collection components that can be useful for some ecological risk assessments, but were not performed for this assessment, include (1) detailed macroscopic and microscopic tissue analysis of aquatic and terrestrial biota, and (2) toxicity testing using study area waters and sediments. However, based on the extensive biological and chemical sampling incorporated into this assessment, it is considered that such additional procedures were unnecessary at this time.

In summary, several sources of uncertainty might contribute to overall uncertainty in the final risk estimates, including those sources discussed in the exposure and hazard sections of this assessment. Throughout this assessment, if levels of uncertainty were unknown, or if impacts associated with uncertainty could not be estimated accurately, a conservative approach was taken. The consistent use of conservative assumptions probably overestimated actual risk to biota in nearly all cases, but no appropriate or reasonable alternative to conservatism has been identified.

7.7 Ecological Risk Assessment Summary and Conclusions

Although many inorganic and organic chemicals were detected in various media at study area locations, only a few chemicals were found at concentrations that are a cause for concern. The primary contaminants determined in this study are chemicals associated with sediments and biota. Risks to biota from surface water COCs are minimal in comparison to those from COCs associated with sediments and biota.

The primary Site related and Study Area contaminant is mercury, which is considered to be a site-related contaminant. This chemical contributed the major portion of the estimated risk from both contaminated sediments (except for aluminum) and contaminated biota. The risk estimates for sediment-associated aluminum which is not considered to be a site-related contaminant are probably overestimated, based on bioavailability. DDT and its metabolites also contributed significantly to the overall risk estimates associated with contaminated sediments. In some locations, phthalate esters (non-site related contaminants) also were important contributors to sediment toxicity.

The predominant contaminant for biota was mercury, followed by PCBs and DDT and its degradation products (DDD and DDE) which are not considered to be sit-related contaminants. This Study Area is somewhat unique because the most hazardous chemicals (mercury, PCBs, DDT) are those that have the greatest effects on food chains/webs. The toxicity hazards associated with these primary study area contaminants are minimal compared to hazards associated with food chain effects. Although some exceptions to this pattern were noted, in general, the least hazardous concentrations of sediment COCs were associated with Background areas, including Reach 1, while the most hazardous concentrations were associated with Reach 2 and, especially, Reach 3; the Eastern Wetlands, Outfall Creek; and the Raceway. Risk estimates based on biota COCs were more evenly distributed throughout sampled reaches in comparison to risk estimates based on sediment COCs. Cumulative risks associated with biota COCs were highest in Reach 3; the risks estimated for the other reaches were considerably lower than those of Reach 3.

In conclusion, the predominant hazards identified by this Ecological Risk Assessment in the Study Area are the adverse effects to upper trophic level predators that ingest contaminated fish and invertebrates and, to a lesser extent, the aqueous toxicity of such contaminants. The sediments that are contaminated with mercury, PCBs, and total DDT should be a source of contamination for some time, due to the persistent nature of these contaminants.

8

8.0 CONCLUSION

8.1 Contaminants in Water and Sediment

Results of this Remedial Investigation indicate that past process wastewater and chemical disposal practices at the Nyanza Site have resulted in surface water, sediment and soil contamination in the wetlands adjacent to the Nyanza Site and in the Sudbury River.

Mercury and chromium contamination is extensive in the sediments and soils of the Eastern Wetlands, a receptor of Site runoff. Other organic Site related contaminants are present in Wetlands sediments and underlying soils including chlorobenzene, dichlorobenzene, trichloroethene, and dichloroethene. The highest concentrations of contaminants in the Study Area by one to three orders of magnitude occur in the Eastern Wetlands. Site related contaminants are also present in the Wetlands surface waters.

Trolley Brook drains the Wetlands and surface water mixes with Chemical Brook before flowing into the Chemical Brook Culvert, and finally outfalls into the Raceway. The Raceway carries contaminated sediments into the Sudbury River.

Mercury and chromium contamination is pervasive in sediments deposited by the streams draining the Eastern Wetlands. These and other inorganic contaminants are generally adsorbed to sediment particles and move throughout the Study Area by sediment transport mechanisms. In that manner, the contaminated sediments are retained in the depositional areas, until resuspension occurs during periods of high water, causing further downstream transport. Samples collected in the downgradient Reach 10 of the Study Area are comparable to background levels detected upstream of the Nyanza Site.

Dissolution of the adsorbed inorganics to the water is not expected to occur under water quality conditions which were found to occur throughout the River. Relatively low concentrations of Site-related contaminants in surface waters compared to high concentrations in sediments indicated that the primary contaminant transport mechanism is sediment transport.

Volatile organic contaminants noted above are present in a pattern indicating the location of a possible ancestral channel through the Eastern Wetlands. Highest contaminant concentrations are present in the northern pond, and the concentrations quickly drop near the outlet of this pond. It is expected that as turbulence increases in the Chemical Brook Culvert, these compounds are volatilized. In this manner they are not persistent in the River. Volatile organic compound contamination is not widespread in the river.

Organic compounds which were noted in the Work Plan to be compounds specific to the Nyanza dye manufacturing process ("Site specific organics": aniline, napthalamines and benzidines) were not detected in the Study Area.

The Sudbury River has an extensive history of industrialization and urbanization and has been impacted by numerous chemical and physical processes. Numerous chemicals were detected in the river system, including PAH compounds, phthalates, pesticides, PCBs, volatile organic compounds, and several metals. These chemicals are generally understood to be non-site related compounds attributable to other point and non point sources.

8.2 Contaminants in Fish

Fish samples revealed the presence of bioaccumulated metals and organic compounds. Most notable was mercury, which is also present in fish tissue in the form of methylmercury. The other organic compounds detected were primarily pesticides and PCBs, which are compounds readily accumulated by predatory fish. Concentrations of mercury and pesticides in fish tissues generally increase with age and size, and are generally higher in the predator group than in the scavenger group.

Sample location was also a factor in the concentrations of mercury in fish. Reservoir 2, which exhibits the highest concentrations of mercury in sediment, also showed the highest concentrations of mercury in fish tissue. Those fish collected downstream contained gradually decreasing concentrations of mercury. It is expected that the dams and impoundments are preventing the upstream migration of fish and their prey, and therefore mercury concentrations in fish should mirror bioavailable mercury in the fish habitat.

8.3 Risk Assessment

The human health risk assessment concludes that there are two categories of individuals which are susceptible to health effects of contaminants found in the Study Area. These individuals are those who; regularly eat fish captured from the Study Area; and use parts of the Study Area for swimming, wading or other intrusive recreational activities.

With few exceptions, hazard quotients (HQs) and hazard (HIs) indices calculated for the recreational and residential sediment exposure scenarios do not exceed unity. However, hazard indices calculated for the COC concentrations detected in the Eastern Wetlands sediments (recreational exposure scenarios) exceed unity when maximum contaminant concentrations are evaluated and a small child is considered the receptor of concern. (In this case, the

hazard index calculated for chemicals affecting the kidney approaches unity (>0.95.)).

In all cases presented for the sediment exposure scenarios, HQs and HIs calculated for the accidental-ingestion exposure route exceed those calculated for the dermal-absorption exposure route. The hazard index calculated for the bordering wetlands (residential exposure scenario) exceeds unity when maximum concentrations are evaluated and a child is considered as the receptor of concern. However, hazard indices calculated on a target organ-specific basis do not exceed unity.

With the exception of fish sampled in Southville Pond (in Reach 1), maximum and/or average mercury concentrations detected in fish tissue samples collected in the Study Area exceed the FDA Action Level for mercury in fish. The fish-ingestion exposure scenarios presented in the risk assessment considered a sports fisherman and subsistence fisherman as receptors of concern. Hazard indices calculated for all COCs detected in fish tissue samples collected during the RI exceed unity in at least one of the cases presented for each surface water body evaluated.

The fact that HQs and HIs exceed unity and the fact that mercury concentrations exceed FDA Action Levels in one or more cases presented for each surface water body evaluated suggests that adverse noncarcinogenic health effects are anticipated for the sports fisherman and subsistence fisherman under the condition of the exposure scenarios considered in the risk assessment. With the exception of the Saxonville impoundment, hazard indices calculated for Nyanza Site contaminants exceed those calculated for "other Sudbury River contaminants."

Cancer risk estimated for the fish-ingestion exposure scenarios range from 0 (Cedar Swamp Pond and Southville Pond, no risk calculated; CSFs not available for COCs) to 5.5 x 10^{-3} (Reservoir No. 2, maximum COC concentrations, subsistence fisherman). As a point of reference, cancer risks for samples collected in the Sudbury Reservoir are 5 x 10^{-4} and 3.6 x 10^{-4} when maximum and average COC concentrations are evaluated and the subsistence fisherman is considered the receptor of concern. Cancer risks estimated for surface water bodies upstream of the Nyanza Site do not exceed 1 x 10^{-3} in any case presented. Cancer risks estimated for Mill Pond, Reservoir No. 2, and Fairhaven Bay exceed 1 x 10^{-3} in at least one case presented. The principal COCs contributing to the estimated excess lifetime cancer risks are arsenic, several pesticides such as 4,4-DDT, and the PCBs. In all cases presented, risks associated with "other Sudbury River contaminants" exceed those estimated for Nyanza Site contaminants.

The predominant contaminant in biota is mercury, followed by PCBs and DDT and its degradation products DDD and DDE. The toxicity hazards associated with these contaminants are probably minimal compared to hazards associated with food chain effects. In general, mean and maximum estimated whole body concentrations of total mercury exceed values that are considered to be protective of humans and nonhuman predators that consume fish. Most fish collected from all Reaches, except background (Reach 1), are associated with mercury concentrations which exceed Food and Drug Administration action levels and Fish and Wildlife Service guidelines. The risks to fish consumers is expected to be greatest for fish collected from Reach 3, followed by Reach 4 and Reach 9.

In general, the surface water contaminants associated with the greatest risks to aquatic animals in most reaches are aluminum, lead, zinc, and bis(2-ethylhexyl)phthalate. Silver appears to pose a significant risk to aquatic biota only in Reach 7. A risk to birds and terrestrial animals is associated with drinking surface waters, from the Outfall Creek and Cold Spring Brook due to elevated concentrations of zinc and bis(2-ethylhexyl)phthalate. This risk is minimal through the other Reaches. For most Reaches, aluminum poses the greatest risk to aquatic plants.

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