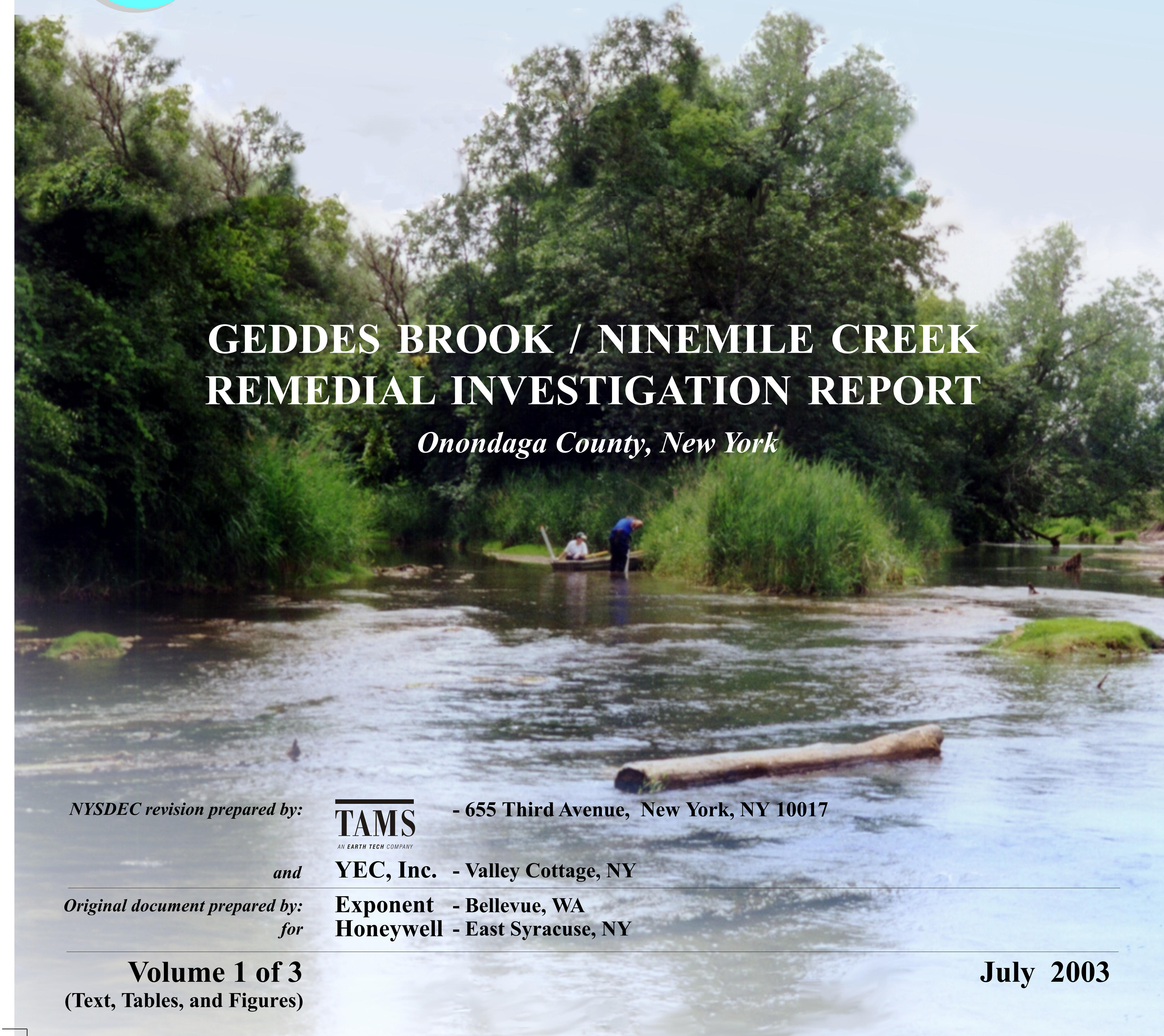
New York State
Department of Environmental Conservation

Division of Environmental Remediation
625 Broadway, Albany, New York 12233-7016



GEDDES BROOK / NINEMILE CREEK REMEDIAL INVESTIGATION REPORT

Onondaga County, New York

NYSDEC revision prepared by: TAMS (AN EARTH TECH COMPANY) - 655 Third Avenue, New York, NY 10017

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Original document prepared by: Exponent - Bellevue, WA
for Honeywell - East Syracuse, NY

Volume 1 of 3
(Text, Tables, and Figures)

July 2003

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Onondaga Lake Project
Contract Number C004365, Task Order 1

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Geddes Brook/Ninemile Creek RI – Contents

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Acronyms and Abbreviations

amsl	above mean sea level
ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
ATBAL	acute toxicities for benthic aquatic life
BBL	Blasland, Bouck & Lee
BCF	biota concentration factor
BERA	baseline ecological risk assessment
BMI	benthic macroinvertebrate index
BTEX	benzene, toluene, ethylbenzene, and xylenes
C&D	construction and demolition
CaCl	calcium chloride
$CaCO_3$	calcite
CAS	Columbia Analytical Services
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIR	Closure Investigation Report
CLP	Contract Laboratory Program
cm	centimeter
cm/sec	centimeters per second
COC	contaminant of concern
COPC	contaminant of potential concern
CPOI	chemical parameter of interest
CSDE	City of Syracuse Department of Engineering
CSF	carcinogenic slope factor
CT	central tendency
CTBAL	chronic toxicities for benthic aquatic life
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
dw	dry weight
ECD	electron capture detection
EPC	exposure point concentration
ER-L	effects range-low
ER-M	effects range-median
ERAGS	Ecological Risk Assessment Guidance for Superfund
FEMA	Federal Emergency Management Agency
FGS	Frontier Geosciences, Inc.
FS	feasibility study
ft	feet/foot
FWIA	Fish and Wildlife Impact Analysis

g	grams
g/day	grams per day
g/mo	grams per month
gal	gallon
GB	Geddes Brook
GC/ECD	gas chromatography/electron capture detection
gpm	gallons per minute
GPS	global positioning system
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Tables
HHB	human health bioaccumulation
HHRA	human health risk assessment
HI	hazard index
Honeywell	Honeywell International Inc.
HQ	hazard quotient
I-690	Interstate 690
IRIS	Integrated Risk Information System
IRM	interim remedial measure
kg	kilogram
kg/day	kilograms per day
kg/yr	kilograms per year
km	kilometer
L	liter
lbs	pounds
lbs/day	pounds per day
LCP	Linden Chemicals and Plastics
LDPE	low-density polyethylene
LEL	lowest effect level
LOAEL	lowest observed adverse effects level
m	meter
m^3/s	cubic meters per second
meq	milliequivalents
meq/L	milliequivalents per liter
Metro	Metropolitan Syracuse Sewage Treatment Plant
mgd	million gallons per day
mi	mile
mm	millimeter
MS	mass spectrometry
MWH	Montgomery Watson Harza, Inc.
NaCl	sodium chloride
NAPL	non-aqueous-phase liquid
NCDC	National Climatic Data Center
NCEA	National Center or Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NMC	Ninemile Creek

NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
NPL	National Priorities List
NRC	National Research Council
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Law
NYSDOT	New York State Department of Transportation
O&M	operations and maintenance
OCDDS	Onondaga County Department of Drainage and Sanitation
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
PMA	percent model affinity
PRP	potentially responsible party
PSA	preliminary site assessment
PTI	PTI Environmental Services
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
RIBS	Rotating Intensive Basin Studies
RME	reasonable maximum exposure
ROD	record of decision
RSCO	recommended soil cleanup objective
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SEL	severe effect level
SOC	stressor of concern
SOP	standard operating procedure
SOPC	stressor of potential concern
SPDES	State Pollutant Discharge Elimination System
SVOC	semivolatile organic compound
SYW	Syracuse West (USGS quadrant sheet)
TAL	Target Analyte List
TAGM	Technical and Administrative Guidance Memorandum
TAMS	TAMS Consultants, Inc.
TCDD	tetrachlorodibenzo-*p*-dioxin
TCL	Target Compound List

TDS	total dissolved solids
TEF	toxicity equivalence factor
TEQ	toxicity equivalence quotient
TOC	total organic carbon
TRV	toxicity reference value
TSS	total suspended solids
UCL	upper confidence limit
USACE	US Army Corps of Engineers
USEPA	US Environmental Protection Agency
USFDA	US Food and Drug Administration
USGS	US Geological Survey
VOC	volatile organic compound
WB	wildlife bioaccumulation
WHO	World Health Organization
ww	wet weight
YOY	young-of-year
yr	year

Glossary

Benthic Community. The community of organisms dwelling at the bottom of a pond, river, lake, or ocean.

Conventional Parameters. Conventional parameters are those measurements that are meant to give a general physical and chemical characterization of the environment, and include methods which utilize gravimetric, spectrophotometric, ion chromatographic, or electrometric analysis.

Depositional. An area in a stream where sediment accumulates due to relatively slow water velocities. Changes in stream flow and water velocity may cause a depositional area to become erosional at times.

Erosional. An area in a stream, typically characterized by relatively high water velocities, where sediment is removed by moving water. Changes in stream flow and water velocity may cause an erosional area to become depositional at times.

Limnology. The study of the biology, physics, and chemistry of lakes and rivers.

Marl. A mixture of clay with lime (calcium carbonate).

Quiescent. In a body of water, an area where the water is still or moving at a relatively low velocity. Quiescent areas are typically depositional because of their relatively low water velocities.

EXECUTIVE SUMMARY

Honeywell International, Inc. (formerly AlliedSignal, Inc.; referred to herein as Honeywell) is currently conducting a remedial investigation and feasibility study (RI/FS) of the Geddes Brook/Ninemile Creek site, located near Onondaga Lake, New York (Figure 1-1 of Chapter 1, Introduction). The Geddes Brook/Ninemile Creek RI/FS is being conducted pursuant to the terms of a Consent Decree (Index # 89-CV-815) entered into with the State of New York, dated March 16, 1992, and associated stipulations (Consent Decree). The Geddes Brook/Ninemile Creek RI/FS is proceeding separately from the Onondaga Lake RI/FS.

To the extent that Geddes Brook and Ninemile Creek have released and continue to release contaminants to Onondaga Lake, the previously issued Onondaga Lake RI, baseline ecological risk assessment (BERA), and human health risk assessment (HHRA) (TAMS, 2002c,a,b) assessed the nature, extent, and risks associated with the impacts on the lake. Geddes Brook and Ninemile Creek were assessed in the Onondaga Lake RI, BERA, and HHRA by measuring sediment and water quality conditions in the lake at the Geddes Brook/Ninemile Creek site's point of discharge and by evaluating contaminant loadings from the site to the lake. By way of contrast, this RI and the associated BERA and HHRA for the Geddes Brook/Ninemile Creek site identify and assess the contamination within these two tributaries and their floodplains.

As part of the Geddes Brook/Ninemile Creek RI/FS, draft BERA and RI documents (Exponent, 2000a,c) were submitted by Honeywell in August 2000 and the draft HHRA was submitted in July 2000 (Exponent, 2000b). The three documents were reviewed by the New York State Department of Environmental Conservation (NYSDEC) and the US Environmental Protection Agency (USEPA), and the HHRA was also reviewed by the New York State Department of Health (NYSDOH). With the concurrence of USEPA, NYSDEC and the New York State Department of Law (NYSDOL) disapproved the draft documents and provided comments to Honeywell in November 2000. After completing additional sampling in 2001, Honeywell submitted revised BERA, HHRA, and RI reports (Exponent, 2001a,b,c). These revised reports were also assessed by these reviewers and, with their concurrence, NYSDEC and NYSDOL disapproved the revised reports in February 2002 (T. Larson, pers. comm., 2002a). The reasons for disapproval of the revised reports are outlined in the joint NYSDEC/NYSDOL determination accompanying this document.

This RI report is the NYSDEC/TAMS Consultants, Inc. (TAMS) rewrite of Honeywell's revised RI report, and it has likewise been reviewed by USEPA. This rewrite has been completed in accordance with USEPA guidance for conducting RI/FSs. Honeywell is scheduled to submit a draft FS report in December 2003 for agency review, based on the findings of this RI and associated risk assessments.

Consistent with the Consent Decree and the Geddes Brook/Ninemile Creek RI/FS Work Plan (NYSDEC, 1998, 2000a), the principal objectives of this RI are to:

- Determine the concentration and distribution of contaminants in Geddes Brook, Ninemile Creek, and associated floodplain areas within the site.

- Determine the human health and ecological significance of contaminants in the Geddes Brook/Ninemile Creek site.

- Develop sufficient data to evaluate the potential remedial alternatives along with their engineering feasibility and relative effectiveness in addressing contamination in the Geddes Brook/Ninemile Creek site.

The Geddes Brook/Ninemile Creek BERA and HHRA, which are components of this RI, are included under separate cover (TAMS, 2003a,b) and are summarized in Chapters 7 (Human Health Risk Assessment) and 8 (Baseline Ecological Risk Assessment) of this report.

For the purposes of this RI, the Geddes Brook/Ninemile Creek site includes the following:

- Geddes Brook sediment and surface water from approximately 2,500 feet (ft) (760 meters [m]) upstream from its intersection with Gerelock Road to the point of discharge into Ninemile Creek and associated floodplain soil from its intersection with the West Flume to the point of discharge into Ninemile Creek.

- Ninemile Creek sediment and surface water from Amboy Dam to the point of discharge into Onondaga Lake and associated floodplain soil from its intersection with Geddes Brook to the point of discharge into Onondaga Lake.

- State and federal wetlands associated with the Geddes Brook/Ninemile Creek site (i.e., Wetland SYW-18 and Wetland SYW-10 east of Interstate 690 [I-690]). Wetland SYW-10 west of I-690 is being evaluated as part of the Maestri 2 site.[1]

The Geddes Brook/Ninemile Creek site is defined as the sediment, floodplain soil, and surface water of Geddes Brook and Ninemile Creek, as discussed above. This definition is based on a conceptual model of the site in which contaminants from Honeywell sites (e.g., LCP Bridge Street, Solvay Wastebeds) were discharged (directly or indirectly) to Geddes Brook and Ninemile Creek, where they settled into the stream beds and floodplains. The accumulated contaminated sediments and floodplain soils of Geddes Brook and Ninemile Creek are sources of contaminants to the surface water and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake. Since, based on surface water and groundwater elevations (Blasland & Bouck, 1989), both Geddes Brook and Ninemile Creek are gaining streams in the study area below Amboy Dam (groundwater normally flows upward, discharging into the stream), the surface waters of these streams do not appear to be significant sources of contamination to the groundwater. While groundwater may discharge

[1] The Maestri 2 site consists of a 10-acre area in a wetland that was filled with mill scale and other wastes from the Crucible Materials Corporation facility, as well as automotive wastes. The wetland adjacent to the Maestri 2 site drains into Ninemile Creek near its mouth. An RI is being performed by the potentially responsible parties (PRPs) at the site.

contaminants to the Geddes Brook/Ninemile Creek site, the sources of that contamination include upland sites which are being, or will be, investigated separately, as appropriate. Thus, groundwater is not evaluated in this RI and associated risk assessments.

In conjunction with the RI/FS, Honeywell entered into an Order on Consent for the Geddes Brook Interim Remedial Measure (IRM) in April 2002 (NYSDEC, 2002). The Geddes Brook IRM is proceeding on a parallel path to the Geddes Brook/Ninemile Creek RI/FS. The objectives of this IRM, as stated in the Order on Consent (NYSDEC, 2002), are to:

- Eliminate, to the extent practicable, within the scope of the IRM, the transport of mercury into Ninemile Creek from Geddes Brook sediments and floodplain soils.

- Eliminate, to the extent practicable, within the scope of the IRM, potential impacts to human health and fish and wildlife resources associated with site-related contamination.

A Geddes Brook IRM Work Plan (Parsons, 2002a) prepared by Honeywell has been reviewed and approved by NYSDEC (T. Smith, pers. comm., 2002, 2003). A supplemental investigation was conducted by Honeywell in December 2002 to principally support the design of the Geddes Brook IRM. The results are discussed in Chapter 5, Nature and Extent of Contamination, and are presented in Appendix M, Geddes Brook IRM Analytical Data and Validation Report, in this RI report. The impact of this IRM on the Geddes Brook/Ninemile Creek site will be further evaluated in the Geddes Brook/Ninemile Creek FS.

This executive summary is organized as follows: the structure and a summary of the key findings of this RI are presented first, followed by summaries of the field and laboratory investigations; the site history and physical characteristics; the sources and potential sources of chemical parameters of interest (CPOIs) to the site; the nature and extent of contamination at the site; the transport and fate of CPOIs; the risk assessments; and, finally, the preliminary remedial action objectives (RAOs).

1. Key Findings

Chapters 1 (Introduction) and 2 (Field and Laboratory Investigations) of this Geddes Brook/Ninemile Creek RI report present information on the site's remedial history and a summary of field and laboratory investigations performed within the Geddes Brook/Ninemile Creek site.

Chapter 3, Site History and Physical Characteristics, provides a detailed discussion of the history and physical characteristics of the Geddes Brook/Ninemile Creek site. The key findings of Chapter 3 include:

- Geddes Brook and Ninemile Creek have undergone extensive changes to their natural state as a result of anthropomorphic activities. Of particular interest to the RI with respect to the CPOIs are impacts due to dredging/rerouting of the stream beds and the disposal of industrial wastes.

- The most downstream reach of Ninemile Creek (i.e., Reach AB; see Chapter 2, Figure 2-2) was rerouted in 1926, thus moving the mouth from Lakeview Point to the present location. Lakeview Point is the current location of Wastebeds 1 to 8. Reach AB extends from the mouth of Ninemile Creek to the large bend near I-690. Reach AB appears to have been dredged and channelized in the late 1960s.

- The next reach of Ninemile Creek (Reach BC; see Chapter 2, Figure 2-2) extends from just north of I-690 to the large bend south of New York State Route 695 (Route 695). Reach BC was rerouted and channelized during the construction of I-690 and Route 695 in the 1950s and the late 1960s, respectively. It is not known how sediments in the original channel may have been disturbed and/or disposed as a result of the rerouting.

- The next upstream reach in Ninemile Creek (Reach CD; see Chapter 2, Figure 2-2) extends from the large bend south of Route 695 to the confluence with Geddes Brook. This reach does not appear to have undergone any significant physical modifications since at least the 1930s.

- A large portion of Ninemile Creek upstream of the confluence with Geddes Brook was rerouted in 1944 to accommodate Honeywell's Wastebeds 9 to 11.

- A small segment of Geddes Brook upstream of its confluence with the West Flume was rerouted during construction of Route 695 in the late 1960s.

Chapter 4, Sources and Potential Sources of Chemical Parameters of Interest, provides information on past and present Honeywell sources and potential sources of CPOIs, as well as potential sources from locations not identified as Honeywell sites. The key findings of Chapter 4 include:

- Honeywell disposed of industrial waste into the Geddes Brook/Ninemile Creek watershed primarily via the West Flume and Wastebeds 1 to 15, and, to a lesser extent, through disposal to the currently inactive Mathews Avenue Landfill. Accordingly, the site has been divided (in this report) into upper and lower Geddes Brook (upstream and downstream of the confluence with the West Flume) and upper and lower Ninemile Creek (upstream and downstream of the confluence with Geddes Brook). Note that while Transect TN-16 in Ninemile Creek is just upstream of the confluence with Geddes Brook, it is included as part of lower Ninemile Creek, as it has apparently been impacted by Geddes Brook.

- CPOIs associated with Honeywell operations include mercury; lead; chlorinated benzenes; benzene, toluene, ethylbenzene, and xylenes (BTEX); polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); and polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs).

- Other potential sources of CPOIs (PAHs and metals) include urban runoff and the disposal by other parties in other landfills.

- Honeywell's historical direct discharges into the West Flume and overflow from the wastebeds into Geddes Brook and Ninemile Creek were of such magnitude that the annual mean flow in lower Ninemile Creek during Honeywell's operations was almost twice the current flow. This increased flow due to Honeywell discharges likely caused the boundaries of the creek to be larger in lower Geddes Brook and lower Ninemile Creek than they are now, with more of the current floodplain frequently underwater at that time.

- The Honeywell operations also caused the total suspended solids (TSS) and total dissolved solids (TDS) loads to be more than twice as great as they are now. These operations had the effect of causing large deposits of Solvay waste (i.e., solids that settled out from the Solvay Wastebeds overflow) to accumulate in the stream beds and floodplains of Geddes Brook and Ninemile Creek that were below the discharge points, primarily in the reaches downstream of the West Flume. Such deposits may be referred to herein as "depositional" sediments.

- Ongoing releases from Honeywell sites continue to impact the levels of CPOIs at the Geddes Brook/Ninemile Creek site.

Chapter 5, Nature and Extent of Contamination, documents the distribution of CPOIs in sediments, floodplain soils, wetland and island soils, surface water, and fish at the Geddes Brook/Ninemile Creek site. The RI data collected by Honeywell and NYSDEC between 1998 and 2002, along with data collected independently of this RI, provide a comprehensive basis for understanding the current nature and extent of CPOIs within the Geddes Brook/Ninemile Creek site. The key findings of this chapter include:

Sediments

- Mercury concentrations in sediment and floodplain soils reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek as well as the stream channel geomorphology and historical changes to the stream channel. Concentrations of total mercury were relatively high (greater than 10 mg/kg) at stations located on the right side of Ninemile Creek facing downstream between Transects TN-15 and TN-10 (within Reach CD). These high concentrations of mercury are also found at deeper intervals in this area. The stretch along the right bank between these transects is a relatively quiescent (i.e., depositional) region within Reach CD, where water entering Ninemile Creek from Geddes Brook appears to hug the shoreline and does not readily mix across the entire Ninemile Creek cross section due to the presence of the islands. The sediments from this area of high mercury concentration were noted as containing Solvay waste materials in the 2001 BBL sediment probing survey.

- Higher concentrations of other metals (i.e., arsenic, nickel, and zinc) at depth were most prevalent at Transects TN-5 and TN-6 in Reach BC of Ninemile Creek and, to a lesser extent, Transects TG-3 and TG-4 in Geddes Brook, with contamination extending to a depth of approximately 10 ft (3 m) in some cases.

- For organic CPOIs in sediments, the highest concentrations were found in lower Ninemile Creek and lower Geddes Brook. There were several elevated concentrations (greater than 1,000 µg/kg) of hexachlorobenzene in lower Geddes Brook and in Reach CD of Ninemile Creek. Concentrations of hexachlorobenzene exceeding 10,000 µg/kg occurred in Geddes Brook just below the discharge point of the West Flume to a depth of about 4 ft (1.28 m). Elevated levels (greater than 1,000 µg/kg) of Aroclors 1254 and 1268 were also detected at some stations in lower Geddes Brook and lower Ninemile Creek. Unlike Aroclor 1254, elevated concentrations of Aroclor 1268 occurred in the deeper sediments (greater than 1 m depth) in Reach CD of Ninemile Creek and in surface sediments (0 to 0.15 m) in Reach AB of Ninemile Creek. The highest concentrations of PCDD/PCDFs (TEQs) were found in Geddes Brook immediately below the confluence with the West Flume.

Floodplain Soils

- Mercury concentrations in soils from floodplain and wetland areas along Ninemile Creek showed a distinct distribution pattern, with concentrations exceeding 10 mg/kg in samples collected near the mouth of the creek and along Reach CD. Floodplain soils collected at depth intervals ranging from 0.3 to 0.9 m during the 2002 supplemental floodplain sampling program in Ninemile Creek (Chapter 5, Figure 5-15) showed elevated levels of mercury as high as 76.9 mg/kg (on the right side, facing downstream, of the mouth of Ninemile Creek in a low-lying wetland area [i.e., Reach AB]) and 43.1 mg/kg (1.5 m from the water's edge on the right bank facing downstream between the two southern islands in Ninemile Creek [i.e., Reach CD]).

  It should be noted that the elevated concentrations of mercury at deeper intervals are localized in areas where Ninemile Creek is characterized as strongly depositional at base flow. These elevated mercury concentrations at depth occur in the low-lying wetland area at the mouth of Ninemile Creek that has historically been exposed to flooding and in Reach CD where the elevated mercury concentrations in floodplain soil are adjacent to the sediments with elevated mercury concentrations at depth.

- Many of the sediments/soils from these areas of high mercury concentrations were identified as containing Solvay waste materials.

- Hexachlorobenzene, PAHs, PCBs, and PCDD/PCDFs were detected at elevated concentrations in floodplain soils, mainly along lower Geddes Brook and along Reach CD of Ninemile Creek.

Surface Water

- Total mercury concentrations in surface water reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek. Total mercury concentrations were higher in the lower reaches of both Geddes Brook and Ninemile Creek than in the upper reaches.

- Total mercury concentrations in the West Flume, lower Geddes Brook, and lower Ninemile Creek have declined since 1990, with concentrations in 1998 at least 77 percent lower than 1990 values in these areas of the system.

- Concentrations of the other inorganics and ionic waste constituents (e.g., chloride, calcium, sodium, and TDS) in surface water clearly indicate the continued impact of Wastebeds 9 to 15 on the Geddes Brook/Ninemile Creek site.

Fish

- The maximum mercury concentration in adult fish from the 1998 data (1,534 µg/kg wet weight in fillets) was detected in lower Ninemile Creek just downstream of the confluence with Geddes Brook.

- The maximum mercury concentration (850 µg/kg) in young-of-year (YOY) fish reported in the 2002 NYSDEC/TAMS data, which were obtained from lower Ninemile Creek samples collected downstream of the mercury source, is nearly 20 times greater than the maximum concentration (46.8 µg/kg) from the 1998 Honeywell/Exponent data, which were obtained from Ninemile Creek YOY fish samples upstream of the source (i.e., upstream of the confluence with Geddes Brook).

Chapter 6, Transport and Fate of Chemical Parameters of Interest, describes these processes and focuses on the following major groups: mercury, inorganics other than mercury, organic compounds, and ionic waste constituents. The key findings of this chapter include:

- Wastes from Honeywell's Syracuse Works were discharged into Geddes Brook and Ninemile Creek via the West Flume and overflow from the Solvay Wastebeds, starting at the time that the wastebeds were first constructed (1926 for Wastebeds 1 to 8 and 1944 for Wastebeds 9 to 15) and with the construction of the LCP Bridge Street Plant (1953). These wastes contained primarily Solvay waste, but included other waste streams as well, and settled into depositional areas downstream of these discharges.

- Mercury and other CPOIs (e.g., hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs) appear to be primarily associated with depositional zones containing Solvay waste materials downstream of the Honeywell LCP Bridge Street site and the West Flume.

- Some of the historical contaminated materials in Ninemile Creek were likely removed during various non-remedial construction operations such as channelization and rerouting of the stream beds.

- The changes in the hydraulic regime of Geddes Brook and Ninemile Creek, caused by the cessation of Honeywell discharges in 1980, have resulted in some of these historically depositional areas becoming more erosional.

- Reach CD contains the highest concentrations of CPOIs in Ninemile Creek, and the reach as a whole is the most erosional in lower Ninemile Creek. The right-hand channel of Reach CD (facing downstream) is depositional at base flow and erosional at high flow.

- Normalization of surface sediment mercury concentrations to iron (normalizing to iron helps to remove variability in concentrations due to changes in factors such as grain size, etc.; see Chapter 6, Section 6.2) indicates that there may be localized areas with uniquely high concentrations of mercury within lower Ninemile Creek.

- Based on load analysis, the sediments of lower Geddes Brook and lower Ninemile Creek are major sources of mercury to the water column and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake at base-flow conditions. However, the source of the mercury measured in lower Ninemile Creek at base flow appears to be heavily influenced by releases from the West Flume, which is the largest external source of mercury to the Geddes Brook/Ninemile Creek site.

- The transport of mercury in Geddes Brook and Ninemile Creek surface water has been measured to increase significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils to Onondaga Lake increases dramatically. Under these high-flow conditions, the sediments and floodplain soils of lower Ninemile Creek become the dominant source of mercury being transported to Onondaga Lake, and are a major component of the annual mercury load to the lake.

- An analysis of loads of TDS in surface water confirms that groundwater from Wastebeds 9 to 15 continues to be a source of ionic waste constituents, primarily in the forms of calcium chloride and sodium chloride, to Geddes Brook and Ninemile Creek.

- The transport of TSS and ionic waste constituents in Geddes Brook and Ninemile Creek surface water increases significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils increases dramatically. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of TSS being transported to Onondaga Lake, and are a major component of the annual TSS and ionic waste constituents load to the lake.

- CPOIs other than mercury (hexachlorobenzene, PCBs, PAHs, PCDD/PCDFs) that are primarily associated with the same sediments as mercury would be expected to have similar transport and fate as mercury. The sediments and floodplain soils containing these CPOIs would be expected to erode under high-flow conditions and ultimately transported to Onondaga Lake.

Chapters 7 and 8 summarize the Geddes Brook/Ninemile Creek HHRA and BERA, respectively (TAMS, 2003b,a). The key findings of the risk assessments include:

Human Health Risk Assessment

As discussed in the HHRA, contamination at the Geddes Brook/Ninemile Creek site presents risks to human health that are above applicable USEPA guidelines. In addition, the primary sources of cancer risks and non-cancer hazards are due to mercury, PCBs, and PCDD/PCDFs as a result of the consumption of fish from the Geddes Brook/Ninemile Creek site. The finding of elevated risk and hazard estimates for mercury is consistent with the fact that concentrations in fish tissues collected from the Geddes Brook/Ninemile Creek site exceed the US Food and Drug Administration (US FDA) action limit.

Baseline Ecological Risk Assessment

As discussed in the BERA, Honeywell-related contaminants at the Geddes Brook/Ninemile Creek site have produced adverse ecological effects at all trophic levels examined. Comparisons of measured tissue concentrations and modeled doses of chemicals to toxicity reference values (TRVs) show exceedances of hazard quotients (HQs) for site-related chemicals throughout the range of the point estimates of risk. Many of the contaminants, such as methylmercury, PCBs, hexachlorobenzene, and PCDD/PCDFs, in Geddes Brook and Ninemile Creek are persistent; therefore, the ecological risks associated with these contaminants are unlikely to decrease significantly in the short term in the absence of remediation. On the basis of these comparisons, it has been determined that all receptors examined are at risk due to contamination at the Geddes Brook/Ninemile Creek site. These receptors, representing various trophic levels and feeding preferences, indicate either impacts or potential impacts to most of the Geddes Brook and Ninemile Creek ecological community.

In addition, ionic waste constituents from the Solvay Process have impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the stream bottom for feeding or spawning.

2. Summary of Field and Laboratory Investigations

As set forth in detail in Chapter 2, field and laboratory investigations for this RI were conducted in the Geddes Brook and Ninemile Creek area from 1998 to 2002. The four major RI field and laboratory investigations conducted by Honeywell and NYSDEC included the following:

- Geddes Brook/Ninemile Creek RI/FS Phase 1 sediment, floodplain soils, surface water, and fish sampling conducted by Exponent for Honeywell in 1998.

- Geddes Brook/Ninemile Creek supplemental RI/Interim Remedial Measure (IRM) sediment and floodplain soils sampling conducted by Blasland, Bouck & Lee (BBL) for Honeywell in 2001.

- Lower Ninemile Creek supplemental RI floodplain soils sampling conducted by O'Brien & Gere for Honeywell in 2002.

- Ninemile Creek supplemental YOY fish sampling conducted by NYSDEC and TAMS in 2002.

Subsequent to these four major RI sampling programs, a supplemental investigation was conducted by Honeywell in December 2002 to principally support the design of the Geddes Brook IRM. The results are discussed in Chapter 5 and are presented in Appendix M in this RI report. The impact of this IRM on the Geddes Brook/Ninemile Creek site will be further evaluated in the Geddes Brook/Ninemile Creek FS.

In addition to the RI sampling programs, Geddes Brook and/or Ninemile Creek have been the subject of numerous investigations in recent years. Some of these were conducted as part of the Onondaga Lake RI (TAMS, 2002c) or for other Honeywell sites and disposal areas adjacent to the Geddes Brook/Ninemile Creek site (e.g., the Solvay Wastebeds and the Mathews Avenue Landfill site). The results of these other studies were evaluated to complement the RI data collected from 1998 to 2002. Studies that were conducted in Geddes Brook and Ninemile Creek that were not part of the Geddes Brook/Ninemile Creek RI/FS and studies of other relevant Honeywell sites are summarized in Chapter 2, Sections 2.13 and 2.14, respectively. The studies conducted independently of the Geddes Brook/Ninemile Creek RI/FS are discussed in Chapter 2 and are summarized in Table 2-1, and include the following:

- Engineering Investigations at Inactive Hazardous Waste Sites in the State of New York: Phase II Investigation, Mercury Sediments – Onondaga Lake, Onondaga County (NYSDEC, 1989).

- Rotating Intensive Basin Studies (RIBS) (NYSDEC, 1992).

- Environmental Assessment of Lower Reaches of Ninemile Creek and Geddes Brook (CDR [for Honeywell], 1991).

- Onondaga Lake RI/FS Mercury and Calcite Mass Balance Investigation Data Report (PTI [for Honeywell], 1993).

- Onondaga Lake RI/FS, West Flume and Ninemile Creek Supplemental Sampling (PTI [for Honeywell],1996).

- Concentrations and Fluxes of Total and Methyl Mercury to Onondaga Lake (Gbondo-Tugbawa, 1997).

- Onondaga County Surface Water Sampling Program, 1999 – 2001 (K. Murphy, pers. comm., 2002).

3. Site History and Physical Characteristics

Geddes Brook and Ninemile Creek are located in Onondaga County, central New York State, in the Oswego River drainage basin on the southern end of Onondaga Lake at roughly 43°4′ north latitude and 76°15′ west longitude. Ninemile Creek, a major tributary to Onondaga Lake, is and has historically been a major source of Honeywell-related CPOIs, particularly mercury and ionic waste constituents, to Onondaga Lake.

The primary historical sources of contamination to the Geddes Brook/Ninemile Creek site originated from the following Honeywell facilities:

- **LCP Bridge Street** – mercury and possibly other CPOIs.
- **Main Plant** – Solvay waste and possibly other CPOIs.
- **Willis Avenue** – chlorinated benzenes and possibly other contaminants.

Historically, the major potential routes of waste transfer from these Honeywell sites to the Geddes Brook/Ninemile Creek site were via direct discharge to the West Flume and through disposal in the Solvay Wastebeds, from which waste could migrate via surface water overflow and groundwater. Minor potential routes of waste transfer include disposal in other nearby sites (e.g., Honeywell's currently inactive Mathews Avenue Landfill) and surface water runoff from urban areas.

Both Geddes Brook and Ninemile Creek have undergone major changes to their flow and sediment regimes as a result of Honeywell's operations. The massive amounts of suspended sediment and dissolved solids caused deposits of Solvay waste and associated calcite to build up in the stream sediment and in the floodplain. Such deposits were noted by CDR (1991) and BBL (2001) in Reach CD of Ninemile Creek below its confluence with Geddes Brook and in the calcite shelf in Reach AB of Ninemile Creek between State Fair Boulevard and the mouth of the creek. The elevated mercury concentrations found at depths greater than 3 ft (1 m) in the sediments and floodplains are evidence of the thicknesses of some of the waste deposits. A summary of the history of the reaches of Ninemile Creek, with a focus on mercury contamination, is provided below (see Chapter 2, Figure 2-2):

- Upper Ninemile Creek (upstream of the confluence with Geddes Brook) – This reach does not appear to have been physically altered since 1944, when it was rerouted to accommodate Honeywell's Wastebeds 9 to 11. There is potential for CPOIs to have entered Ninemile Creek from wastebed overflows in this reach.

- Reach CD (from the confluence with Geddes Brook to the large bend below the islands) – This reach, which does not appear to have been physically altered since the 1930s, contains extensive Solvay waste and associated calcite deposits and also contains the highest concentrations of mercury (see Chapter 5) in the sediments and floodplain of Ninemile Creek. These deposits are now eroding as the creek attempts to achieve an equilibrium under the new flow and solids regimes resulting from the cessation of Honeywell's discharges in 1980.

- Reach BC (from the bend below the islands to the bend below I-690) – This reach was rerouted in the late 1960s, and this rerouting may be why little evidence of Solvay waste and associated calcite deposits have been found, despite the fact that Reach BC appears to be primarily depositional, based on field observation (BBL, 2001). The mercury concentrations in this reach are lower than the concentrations seen in Reach CD.

- Reach AB (from the bend below I-690 to the mouth of Ninemile Creek) – This reach appears to have been dredged and channelized in the late 1960s, with remnants of the Solvay waste and associated calcite deposits in the shelf along the right-hand (facing downstream) bank. The mercury concentrations in this reach are higher than the concentrations in Reach BC. Reach AB appears to be highly depositional, based on field observation (BBL, 2001).

4. Sources and Potential Sources of Chemical Parameters of Interest

The analysis of sources and potential sources and migration pathways of CPOIs in Geddes Brook and Ninemile Creek, discussed in detail in Chapter 4, includes:

- A summary of existing information on the migration and disposal of CPOIs to the Geddes Brook/Ninemile Creek site from upland sites associated with historical Honeywell discharges.

- A summary of existing information on the migration and disposal of CPOIs to the Geddes Brook/Ninemile Creek site from upland sites associated with potential sources not identified as Honeywell sites.

Chemical parameters of interest include a broad range of chemicals (e.g., hazardous substances, such as mercury, chlorinated benzenes, and PCBs, and potentially less hazardous stressors, such as calcium and chloride) that are investigated and evaluated in this RI in order to determine the nature and extent of contamination within the Geddes Brook/Ninemile Creek site. These CPOIs are defined in Chapter 1, Section 1.4 and are those elements or compounds that were selected as contaminants of potential concern (COPCs), contaminants of concern (COCs), or stressors of concern (SOCs) in the BERA and HHRA (TAMS, 2003a,b), and through the screening performed as part of this RI (Appendix J, Sediment, Soil, and Surface Water Screening Tables).

As discussed in Chapter 1, Section 1.3, Honeywell's manufacturing/disposal operations represent one of the most important historical sources of CPOIs to the Geddes Brook/Ninemile Creek site. Discharges from the Honeywell LCP Bridge Street site to the West Flume and Wastebeds 12 to 15 (and possibly Wastebeds 9 to 11), and subsequently into Geddes Brook and Ninemile Creek, have contributed the greatest amount of mercury and other hazardous substances. However, wastes from the Main Plant site, and possibly the Willis Avenue Plant, also entered the site through discharges into the West Flume and through discharges, seeps, and groundwater from Wastebeds 1 to 15. Wastes originating from the Honeywell plants may have also entered the Geddes Brook/Ninemile Creek site from the Mathews Avenue Landfill site.

CPOIs being transported or potentially being transported to the Geddes Brook/Ninemile Creek site from the Honeywell sites include, among others:

- Mercury and other metals.
- BTEX compounds.
- Chlorinated benzenes.
- PAHs.
- PCBs.
- PCDD/PCDFs.
- Ionic waste constituents.

Honeywell sites have contributed contaminants to Geddes Brook and Ninemile Creek. Contaminants from other potential sources in the watershed may have also reached Geddes Brook and Ninemile Creek. In addition to runoff from developed areas in the Geddes Brook and Ninemile Creek basins, industrial and solid wastes have been disposed of near Geddes Brook, including the following:

- An area near Geddes Brook, downstream of the West Flume (State Fair Landfill).

- Areas near Geddes Brook, upstream of the West Flume near Honeywell's Mathews Avenue Landfill site (Village of Solvay Landfill, Pass & Seymour landfill, Frazer & Jones landfill, and Stanton Foundry landfill).

5. Nature and Extent of Contamination

This chapter of the RI documents the nature and extent of contamination in the sediments, floodplain soils, wetland and island soils, surface water, and fish of the Geddes Brook/Ninemile Creek site. The RI data collected by Honeywell and NYSDEC between 1998 and 2002, along with data not collected directly as part of this RI, provide a comprehensive basis for understanding the current nature and extent of contamination in the Geddes Brook/Ninemile Creek site.

Most CPOIs in the sediments at various locations in the site are present at concentrations exceeding NYSDEC sediment screening criteria. Mercury concentrations in sediment and floodplain soils reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek as well as the stream channel geomorphology and historical changes to the stream channel. Concentrations of total mercury were relatively high (greater than 10 mg/kg) at stations located on the right side of Ninemile Creek facing downstream between Transects TN-15 and TN-10 (within Reach CD; see Chapter 2, Figure 2-2 and Chapter 5, Figures 5-1a, 5-1b, and 5-2). These high concentrations of mercury are found in shallow sediments (0 to 0.30 m) as well as deeper intervals in this area. The stretch along the right bank between these transects is a relatively quiescent (i.e., depositional) region within Reach CD, where water entering Ninemile Creek from Geddes Brook does not readily mix across the entire Ninemile Creek cross section due to the presence of the islands. The sediments from this area of high mercury concentration were noted as containing Solvay waste materials in the 2001 BBL sediment probing survey. This area also contains the highest concentrations of methylmercury, arsenic, nickel, and zinc in Ninemile Creek. Higher concentrations of other metals at depth were most prevalent at Transects TN-5 and TN-6 in Reach BC of Ninemile Creek and, to a lesser extent, Transects TG-3 and TG-4 in Geddes Brook, with contamination extending to a depth of approximately 10 ft (3 m) in some cases.

The highest concentrations of organic CPOIs in sediments were found in lower Ninemile Creek and lower Geddes Brook. There were several elevated concentrations (greater than 1,000 µg/kg) of hexachlorobenzene in lower Geddes Brook and in Reach CD of Ninemile Creek. Concentrations of hexachlorobenzene exceeding 10,000 µg/kg occurred in Geddes Brook just below the discharge point of the West Flume to a depth of about 4 ft (1.28 m). Elevated levels (greater than 1,000 µg/kg) of Aroclors 1254 and 1268 were also detected at some stations in lower Geddes Brook and lower Ninemile Creek. Unlike Aroclor 1254, elevated concentrations of Aroclor 1268 occurred in the deeper sediments (greater than 1 m depth) in Reach CD of Ninemile Creek and in surface sediments (0 to 0.15 m) in Reach AB of Ninemile Creek. The highest concentrations of PCDD/PCDFs and toxicity equivalence quotients (TEQs) were found in Geddes Brook immediately below the confluence with the West Flume.

Mercury concentrations in soils from floodplain and wetland areas along Ninemile Creek showed a distinct distribution pattern, with elevated mercury concentrations exceeding 10 mg/kg in samples collected near the mouth of the creek and along Reach CD. Floodplain soils collected at depth intervals ranging from 0.3 to 0.9 m during the 2002 supplemental floodplain sampling program (Chapter 5, Figure 5-15) showed elevated levels of mercury as high as 76.9 mg/kg (on the right side of the mouth of Ninemile Creek in a low-lying wetland area [i.e., Reach AB]) and 43.1 mg/kg (1.5

m from the water's edge on the right bank facing downstream between the two southern islands in Ninemile Creek [i.e., Reach CD]).

It should be noted that the elevated concentrations of mercury at deeper intervals are localized in areas where Ninemile Creek is characterized as highly depositional at base flow. These elevated mercury concentrations at depth occur in the low-lying wetland area at the mouth of Ninemile Creek that has historically been exposed to flooding and in Reach CD where the elevated mercury concentrations in floodplain soil are adjacent to the sediments with elevated mercury concentrations at depth.

The sediments/soils from these areas of high mercury concentrations were identified as containing Solvay waste materials. Hexachlorobenzene, PAHs, PCBs, and PCDD/PCDFs were also detected at elevated concentrations in floodplain soils, mainly along lower Geddes Brook and along Reach CD of Ninemile Creek.

As with sediment, total mercury concentrations in surface water reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek. Total mercury concentrations were higher in the lower reaches of both Geddes Brook and Ninemile Creek than in the upper reaches.

Total mercury concentrations in the West Flume, lower Geddes Brook, and lower Ninemile Creek have declined since 1990, with concentrations in 1998 at least 77 percent lower than 1990 values in these areas of the system. Concentrations of the other inorganics and conventional parameters (e.g., chloride, calcium, sodium, and TDS) in surface water clearly indicate the impact of Wastebeds 9 to 15 on the Geddes Brook/Ninemile Creek site.

With respect to fish data, mercury concentrations were as follows:

- **1998 data** – Mercury concentrations in adult fish ranged from 68.3 to 1,534 µg/kg wet weight in fillets and from 8.4 to 987.5 µg/kg wet weight in remainder tissues. Mercury levels detected in YOY fish collected in Ninemile Creek upstream of the mercury source (i.e., Geddes Brook) ranged from 18.1 to 46.8 µg/kg wet weight.

- **2000 data** – Mercury concentrations in adult fish ranged from 467 to 904 µg/kg wet weight in fillets and from 379 to 734 µg/kg wet weight in remainder tissue. Mercury was detected in YOY fish collected at the mouth of Ninemile Creek at concentrations ranging from 144 to 224 µg/kg wet weight.

- **2002 data** – Mercury was detected in all YOY fish samples collected downstream of the source in Ninemile Creek at concentrations ranging from 180 to 850 µg/kg wet weight.

6. Transport and Fate of Chemical Parameters of Interest

Chapter 6 discusses the transport of contaminants from Geddes Brook to Ninemile Creek, and from Ninemile Creek to Onondaga Lake, as well as the fate of contaminants within the Geddes Brook/Ninemile Creek site. Mercury is of particular importance in the discussion; however, other CPOIs are also discussed. Using the distribution of CPOIs in sediments and floodplain soils, and concentrations and loads of mercury and TDS in surface water, a transport and fate analysis of the CPOIs in the Geddes Brook/Ninemile Creek site was performed. The major conclusions of this analysis include the following:

- Wastes from the Honeywell Syracuse Works were discharged into Geddes Brook and Ninemile Creek via the West Flume and overflow from the Solvay Wastebeds, starting at the time that the wastebeds were first constructed (1926 for Wastebeds 1 to 8, and 1944 for Wastebeds 9 to 15) and with the construction of the LCP Bridge Street Plant (1953). These wastes contained primarily Solvay waste, but included other waste streams.

- Mercury and other CPOIs (e.g., hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs) appear to be primarily associated with depositional zones containing Solvay waste materials downstream of the Honeywell LCP Bridge Street site and the West Flume.

- Some of the historical contaminated materials in Ninemile Creek were likely removed during various non-remedial construction operations such as channelization and rerouting of the stream beds.

- The changes in the hydraulic regime of Geddes Brook and Ninemile Creek, caused by the cessation of Honeywell discharges in 1980, have resulted in some of these historically depositional areas becoming more erosional.

- Reach CD contains the highest concentrations of CPOIs in Ninemile Creek, and the reach as a whole is the most erosional in lower Ninemile Creek. The right-hand channel of Reach CD (facing downstream) is depositional at base flow and erosional at high flow.

- Normalization of surface sediment mercury concentrations to iron (normalizing to iron helps to remove variability in concentrations due to changes in factors such as grain size, etc.; see Chapter 6, Section 6.2) indicates that there may be localized areas with uniquely high concentrations of mercury within lower Ninemile Creek.

- Based on load analysis, the sediments of lower Geddes Brook and lower Ninemile Creek are major sources of mercury to the water column and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake at base-flow conditions. However, the source of the mercury measured in lower Ninemile

Creek at base flow appears to be heavily influenced by releases from the West Flume, which is the largest external source of mercury to the Geddes Brook/Ninemile Creek site.

- The transport of mercury in Geddes Brook and Ninemile Creek surface water has been measured to increase significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils to Onondaga Lake increases dramatically. Under these high-flow conditions, the sediments and floodplain soils of lower Ninemile Creek become the dominant source of mercury being transported to Onondaga Lake, and are a major component of the annual mercury load to the lake.

- An analysis of loads of TDS in surface water confirms that groundwater from Wastebeds 9 to 15 continues to be a source of ionic waste constituents, primarily in the forms of calcium chloride and sodium chloride, to Geddes Brook and Ninemile Creek.

- The transport of TSS and ionic waste constituents in Geddes Brook and Ninemile Creek surface water increases significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils increases dramatically. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of TSS being transported to Onondaga Lake, and are a major component of the annual TSS and ionic waste constituents load to the lake.

- CPOIs other than mercury (hexachlorobenzene, PCBs, PAHs, PCDD/PCDFs) that are primarily associated with the same sediments as mercury would be expected to have similar transport and fate as mercury. The sediments and floodplain soils containing these CPOIs would be expected to erode under high-flow conditions and ultimately transported to Onondaga Lake.

7. Human Health Risk Assessment

The objective of the HHRA is to evaluate the potential for adverse human health effects associated with current and future exposures to chemicals present in the fish, sediment, soil, and surface water of the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those chemicals (i.e., under the no action alternative). For cancer risks, the acceptable risk levels, as specified by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR § 300.430[e][2][i][A][2]), range from an excess upper-bound lifetime cancer risk to an individual of 1×10^{-4} to 1×10^{-6}, with 1×10^{-6} as the point of departure for determination of remedial goals. For non-cancer hazards, the target hazard level is a hazard index (HI) of 1.0 or less, the level below which adverse health effects are considered to be unlikely. Key findings of the HHRA include:

- For the reasonable maximum exposure (RME) scenario for consumption of fish, the calculated non-cancer hazards (from 4.1 for adults to 6.4 for young children) exceeded the non-cancer target level (1.0) and the calculated cancer risks (from 2.9×10^{-5} for young children to 9.3×10^{-5} for adults) approached the upper end of the 10^{-6} to 10^{-4} risk range. For the RME scenario, the calculated total cancer risk to adults and older children across all pathways (ranging from 2.4×10^{-4} to 2.7×10^{-4}) exceeded the high end of the cancer risk range (10^{-4}), and exceeded the low end of the risk range (10^{-6}) by more than two orders of magnitude. The RME total non-cancer hazards across all pathways (ranging from 4.6 to 6.4) for all recreational receptors exceeded the target HI (1.0) by a factor of four or more.

- The calculated central tendency (CT) non-cancer HIs for all receptors were less than the target threshold (i.e., less than 1). CT total cancer risks for all receptors, ranging from 1×10^{-6} for construction workers to 9.4×10^{-6} for older child recreational receptors, were below the upper end of the 10^{-6} to 10^{-4} risk range.

- RME cancer risks for 17 of the 36 pathways other than fish ingestion equaled or exceeded the low end (1×10^{-6}) of the cancer risk range (10^{-6} to 10^{-4}), with the highest of these being 9.1×10^{-5} for adult exposure to Upper Geddes Brook surface water and 7.8×10^{-5} for older child exposure to Upper Geddes Brook sediments. For the CT cancer risk calculations, the low end of the cancer risk range was equaled or exceeded in three of the 36 pathways other than fish ingestion, with a maximum CT risk of about 4.5×10^{-6} for older child exposure to Upper Geddes Brook surface water.

8. Baseline Ecological Risk Assessment

The objective of the BERA is to evaluate the potential for adverse ecological effects associated with current exposures to chemicals and stressors present in the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those contaminants (i.e., under the no action alternative). Key findings of the BERA include:

- Honeywell-related contaminants within the Geddes Brook/Ninemile Creek site have produced adverse ecological effects at all trophic levels examined.

- Honeywell's ionic wastes have also impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the streams for feeding or spawning.

- Comparisons of measured tissue concentrations and modeled doses (i.e., intake) of chemicals to TRVs show exceedances of HQs for site-related chemicals throughout the range of the point estimates of risk. Many of the contaminants in the Geddes Brook/Ninemile Creek site are persistent and, therefore, the ecological risks associated with these contaminants are unlikely to decrease significantly in the short term in the absence of remediation. The various field studies performed on site indicate that contaminant levels have not decreased substantially in some of the site media (i.e., sediments, soils, fish) over the last 15 years. On the basis of these comparisons, it has been determined in the BERA that all receptors examined are at risk due to contamination at the Geddes Brook/Ninemile Creek site. These receptors, representing various trophic levels and feeding preferences, indicate either impacts or potential impacts to most of the Geddes Brook and Ninemile Creek ecological community.

9. Preliminary Remedial Action Objectives

Pursuant to USEPA guidance, preliminary RAOs for the Geddes Brook/Ninemile Creek site are derived from key conclusions of the RI, including the analysis of the nature and extent of contamination, transport and fate of contaminants, and the risk assessments. The key conclusions of the RI for purposes of developing RAOs are that:

- Elevated levels of metals and organic compounds result in adverse impacts (known or modeled) to all trophic levels of the Geddes Brook/Ninemile Creek site ecosystem examined.

- Honeywell's ionic wastes have impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the streams for feeding or spawning.

- There are potential non-cancer hazards for humans, based primarily on the consumption of fish. The potential total cancer risk from consumption of fish and exposure to sediment, soil, and surface water exceeds the upper end of USEPA's specified risk range.

- The major historical external sources of mercury at the Geddes Brook/Ninemile Creek site were the disposal of wastes containing CPOIs from the various Honeywell upland sites either directly, via the West Flume, or through migration from the Solvay Wastebeds into Geddes Brook and Ninemile Creek.

- Current groundwater releases from Honeywell's Wastebeds 1 to 15 do not appear to be a major source of mercury to Geddes Brook and Ninemile Creek.

- Groundwater releases from Honeywell's Wastebeds 9 to 15 have been, and continue to be, major external sources of ionic waste constituents to the Geddes Brook/Ninemile Creek site.

- The current major external source of mercury to the Geddes Brook/Ninemile Creek site is the Honeywell LCP Bridge site, via the West Flume. For the remedial actions at the Geddes Brook/Ninemile Creek site to be fully effective in reducing risks, this external source will need to be remediated under a separate program and is not included in the preliminary RAOs for the Geddes Brook/Ninemile Creek site specified below. The remedial design at Operable Unit 1 (OU-1) is underway at this site. An RI/FS is underway at OU-2.

- The major internal sources of mercury are the sediments and floodplain soils of lower Geddes Brook and lower Ninemile Creek.

- Surface water is the major transport mechanism for sediment containing mercury and other CPOIs in Geddes Brook and Ninemile Creek.

- Mercury and other CPOIs in Geddes Brook and Ninemile Creek are transported to Onondaga Lake. The Onondaga Lake RI (TAMS, 2002c) established that CPOIs transported to the lake remain available to the environment.

The preliminary RAOs for the Geddes Brook/Ninemile Creek site, which will be addressed pursuant to the FS, are as follows:

- To eliminate or reduce, to the extent practicable, releases of mercury and other CPOIs from the sediments and floodplain soils of lower Geddes Brook and lower Ninemile Creek.

- To eliminate or reduce, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources, as well as potential risks to humans.

- To reduce, to the extent practicable, levels of mercury and other CPOIs in surface water in order to meet surface water quality standards.

1. INTRODUCTION

Honeywell International, Inc. (formerly AlliedSignal, Inc.; referred to herein as Honeywell) is currently conducting a remedial investigation and feasibility study (RI/FS) of the Geddes Brook/Ninemile Creek site, located near Onondaga Lake, New York (Figure 1-1). The Geddes Brook/Ninemile Creek RI/FS is being conducted pursuant to the terms of a Consent Decree (Index # 89-CV-815) entered into with the State of New York, dated March 16, 1992, and associated stipulations (Consent Decree). The Geddes Brook/Ninemile Creek RI/FS is proceeding separately from the Onondaga Lake RI/FS.

To the extent that Geddes Brook and Ninemile Creek have released and continue to release contaminants to Onondaga Lake, the previously issued Onondaga Lake RI, baseline ecological risk assessment (BERA), and human health risk assessment (HHRA) (TAMS, 2002c,a,b) assessed the nature, extent, and risks associated with the impacts on the lake. Geddes Brook and Ninemile Creek were assessed in the Onondaga Lake RI, BERA, and HHRA by measuring sediment and water quality conditions in the lake at the Geddes Brook/Ninemile Creek site's point of discharge and by evaluating contaminant loadings from the site to the lake. By way of contrast, this RI and the associated BERA and HHRA for the Geddes Brook/Ninemile Creek site identify and assess the contamination within these two tributaries and their floodplains.

As part of the Geddes Brook/Ninemile Creek RI/FS, draft BERA and RI documents (Exponent, 2000a,c) were submitted by Honeywell in August 2000 and the draft HHRA was submitted in July 2000 (Exponent, 2000b). The three documents were reviewed by the New York State Department of Environmental Conservation (NYSDEC) and the US Environmental Protection Agency (USEPA), and the HHRA was also reviewed by the New York State Department of Health (NYSDOH). With the concurrence of USEPA, NYSDEC and the New York State Department of Law (NYSDOL) disapproved the draft documents and provided comments to Honeywell in November 2000. After completing additional sampling in 2001, Honeywell submitted revised BERA, HHRA, and RI reports (Exponent, 2001a,b,c). These revised reports were also assessed by these reviewers and, with their concurrence, NYSDEC and NYSDOL disapproved the revised reports in February 2002 (T. Larson, pers. comm., 2002a). The reasons for disapproval of the revised reports are outlined in the joint NYSDEC/NYSDOL determination accompanying this document.

This RI report is the NYSDEC/TAMS Consultants, Inc. (TAMS) rewrite of Honeywell's revised RI report, and it has likewise been reviewed by USEPA. This rewrite has been completed in accordance with USEPA guidance for conducting RI/FSs. Honeywell is scheduled to submit a draft FS report in December 2003 for agency review, based on the findings of this RI and associated risk assessments.

In conjunction with the RI/FS, Honeywell entered into an Order on Consent for the Geddes Brook Interim Remedial Measure (IRM) in April 2002 (NYSDEC, 2002). The Geddes Brook IRM is proceeding on a parallel path to the Geddes Brook/Ninemile Creek RI/FS. The objectives of this IRM, as stated in the Order on Consent (NYSDEC, 2002), are to:

- Eliminate, to the extent practicable, within the scope of the IRM, the transport of mercury into Ninemile Creek from Geddes Brook sediments and floodplain soils.

- Eliminate, to the extent practicable, within the scope of the IRM, potential impacts to human health and fish and wildlife resources associated with site-related contamination.

A Geddes Brook IRM Work Plan (Parsons, 2002a) prepared by Honeywell has been reviewed and approved by NYSDEC (T. Smith, pers. comm., 2002, 2003). A supplemental investigation was conducted by Honeywell in December 2002 to principally support the design of the Geddes Brook IRM. The results are discussed in Chapter 5, Nature and Extent of Contamination, and are presented in Appendix M, Geddes Brook IRM Analytical Data and Validation Report (2002), in this RI report. The impact of this IRM on the Geddes Brook/Ninemile Creek site will be further evaluated in the Geddes Brook/Ninemile Creek FS.

1.1 Purpose and Organization

The purpose of this RI report is to present the results of studies conducted as part of this RI, and conducted independently of this RI but believed to be appropriate for inclusion in this RI, in order to evaluate: the nature and extent of contamination, including investigations to identify and determine the distribution of chemical parameters of interest (CPOIs) in water, sediment, soil, and fish tissue, and human health and ecological risks. The CPOIs for the RI, which are further defined in Chapter 5, are those elements or compounds that were selected as contaminants of potential concern (COPCs), contaminants of concern (COCs), or stressors of concern (SOCs) in the Geddes Brook/Ninemile Creek BERA and HHRA (TAMS, 2003a,b).

The CPOIs include contaminants considered hazardous, such as mercury and polychlorinated biphenyls (PCBs), as well as potentially less hazardous stressors, such as calcium and chloride. The CPOIs were identified based on an evaluation of the comprehensive chemical analysis of samples collected within the site, which is defined in Section 1.2. The list of CPOIs includes Honeywell-related chemical parameters, as well as chemical parameters found at the site that may not be Honeywell-related. As stated in the Geddes Brook/Ninemile Creek RI/FS Work Plan (NYSDEC, 1998, 2000a), the principal objectives of this RI are to:

- Determine the concentration and distribution of contaminants in Geddes Brook, Ninemile Creek, and associated floodplain areas within the site.

- Determine the ecological and human health significance of contaminants in the Geddes Brook/Ninemile Creek site.

- Develop sufficient data to evaluate the potential remedial alternatives along with their engineering feasibility and relative effectiveness in addressing Honeywell-related contamination in the Geddes Brook/Ninemile Creek site.

This RI report is structured in accordance with USEPA's guidance for reporting on site investigations (USEPA, 1988, 1990) under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This chapter provides a site description, site history and a summary of CPOIs for the site. The remainder of this report consists of nine chapters, as follows:

- Chapter 2, Field and Laboratory Investigations, provides a summary of the investigations performed within the Geddes Brook/Ninemile Creek site that are applicable to the RI.

- Chapter 3, Site History and Physical Characteristics, provides an overview of the site's history and physical characteristics based on both data collected as part of the RI and data from other sources.

- Chapter 4, Sources and Potential Sources of Chemical Parameters of Interest, describes the sources and potential sources of CPOIs to the Geddes Brook/Ninemile Creek site based on historical and recent information.

- Chapter 5, Nature and Extent of Contamination, describes the measured concentration and distribution of CPOIs at the site based on data collected during the RI and during other applicable studies.

- Chapter 6, Transport and Fate of Chemical Parameters of Interest, describes the transport and fate of various substances, including mercury and other CPOIs, at the site.

- Chapter 7, Human Health Risk Assessment, provides a summary of the HHRA. The complete Geddes Brook/Ninemile Creek HHRA report is presented under separate cover (TAMS, 2003b).

- Chapter 8, Baseline Ecological Risk Assessment, provides a summary of the BERA. The complete Geddes Brook/Ninemile Creek BERA report is presented under separate cover (TAMS, 2003a).

- Chapter 9, Conclusions, summarizes the major findings of the RI, as well as preliminary remedial action objectives (RAOs).

- Chapter 10, References, presents references for all documents and personal communications cited in the main body of the report.

- Appendix A presents the analytical data for the 1998 Geddes Brook/Ninemile Creek field investigation.

- Appendix B presents the quality assurance review summaries for the 1998 Geddes Brook/Ninemile Creek field investigation.

- Appendix C presents the raw data and quality assurance review summary for the sediment toxicity tests conducted in 1998.

- Appendix D presents the raw data and quality assurance review summary for the benthic macroinvertebrate (BMI) survey conducted in 1998.

- Appendix E presents the analytical data for the 2001 Geddes Brook/Ninemile Creek field investigation along with data collected in 2000 in Wetland SYW-10 near the mouth of Ninemile Creek.

- Appendix F presents the quality assurance review summaries for the 2001 field investigation.

- Appendix G, which is divided into Appendices G1 and G2, presents the analytical data and quality assurance review summaries for the 2002 supplemental Ninemile Creek floodplain soil (G1) and young-of-year (YOY) fish sampling (G2) programs.

- Appendix H presents the results of the 1998 hydrological evaluation.

- Appendix I provides statistical summaries of the 1992 and 1998 to 2002 analytical data.

- Appendix J presents screening of the 1998 to 2002 sediment, soil, and surface water analytical data against relevant NYSDEC and USEPA screening criteria, standards, and guidance values.

- Appendix K presents contaminant profiles for sediment and soil for samples collected from 1998 to 2002 in the Geddes Brook/Ninemile Creek site.

- Appendix L presents the data summaries for data collected independently of this RI.

- Appendix M presents the analytical data and sample location maps for the 2002 Geddes Brook IRM field investigation, as provided by Honeywell.

NYSDEC/TAMS obtained some information, including sources of historical contamination, in this RI report and accompanying BERA and HHRA (TAMS, 2003a,b), from, among other sources, reports and materials prepared by Honeywell and its consultants. While the accuracy of the information provided by Honeywell and its consultants is accepted for purposes of these reports, it must be noted that pursuant to paragraph 68 of the Consent Decree, discovery in the underlying litigation has been stayed. Consequently, the information furnished by Honeywell and its consultants, as well as information provided by third-party sources, has not been verified through the formal discovery process. New York State reserves the right, consistent with and without limitation to its rights under paragraphs 33 and 34 of the Consent Decree and under state and federal law, to correct or amend any information in the RI and risk assessment reports if, without limitation: (a) discovery is conducted, and (b) that discovery reveals information supporting such correction or amendment.

1.2 Site Description and Definition

Geddes Brook and Ninemile Creek are located southwest of Onondaga Lake (Figure 1-2). Ninemile Creek originates at Otisco Lake and flows approximately 16 miles (mi) (26 kilometers [km]) northeast to its mouth at Onondaga Lake. Ninemile Creek receives surface inflow from Beaver Meadow Brook and Geddes Brook at approximately 2.8 mi (4.5 km) and 1.3 mi (2.1 km), respectively, upstream from Onondaga Lake (Figure 1-2). Between Amboy Dam and Onondaga Lake, Ninemile Creek flows adjacent to Wastebeds 1 to 8, 9 to 11, and 12 to 15. Upstream of the dam, Ninemile Creek flows through woodlands, farmlands, and some light industrial/commercial areas. Ground surface elevations range from approximately 400 feet (ft) (122 meters [m]) above mean sea level (amsl) at the most upstream section of Ninemile Creek addressed in this study, to approximately 363 ft (111 m) amsl where the creek enters Onondaga Lake.

Geddes Brook originates in the town of Camillus (located southwest of Syracuse, New York). Geddes Brook flows approximately 3 mi (5 km) northeast to its confluence with the West Flume, a drainage ditch that passes through the LCP Bridge Street site, and an additional 0.3 mi (0.5 km) north to Ninemile Creek on the perimeter of the New York State Fairgrounds in Solvay, New York (Figure 1-2). The West Flume will be remediated by Honeywell as part of the LCP Bridge Street site. Before entering Ninemile Creek, Geddes Brook flows through or adjacent to areas formerly used for commercial and/or industrial purposes. Upstream of the West Flume, Geddes Brook flows through residential and commercial areas of Geddes, New York. Ground surface elevations range from approximately 430 ft (130 m) amsl at the most upstream section of Geddes Brook addressed in this study, to approximately 370 ft (113 m) amsl at the confluence of Geddes Brook and Ninemile Creek.

For the purposes of this RI, the Geddes Brook/Ninemile Creek site includes the following:

- Geddes Brook sediment and surface water from approximately 2,500 ft (760 m) upstream from its intersection with Gerelock Road to the point of discharge into Ninemile Creek and associated floodplain soil from its intersection with the West Flume to the point of discharge into Ninemile Creek.

- Ninemile Creek sediment and surface water from Amboy Dam to the point of discharge into Onondaga Lake and associated floodplain soil from its intersection with Geddes Brook to the point of discharge into Onondaga Lake.

- State and federal wetlands associated with the Geddes Brook/Ninemile Creek site (i.e., Wetland SYW-18 and Wetland SYW-10 east of I-690). Wetland SYW-10 west of I-690 is being evaluated as part of the Maestri 2 site.[1]

The Geddes Brook/Ninemile Creek site is defined as the sediment, floodplain soil, and surface water of Geddes Brook and Ninemile Creek, as discussed above. This definition is based on a conceptual model of the site in which contaminants from Honeywell sites (e.g., LCP Bridge Street, Solvay Wastebeds) were discharged (directly or indirectly) to Geddes Brook and Ninemile Creek, where they settled into the stream beds and floodplains. The accumulated contaminated sediments and floodplain soils of Geddes Brook and Ninemile Creek are sources of contaminants to the surface water and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake. Since, based on surface water and groundwater elevations (Blasland & Bouck, 1989), both Geddes Brook and Ninemile Creek are gaining streams in the study area below Amboy Dam (groundwater normally flows upward, discharging into the stream), the surface waters of these streams do not appear to be significant sources of contamination to the groundwater. While groundwater may discharge contaminants to the Geddes Brook/Ninemile Creek site, the sources of that contamination include upland sites which are being, or will be, investigated separately, as appropriate. Thus, groundwater is not evaluated in this RI and associated risk assessments.

The major features in the Geddes Brook and Ninemile Creek vicinity are shown in a recent aerial photograph presented as Figure 1-2. Chapter 3 provides detailed discussion of the Geddes Brook/Ninemile Creek area.

1.3 History of the Site and Surrounding Area

This section summarizes the history of industrial activities related to Geddes Brook and Ninemile Creek. Unless otherwise noted, the information below is based on Honeywell's Onondaga Lake RI/FS Site History Report (PTI, 1992).

1.3.1 General Industrial and Commercial Development

The salt springs in the region of Geddes Brook and Ninemile Creek, first described by settlers in 1786, supported a major salt recovery industry that thrived during the nineteenth century and fostered the development of an extensive infrastructure in the region, including railroads and the Erie Canal system. Over time, this infrastructure supported the establishment of a number of additional industries near the study area and near Onondaga Lake, including Honeywell's soda ash, benzene, toluene, xylenes, chlorinated benzenes, chlor-alkali, and hydrogen peroxide manufacturing facilities; petroleum-product storage facilities; a fertilizer production plant; a steel foundry; a manufacturing plant for vehicle accessories; a pottery and china manufacturing plant; and industries including pharmaceuticals, air conditioning, general appliances, and electronics manufacturing. In addition to

[1] The Maestri 2 site consists of a 10-acre area in a wetland that was filled with mill scale and other wastes from the Crucible Materials Corporation facility, as well as automotive wastes. The wetland adjacent to the Maestri 2 site drains into Ninemile Creek near its mouth. An RI is being performed by the potentially responsible parties (PRPs) at the site.

industry, an evolving municipal wastewater management system, which has influenced Onondaga Lake and its tributaries, has existed since the early 1800s.

The region surrounding the Geddes Brook/Ninemile Creek site experienced residential and economic growth during the twentieth century. Paralleling increased development in the area, the population of Onondaga County rose from approximately 160,000 in 1900 to 458,336 in 2000 (US Census Bureau, 2002). Much of the population is, and has historically been, located in the Syracuse metropolitan area, which is near the southeastern end of Onondaga Lake.

Both Geddes Brook and Ninemile Creek were rerouted during the development of the area. Geddes Brook was rerouted and channelized during construction of residential and commercial areas and to accommodate local roads, New York State Route 695 (Route 695), and railroad tracks. Ninemile Creek was rerouted and channelized to accommodate the Solvay Wastebeds, local roads, and Route 695. These historical changes in the physical characteristics of the Geddes Brook/Ninemile Creek site are further discussed in Chapter 3.

The industrial nature of this area, as well as the infrastructure and other development, influenced the site and contributed to its current condition. Honeywell facilities and disposal areas near the Geddes Brook/Ninemile Creek site (Figure 1-3) are discussed below.

1.3.2 Honeywell Facilities and Disposal Areas near Geddes Brook/Ninemile Creek

Honeywell's predecessor companies, which operated manufacturing facilities in Solvay, New York from 1881 to 1986, included:

- Allied Chemical and Dye Corp., which was incorporated on December 17, 1920 and included the following companies: General Chemical, Barrett Co., National Aniline and Chemical Co., Solvay Process Co., and Semet Solvay Co.

- Allied Chemical and Dye Corp., which was renamed as Allied Chemical Corp. on April 28, 1958.

- Allied Chemical Corp., which was renamed as Allied Corporation on April 27, 1981.

- Allied Corporation, which merged into AlliedSignal, Inc. on September 18, 1985.

- AlliedSignal, Inc., merged into Honeywell on December 1, 1999.

The availability of natural deposits of salt and limestone in greater Onondaga County was the primary reason for locating the facilities in Solvay. Initially, the Solvay Process Company used brine collected locally, but, in 1889, the company had started utilizing the salt formations in the Tully Valley about 20 miles (33 km) away. The Solvay Process Company, founded in 1881, used the ammonia soda (Solvay) process to produce soda ash, a product used in a variety of applications, including the manufacture of neutralization agents, detergent, industrial chemicals, and glass. Honeywell subsequently expanded its operation to three locations – the Main Plant, the Willis Avenue plant, and the Bridge Street plant – which are collectively described in this report as the Syracuse Works.

The Syracuse Works had three major product lines, as follows:

- **Soda Ash** – The soda ash product line produced primarily light and dense soda ash (Na_2CO_3) and a variety of related products, including sodium bicarbonate ($NaHCO_3$, or baking soda), sodium nitrite ($NaNO_2$), ammonium bicarbonate (NH_4HCO_3), ammonium chloride (NH_4Cl), calcium chloride ($CaCl_2$), sodium sesquicarbonate ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$, or "snowflake"), and caustic soda (NaOH).

- **Chlor-Alkali** – The chlor-alkali product line produced primarily liquid chlorine, caustic soda (NaOH), and caustic potash (KOH). In addition, potassium carbonate (K_2CO_3) and potassium bicarbonate ($KHCO_3$) were produced by carbonating caustic potash. Hydrogen gas was produced as a byproduct of the chlor-alkali process and was used in the manufacture of hydrogen peroxide (H_2O_2) and as a fuel in the power section of the Main Plant.

- **Benzene, Toluene, Xylenes, and Chlorinated Benzenes** – The benzene, toluene, and xylenes product line produced benzene, toluene, and xylenes, heavy hydrocarbons (tars), and naphthalene. The chlorinated benzenes product line produced chlorobenzene, liquid and crystal paradichlorobenzene, liquid and emulsified orthodichlorobenzene, and trichlorobenzenes. Hydrochloric or muriatic acid (HCl) was a marketed byproduct of the chlorinated benzene product line and was also used to lower the pH of feed brine in the chlor-alkali processes.

The Main Plant at the Syracuse Works manufactured soda ash and related products from 1884 to 1986 and benzene, toluene, xylenes, and naphthalene from 1917 to 1970. The Willis Avenue plant manufactured chlorinated benzenes and chlor-alkali products from 1918 to 1977. Chlor-alkali production by the diaphragm cell process was in operation at the Willis Avenue plant from 1918 until 1977. The mercury cell process was used at the Willis Avenue plant for chlor-alkali production from approximately 1947 (or possibly earlier) until 1977. Starting in 1953, the Bridge Street plant produced chlor-alkali products, as well as hydrogen peroxide, using the mercury cell electrolytic process. Diaphragm cells were added to the Bridge Street operation in 1968. The plant was sold to Linden Chemicals and Plastics (LCP) of New York in 1979. LCP continued to operate the plant until 1988.

In addition to the three major product lines, Honeywell facilities at the Main Plant produced coke and producer gas (a mixture of carbon monoxide, nitrogen, hydrogen, methane, carbon dioxide, and oxygen) for a limited time and generated electricity and steam for use in the manufacturing processes. Several products (i.e., nitric and picric acids; salicylic acid and methylsalicylate; benzyl chloride, benzoic acid, benzaldehyde, and phthalic anhydride; phenol; and hydrogen peroxide) were manufactured for only short periods of time as either startup operations that were later relocated or as part of pilot plant or developmental laboratory activity.

LCP Bridge Street Site

The LCP Bridge Street site, which includes the West Flume, is a source of mercury and historically other CPOIs to Geddes Brook, a tributary of Ninemile Creek. Geddes Brook receives discharge from the West Flume (formerly referred to as the "West Sewer" by AlliedChemical [NYSDOH, 1951]), a drainage ditch that passes through the LCP Bridge Street facility (TAMS, 2002c).

The LCP Bridge Street site consists of 20 acres (8 hectares) of land used for various industrial activities (including a mercury and diaphragm cell chlor-alkali production facility that operated from 1953 to 1988). The RI and risk assessments, based on data collected by Honeywell and NYSDEC, were completed by NYSDEC and TAMS in 1998. The FS for the site (Gradient and Parsons, 1999) was reviewed by NYSDEC, which issued a record of decision (ROD) in September 2000 (NYSDEC, 2000b). The buildings at the site were demolished as part of two IRMs. Remediation (described below) will commence pending completion and NYSDEC approval of the remedial design, which is being carried out under the terms of the NYSDEC-approved remedial design work plan (Parsons, 2002b). The wastes from the LCP Bridge Street plant were discharged to the West Flume, a tributary to Geddes Brook, which in turn is a tributary of Ninemile Creek. A detailed history of ownership, manufacturing processes, and waste management at the plant was described in the LCP Bridge Street RI report (NYSDEC/TAMS, 1998) and is discussed further in Chapter 4.

Solvay Wastebeds

An important feature of waste management at the Syracuse Works was the use of wastebeds located near the Geddes Brook/Ninemile Creek site and Onondaga Lake. The locations of the Solvay Wastebeds adjacent to the Geddes Brook/Ninemile Creek site (i.e., Wastebeds 1 to 15) are shown in Figure 1-3. In brief, the wastebeds that are located adjacent to the Geddes Brook/Ninemile Creek site were utilized as follows:

- From the 1920s to 1944, Wastebeds 1 to 8 were used to dispose of Honeywell's wastes, including those generated from the manufacture of soda ash. The mouth of Ninemile Creek was rerouted to allow for the construction of these wastebeds. Wastebeds 1 to 8 were subsequently transferred to New York State and Onondaga County. Groundwater from Wastebeds 1 to 8 discharges predominantly to Onondaga Lake.

- From 1944 to 1986, wastes from the soda ash and other operations were disposed of in Wastebeds 9 to 11 and 12 to 15, as described by Blasland & Bouck (1989) and Blasland, Bouck & Lee (BBL) (1999). Ninemile Creek was rerouted to allow for the construction of these wastebeds. Groundwater from

Wastebeds 9 to 15 discharges to Ninemile Creek and serves as a migration pathway for wastebed constituents.

- Other uses were as landfills for slag and wastewater treatment sludges from the Crucible Materials Corporation (a portion of Wastebed 5); for Metropolitan Syracuse Sewage Treatment Plant (Metro) sewage sludge disposal (portions of Wastebeds 5 and 12 to 15); sites for construction of parking lots for the New York State Fair (portions of Wastebeds 5, 7, and 8); and construction of I-690 (portions of Wastebeds 7 to 8).

Wastebeds 1 to 8 are to be further investigated. Wastebeds 9 to 15 are currently being evaluated by NYSDEC's Solid Waste Program. The sources and potential sources of CPOIs influencing the Geddes Brook/Ninemile Creek site, including these wastebeds, are discussed in more detail in Chapter 4.

It should be noted that several wastebeds exist in addition to Wastebeds 1 to 15. These additional wastebeds are discussed in the Onondaga Lake RI (TAMS, 2002c).

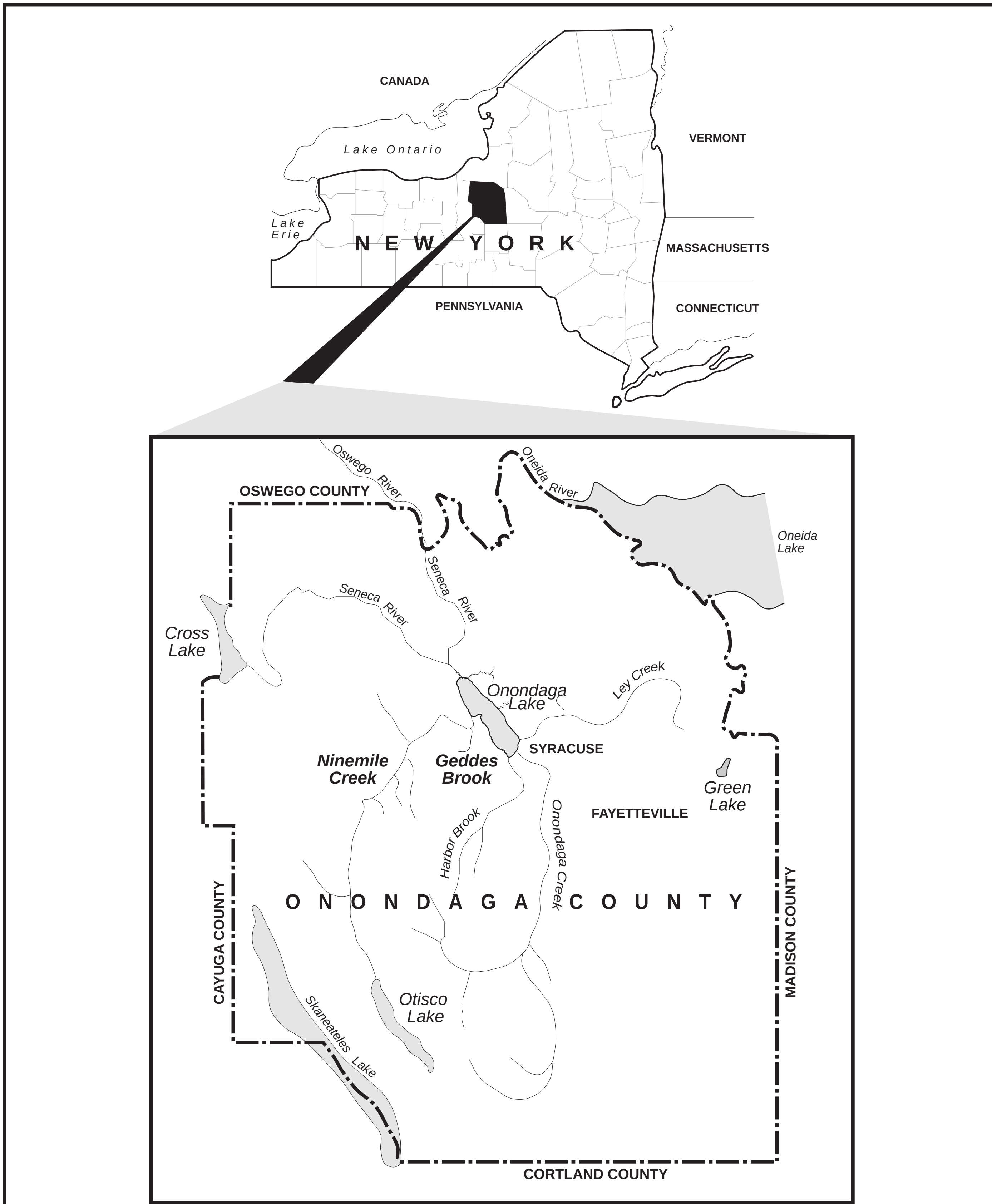
Mathews Avenue Landfill Site

An additional waste disposal area adjacent to Geddes Brook that was used by Honeywell is the currently inactive Mathews Avenue Landfill, which is bordered by the Old Erie Canal on the north and Geddes Brook to the west (see Figures 1-2 and 1-3). Honeywell entered into an Order on Consent (NYS index # D07-0007-01-01) in September 2002 for implementation of a preliminary site assessment (PSA) and, if warranted, an RI/FS. The Mathews Avenue Landfill was operated by Honeywell as a 6 NYCRR Part 360 construction and demolition (C&D) debris disposal site and may have received debris from the LCP Bridge Street site (Montgomery Watson Harza [MWH], 2002). Honeywell applied for closure of the landfill in 1988 under Part 360, and environmental sampling was performed by Honeywell at the landfill (MWH, 2002). Mercury and other CPOIs (e.g., chlorinated benzenes, volatile organic compounds [VOCs], PCBs, and lead) were detected in a sediment sample collected by NYSDEC at a location, adjacent to the landfill, that is drained to Geddes Brook via a tributary (drainage ditch) (MWH, 2002). Additional information can be found in Chapter 4.

1.4 Chemical Parameters of Interest

The CPOIs for the RI are defined as those elements or compounds that were selected as CPOIs, COPCs, COCs, or SOCs in the RI, BERA (TAMS, 2003a), and HHRA (TAMS, 2003b) and are presented in Table 1-1. Consistent with USEPA guidance, the methods used to select COPCs, COCs, and SOCs were intended to ensure that no chemicals detected at levels of potential human health or ecological concerns were excluded. Justification for selection of these COPCs, COCs, and SOCs is discussed in detail in the human health and ecological risk assessments, which are summarized in Chapters 7 and 8, respectively, of this RI report. The complete HHRA and BERA reports are provided under separate cover (TAMS, 2003b,a).

Consistent with USEPA guidance, COPCs for the HHRA were selected by comparing site concentrations to conservative risk-based concentrations (RBCs) derived by USEPA. For the BERA, COC/SOCs for specific media, including water, sediment, soil, and fish, were selected by comparing maximum site concentrations to the minimum (i.e., most conservative) screening criterion, when available, and using a number of criteria to refine them.



Source: Exponent, 2001c

Figure 1-1. Location of Geddes Brook, Ninemile Creek, and Onondaga Lake

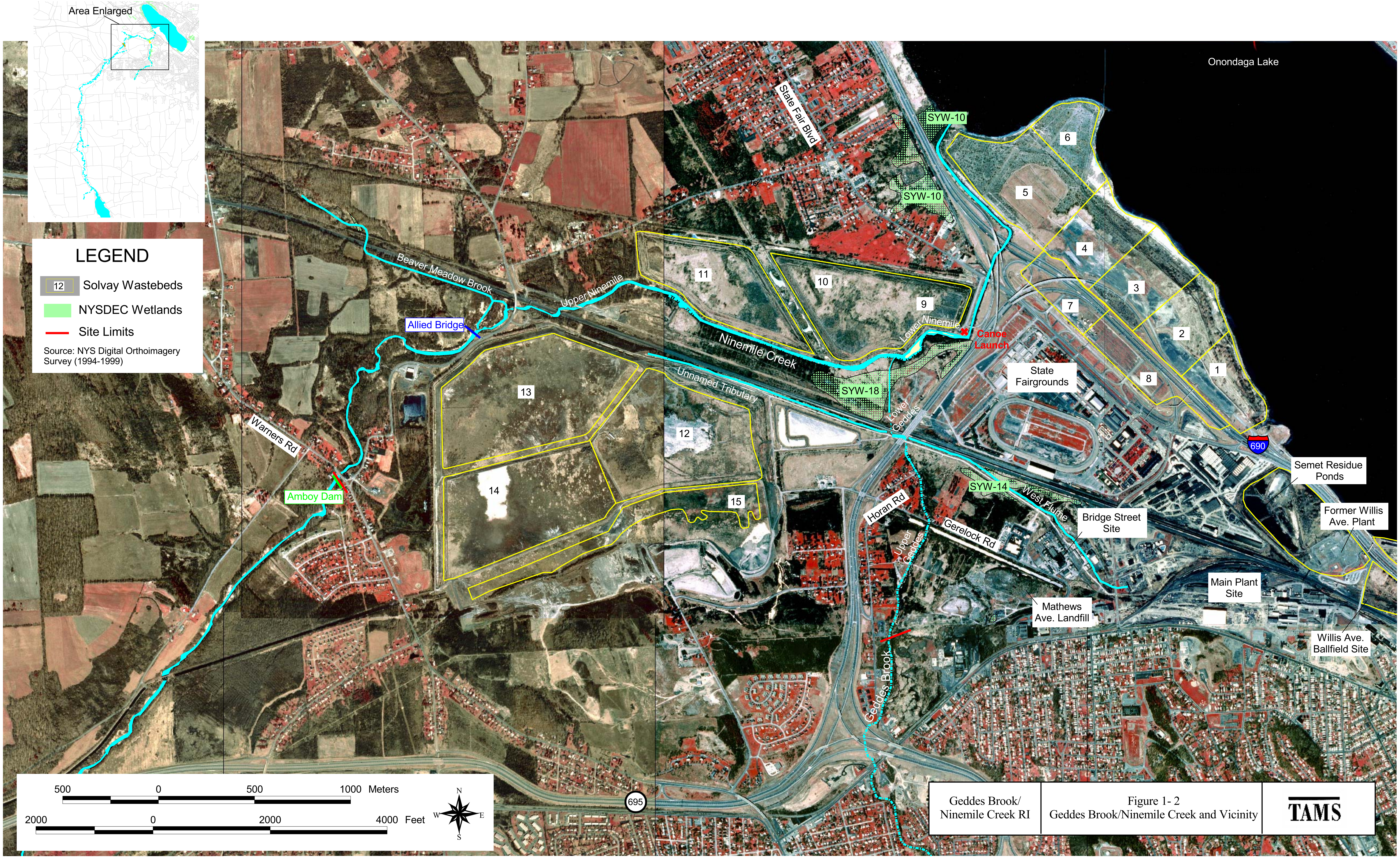
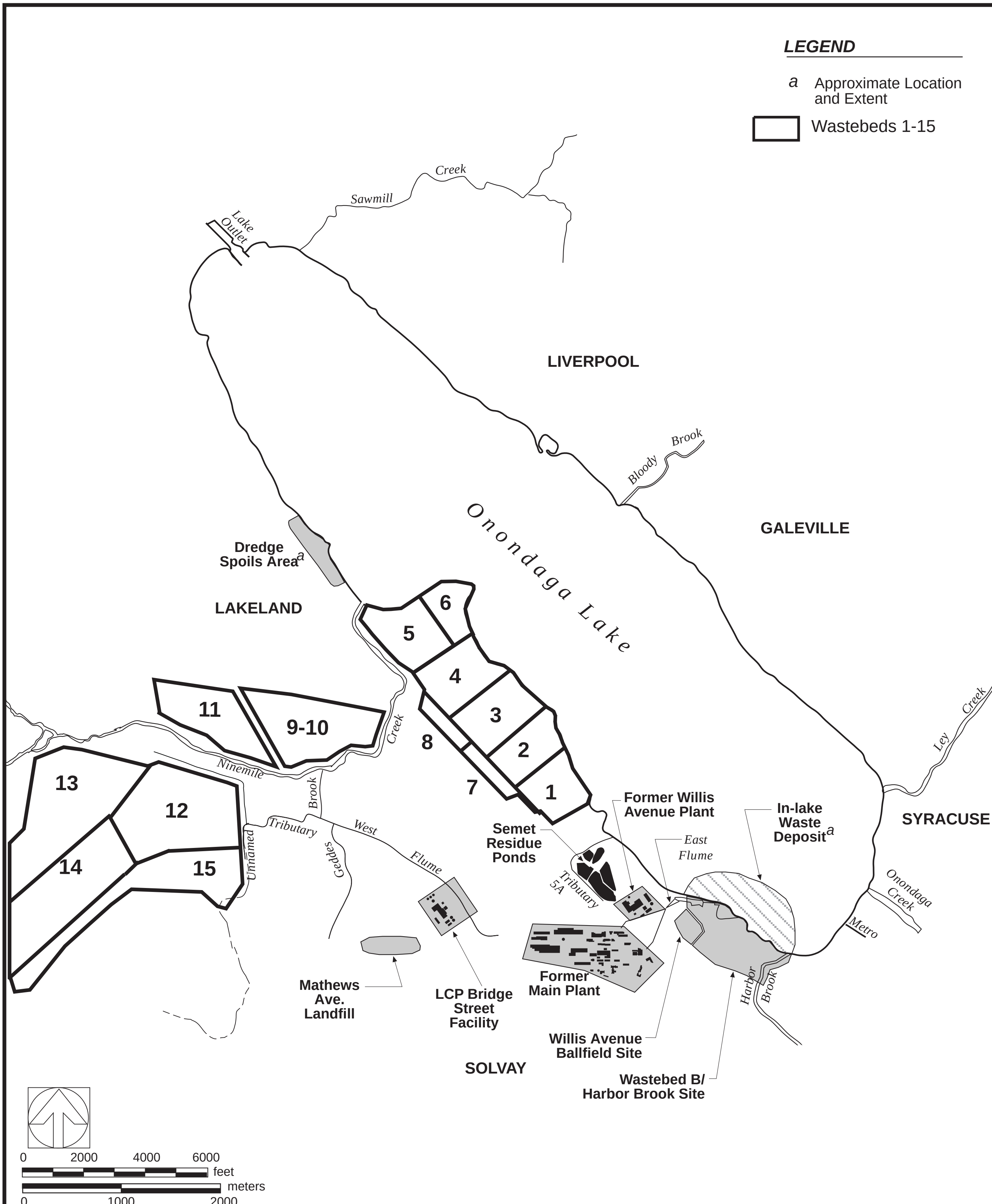


Figure 1- 2 Geddes Brook/Ninemile Creek and Vicinity



Source: Modified from NYSDEC/TAMS, 2002a

Figure 1-3. Locations of Various Honeywell Former Facilities and Disposal Areas near Geddes Brook/Ninemile Creek

Table 1-1. Chemical Parameters of Interest for the Remedial Investigation, Human Health and Baseline Ecological Risk Assessments for Geddes Brook/Ninemile Creek

	Media Screening				Food-Web Screening							
Chemical Parameters of Interest	Surface Water	Sediment	Soil[a]	Fish[b]	Tree Swallow	Belted Kingfisher	Great Blue Heron	Red-Tailed Hawk	Little Brown Bat	Short-Tailed Shrew	Mink	River Otter
Total Metals and Cyanide												
Aluminum	X^{R}	X^{H}	$X^{H, R}$									
Antimony	X^{H}	X^{H}	X^{H}									
Arsenic	X^{R}	$X^{E, H, R}$	$X^{E, H, R}$	$X^{E, H}$	X^{E}				X^{E}	X^{E}	X^{E}	X^{E}
Barium	$X^{E, R}$		X^{R}		X^{E}				X^{E}	X^{E}		
Beryllium			X^{R}									
Cadmium	X^{H}	X^{R}	$X^{E,R}$	X^{H}						X^{E}		
Calcium			X^{R}									
Chromium	X^{H}	$X^{H, R}$	$X^{E, H, R}$		X^{E}				X^{E}	X^{E}		
Cobalt			X^{R}						X^{E}			
Copper		$X^{E, R}$	$X^{E, R}$	X^{H}	X^{E}				X^{E}			
Iron	X^{R}	$X^{H, R}$	$X^{E, H, R}$	X^{H}								
Lead	$X^{E, H}$	$X^{E, H, R}$	$X^{E, H, R}$		X^{E}			X^{E}	X^{E}	X^{E}		
Manganese	$X^{E, H,R}$	$X^{E, H, R}$	$X^{E, H, R}$									
Magnesium			X^{R}									
Mercury/methylmercury	$X^{E, H,R}$	$X^{E, H, R}$	$X^{E, H, R}$	$X^{E, H}$	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}
Nickel		$X^{E,R}$	$X^{E,R}$	X^{H}	X^{E}				X^{E}			
Potassium			X^{R}									
Selenium		X^{H}	$X^{E, R}$	$X^{E, H}$	X^{E}	X^{E}			X^{E}	X^{E}	X^{E}	X^{E}
Sodium			X^{R}									
Thallium	$X^{H,R}$	X^{H}	$X^{E, H, R}$		X^{E}	X^{E}			X^{E}	X^{E}	X^{E}	X^{E}
Vanadium			$X^{E,R}$	X^{H}					X^{E}	X^{E}	X^{E}	
Zinc		$X^{E, R}$	$X^{E,R}$	$X^{E, H}$	X^{E}	X^{E}	X^{E}		X^{E}			
Cyanide		X^{H}	$X^{H, R}$									
Volatile Organic Compounds												
2-Butanone			X^{R}									
Acetone			X^{R}									
Benzene		X^{R}										
Chlorobenzene	X^{R}											
Chlorinated Aromatic Hydrocarbons												
Halogenated Alkenes												
Methylene chloride		X^{E}	X^{R}									
Miscellaneous Volatile Organic Compounds												
Carbon disulfide		X^{E}										
Semivolatile Organic Compounds												
1,3-Dichlorobenzene			X^{R}									
Dichlorobenzenes (sum)		$X^{E, R}$	X^{R}									
Trichlorobenzenes (sum)		X^{R}										
Dibenzofuran			X^{R}									
Chlorinated Aromatic Hydrocarbons												
Hexachlorobenzene		$X^{E, H, R}$	$X^{E, H, R}$	X^{H}	X^{E}			X^{E}	X^{E}	X^{E}	X^{E}	
Hexachlorobutadiene		X^{R}										
Low Molecular Weight Polycyclic Aromatic Hydrocarbons												
2-Methylnaphthalene		X^{R}	X^{R}									
Acenaphthene			X^{R}									
Acenaphthylene			X^{R}									
Anthracene		X^{R}	X^{R}									
Fluorene		X^{R}	X^{R}									
Naphthalene		X^{R}	X^{R}									
Phenanthrene		$X^{H, R}$	$X^{H, R}$									
High Molecular Weight Polycyclic Aromatic Hydrocarbons												
Benz[a]anthracene		$X^{H, R}$	$X^{H, R}$									
Benzo[a]pyrene		$X^{H,R}$	$X^{H, R}$									
Benzo[b]fluoranthene		$X^{H, R}$	$X^{H,R}$									
Benzo[ghi]perylene			$X^{H, R}$									
Benzo[k]fluoranthene		X^{R}	$X^{H, R}$									
Chrysene		X^{R}	X^{R}									
Dibenz[a,h]anthracene		X^{H}	$X^{H, R}$									

Table 1-1. (cont.)

CPOIs	Media Screening				Food-Web Screening							
	Surface Water	Sediment	Soil[a]	Fish[b]	Tree Swallow	Belted Kingfisher	Great Blue Heron	Red-Tailed Hawk	Little Brown Bat	Short-Tailed Shrew	Mink	River Otter
Fluoranthene		X^{R}	X^{R}									
Indeno[1,2,3-cd]pyrene		$X^{H, R}$	$X^{H,R}$									
Pyrene		X^{R}	X^{R}									
Polycyclic Aromatic Hydrocarbons												
Polycyclic aromatic hydrocarbons (sum)		X^{E}	X^{E}		X^{E}			X^{E}	X^{E}	X^{E}	X^{E}	
Phenols												
Phenol		$X^{E,R}$	$X^{E, R}$									
4-Methylphenol			X^{R}									
2-Methylphenol		X^{E}										
Phthalates												
bis[2-Ethylhexyl]phthalate		$X^{E, R}$										
Di-n-butlyphthalate			X^{R}									
Organonitrogen Compounds												
3-Nitroaniline			X^{H}									
N-Nitroso-di-*n* -propylamine			X^{H}									
Pesticides												
a-Chlordane		X^{E}	X^{E}									
g-Chlordane		X^{E}	X^{E}									
Aldrin			X^{R}									
Chlordanes (sum)		$X^{E, R}$	$X^{E, R}$							X^{E}	X^{E}	
Dieldrin		$X^{H, R}$	$X^{E, R}$	X^{H}				X^{E}		X^{E}	X^{E}	
Endrin		X^{R}	$X^{E, R}$					X^{E}		X^{E}		
Aldrin and Dieldrin (sum)		X^{R}										
4,4-DDD		X^{R}	X^{R}	X^{H}								
4,4-DDE		X^{R}	X^{R}	X^{H}								
4,4-DDT		X^{R}	X^{R}	X^{H}								
DDT and metabolites (sum)		X^{E}	$X^{E, R}$			X^{E}	X^{E}	X^{E}				
a-Endosulfan												
b-Endosulfan												
Endosulfans (sum)		$X^{E, R}$										
Heptachlor epoxide		$X^{E, H}$	X^{R}	X^{H}								
Heptachlor and heptachlor epoxide (sum)		$X^{E, R}$	$X^{E, R}$									
Hexachlorocyclohexane (b and sum)		X^{R}	$X^{E, R}$									
Methoxychlor		X^{R}										
Polychlorinated Biphenyls												
Aroclor 1248			X^{H}	X^{H}								
Aroclor 1254		X^{H}	X^{H}	X^{H}								
Aroclor 1260		X^{H}	X^{H}	X^{H}								
Aroclor 1268		X^{H}	X^{H}									
PCBs (sum of Aroclors)		$X^{E, H, R}$	$X^{E, H, R}$	$X^{E, H}$	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}
Dioxins/Furans	X^{H}	$X^{H, R}$	$X^{E,H}$	$X^{E, H}$	X^{E}	X^{E}		X^{E}	X^{E}	X^{E}	X^{E}	X^{E}
Other Substances												
Calcite		X^{E}										
Chloride	X^{E}											
Sodium	X^{E}											
Total dissolved solids	X^{E}											

Note: These CPOIs were identified in RI Appendix J, HHRA (TAMS, 2003b), and BERA (TAMS, 2003a) for Geddes Brook/Ninemile Creek.

BERA - baseline ecological risk assessment
CPOIs - chemical parameters of interest
HHRA - human health risk assessment

X^{E} - CPOIs retained in the BERA
X^{H} - CPOIs retained in the HHRA
X^{R} - CPOIs retained in the RI

[a] Screened for protection of invertebrates, microbes, and plants in the BERA (TAMS, 2003a) and for protection of human health in the HHRA (TAMS, 2003b).

[b] Reconstituted (whole-body) fish data were screened against toxicity thresholds developed from the literature for protection of fish in the BERA (TAMS, 2003a). Fish fillet data were screened for protection of human health in the HHRA (TAMS, 2003b).

2. FIELD AND LABORATORY INVESTIGATIONS

Field and laboratory investigations were conducted by Honeywell with NYSDEC oversight in 1998, 2001, and 2002 to satisfy data requirements, as set forth in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and applicable USEPA guidance, for the Geddes Brook/Ninemile Creek remedial investigation (RI). In addition, for this RI and the accompanying Geddes Brook/Ninemile Creek baseline ecological risk assessment (BERA) (TAMS, 2003a), NYSDEC and TAMS conducted supplemental young-of-year (YOY) fish sampling in October 2002.

The four major RI sampling programs conducted by Honeywell and NYSDEC included the following:

- Geddes Brook/Ninemile Creek RI/FS, Phase 1 sampling conducted by Exponent for Honeywell in 1998.

- Geddes Brook/Ninemile Creek supplemental RI/interim remedial measure (IRM) sampling conducted by Blasland, Bouck & Lee (BBL) for Honeywell in 2001.

- Ninemile Creek supplemental RI floodplain sampling conducted by O'Brien & Gere for Honeywell in 2002.

- Ninemile Creek supplemental YOY fish sampling conducted by NYSDEC and TAMS in 2002.

These investigations are discussed in Sections 2.1 through 2.12.

Subsequent to these four major RI sampling programs, a supplemental investigation was conducted by Honeywell in December 2002 in accordance with the approved Geddes Brook IRM Work Plan (Parsons, 2002a; T. Smith, pers. comm., 2002, 2003). These data will be used to facilitate the design of the Geddes Brook IRM and are briefly discussed in Chapter 5, Nature and Extent of Contamination. Honeywell's data tables, sample location figures, and validation report, which were prepared by Parsons and submitted to NYSDEC in May 2003 (J. McAuliffe, pers. comm., 2003), are included in Appendix M, Geddes Brook IRM Analytical Data and Validation Report (2002), of this RI report. The results were evaluated in the Geddes Brook/Ninemile Creek BERA and human health risk assessment (HHRA) (TAMS, 2003a,b).

In addition to the RI sampling programs, Geddes Brook and/or Ninemile Creek have been the subject of numerous investigations in recent years. Some of these were conducted as part of the Onondaga Lake RI (TAMS, 2002c) or for other adjacent Honeywell sites and disposal areas (e.g., the Solvay Wastebeds and the Mathews Avenue Landfill site). The results of these other studies were evaluated to complement the RI data collected from 1998 to 2002. Studies that were conducted in Geddes Brook and Ninemile Creek that were not part of the Geddes Brook/Ninemile Creek RI/FS and studies of other relevant Honeywell sites are summarized in Sections 2.13 and 2.14, respectively. All of the studies discussed in this chapter are summarized in Tables 2-1 to 2-7. The sampling stations from these studies, to the extent that data from the studies were used in the BERA and HHRA, are summarized in Table 2-8.

It should be noted that while the information contained in this chapter is based on verified data, NYSDEC or its representatives were not able to provide complete oversight of all sampling activities conducted by Honeywell and therefore cannot attest to whether proper techniques were used by Honeywell in every instance.

2.1 Remedial Investigation Sampling Summary (1998 – 2002)

This section summarizes the field and laboratory investigations conducted for the Geddes Brook/Ninemile Creek RI/FS from 1998 through 2002, as described below. Each of these investigations is further described in Sections 2.2 through 2.12. To summarize:

- The investigations performed in 1998 by Honeywell/Exponent included habitat and hydrological evaluations; surface water, sediment, and floodplain soil sampling; sediment toxicity testing; a benthic macroinvertebrate (BMI) survey; and fish and muskrat sampling. Sampling was conducted in both Geddes Brook and Ninemile Creek. These investigations were designed to provide comprehensive data on the concentration and distribution of substances in Geddes Brook and Ninemile Creek and to provide information on habitat, hydrology, and sediment toxicity for use in the Geddes Brook/Ninemile Creek BERA and HHRA (TAMS, 2003a,b). Details of each of these investigations are presented in Sections 2.2 through 2.7.

- A wetlands delineation was performed in 2000 by Honeywell/Exponent along lower Geddes Brook and Ninemile Creek (from just upstream of its confluence with Geddes Brook down to State Fair Boulevard). This delineation is described below in Section 2.8 and in Appendix E of the BERA (TAMS, 2003a).

- A sediment, island soil, and floodplain soil sampling program was conducted in 2001 by BBL for Honeywell to support the design of a proposed IRM for Geddes Brook and Ninemile Creek and to supplement the initial RI data. The sampling program is described in Section 2.9.

- The investigations conducted in 2002 included supplemental floodplain soil sampling adjacent to Ninemile Creek and YOY fish sampling in Ninemile Creek. The 2002 supplemental floodplain soil sampling program was conducted by O'Brien & Gere for Honeywell in accordance with the Ninemile Creek Supplemental Sampling Program (O'Brien & Gere, 2002a).The supplemental YOY fish sampling was conducted by NYSDEC and TAMS in accordance with the Work Plan for YOY Fish Collection in Ninemile Creek (TAMS, 2002d). These investigations are described below in Sections 2.11 and 2.12, respectively.

Section 2.10 summarizes the laboratory analyses and data quality for Honeywell's 1998 and 2001 investigations. The 1998 investigations were conducted in accordance with the Geddes Brook/Ninemile Creek RI/FS Work Plan (NYSDEC, 1998, 2000a) and its components, the sampling and analysis plan and quality assurance project plan (QAPP). Sections 2.11 and 2.12 summarize the laboratory analyses for the supplemental soil and YOY fish sampling conducted in 2002, respectively. The 2001 and 2002 investigations were conducted in accordance with sampling plans whose methodology and support procedures were adapted from the Geddes Brook/Ninemile Creek RI/FS Work Plan and QAPP (NYSDEC, 1998, 2000a) to provide comparability of data.

Chemical data from the 1998, 2000, 2001, and 2002 investigations are presented in Appendices A (Analytical Data Collected by Honeywell/Exponent [1998]), E (Analytical Data Collected by Honeywell/Exponent/BBL [2000/2001]), G (Ninemile Creek Supplemental RI Floodplain Soil and Fish Sampling [2002] – Analytical Data and Validation Reports), and M and are discussed in Chapter 5 of this RI report, as well as in the BERA and HHRA (TAMS, 2003a,b). Raw data for the sediment toxicity tests and BMI survey are presented in Appendices C (Sediment Toxicity Test Data and Quality Assurance Review Summary [1998]) and D (Benthic Macroinvertebrate Survey Data and Quality Assurance Review Summary [1998]). The results of the habitat evaluation, wetlands delineation, sediment toxicity tests, and BMI survey are discussed in the BERA (TAMS, 2003a). The results of the hydrological evaluation are presented in Appendix H, Hydrological Evaluation, and discussed in Chapter 3, Site History and Physical Characteristics.

Background information on land uses and sources and potential sources of contamination to areas upstream of the site is presented in Chapters 1 (Introduction) and 4 (Sources and Potential Sources of Chemical Parameters of Interest) of this RI report.

2.2 Habitat Evaluation (1998)

The objective of Honeywell's habitat evaluation was to assess the value of the Geddes Brook/Ninemile Creek site as habitat for fish and wildlife and its resource value to wildlife and humans. The habitat evaluation included a spawning survey to evaluate the current and/or potential value of Geddes Brook and Ninemile Creek as spawning areas for the fish forage base in Onondaga Lake. The results of the ecological checklist are contained in BERA Appendix B and discussed in BERA Chapter 3, and the fish spawning habitat survey is discussed in BERA Appendix F (TAMS, 2003a).

A survey of the various community types in and around the Geddes Brook and Ninemile Creek study area allowed for an assessment of the accessibility and suitability of habitats at the site for wildlife species. A combination of field observations and aerial-photograph interpretation were used to characterize the ecological communities within 0.5 miles (mi) (0.8 kilometers [km]) of the site, as required for the BERA.

Fieldwork pertaining to habitat evaluations of the Geddes Brook/Ninemile Creek site was conducted by Honeywell in July and October 1998, with the exception of the spawning survey that was completed by Honeywell in July 2000. Field staff walked the length of all aboveground (i.e., not diverted underground through culverts) portions of Geddes Brook between the shopping complex southwest of West Genesee Street and the confluence with Ninemile Creek (Figure 2-1). Ninemile Creek was surveyed on foot at the Three Aqueduct Park reference station (NM1; Figure 2-1), and traveled by canoe from Amboy Dam to the mouth at Onondaga Lake. During these field evaluations, field staff used bound field notebooks and photography to document aquatic habitat features, terrestrial community types, dominant plant species, and wildlife observations.

Interpretation of aerial photographs taken in May 1998 permitted the evaluation of terrestrial communities within 0.5 mi (0.8 km) of the study area that were not surveyed during the habitat evaluation. Comparison of the surveyed area with the aerial photographs allowed limited ground-truthing of the photographs, and facilitated the interpretation of areas on the photographs that were not surveyed in person.

The fish spawning habitat survey was performed in July 2000. The spawning survey area extended from Station NM1 to the mouth of Ninemile Creek and from Station GB1 to the mouth of Geddes Brook (Figure 2-1). In reaches of Geddes Brook that were upstream of Station GB3 (i.e., upstream of the confluence with the West Flume), the survey was restricted to accessible representative areas. The survey focused on assessing suitability of habitat for spawning for the following species:

- Blacknose dace (*Rhinichthys atratulus*).
- Brown trout (*Salmo trutta*).
- Creek chub (*Semotilus aromaculatus*).
- Smallmouth bass (*Micropterus dolomieu*).
- Tessellated darter (*Etheostoma olmstedi*).
- White sucker (*Catostomus commersoni*).

The spawning habitat survey consisted of walking or canoeing the area and recording information on habitat type (riffle, run, or pool), water depth, substrate, gradient, cover, current velocity, and temperature. Observations of general habitat use by fish during the survey were also recorded. As discussed in the BERA (TAMS, 2003a) and presented in the survey report included in Appendix F of the BERA, these data were compared to optimal and appropriate habitat suitability criteria derived from the literature for each of the six fish species.

2.3 Hydrologic Evaluation (1998)

The hydrologic evaluation conducted by Honeywell was designed to provide qualitative and quantitative information on the patterns and likelihood of sediment transport through downstream portions of Geddes Brook and Ninemile Creek. In Geddes Brook, the reach of interest was from West Genesee Street to the confluence with Ninemile Creek; in Ninemile Creek, the reach of interest was from Amboy Dam to the mouth. During a field survey of these streams in October 1998, observations regarding the bed, bank, and channel conditions and geometry were recorded. Results are presented in Appendix H and discussed in Chapter 3.

To facilitate field observations in 1998, the study reach in each channel was divided into segments based on slope, planform morphology, relationship to significant tributaries, and hydraulic roughness. Segmentation of Geddes Brook and Ninemile Creek is summarized as follows:

- In Ninemile Creek, the segment designation used by Honeywell (CDR Environmental Specialists [CDR], 1991) was employed. Determination of segment boundaries for Ninemile Creek was based exclusively on changes in channel slope. Delineation of the segments was possible on the basis of a large-scale (1:1,200) topographic map of the study segment produced from aerial photogrammetry (CDR, 1991).

- For Geddes Brook, topographic mapping of this level of detail was not available (except for the downstream-most 330 ft [100 m]), and no prior studies had consistently separated the study reach into segments. The topographic control available was the US Geological Survey (USGS) Syracuse West 7.5′ quadrangle. Therefore, the segmentation of the study reach was performed in the field during an initial reconnaissance and reflected changes in sinuosity, channel size, presence of hydraulic controls, and relationship to contaminant sources.

One or more typical channel cross-sections were surveyed in each stream segment during the course of the channel survey using a Sokkia Abney level, fiberglass-reinforced tape, and fiberglass surveying rod fitted with a rod level. Locations along the tape were measured to the nearest 0.1 ft increment and rod readings were measured to the nearest 0.01 ft increment (decreasing to the nearest 0.05 ft increment on particularly long cross sections). Where possible, the cross sections were surveyed by wading across the channel with the surveying rod. Where the channel was too deep to wade safely, a canoe was used by securing it to a tag line tied between the cross-section endpoints.

Streams typically present two morphological conditions: riffles (shallow, fast-moving, turbulent water) and pools (deep, slow-moving, laminar flow). However, due to variations within Geddes Brook and Ninemile Creek, cross-section locations were chosen by Honeywell based on gross channel geometry considered typical of the transport characteristics of each segment, so that there were three basic types of stream segments (instead of two), as follows:

- In relatively straight segments, the dominant change in channel geometry was associated with undulations in the channel bed. Therefore, the cross sections were representative of these two morphologic conditions (i.e., riffle or pool), if they were present.

- In more sinuous segments without substantial in-stream vegetation, pools were associated with bends and riffles with inter-bend areas. The cross sections were again representative of these two morphologic conditions (i.e., riffle or pool).

- In segments with considerable in-stream vegetation, the vegetation often causes localized variations of the stream bed. In these stream sections, the cross sections were located to characterize the more uniform portions of the channel away from any localized conditions caused by vegetation, so that the cross sections thus represent areas of maximum sediment transport capacity.

Concurrent with measurements of channel cross-sections, the thickness of unconsolidated sediment was determined for cross sections in Ninemile Creek upstream of Geddes Brook and in Geddes Brook upstream of the West Flume using 4 ft (1.2 m) and 8 ft (2.4 m) lengths of 0.5 in (1.2 cm) diameter steel reinforcing bar (rebar). The rebar was pushed into the sediment to the point of refusal, and the length above the sediment-water interface was then measured with the leveling rod and/or tape. Similar sediment probing had been accomplished for the downstream portions of the study reach in an earlier (December 1997) survey (NYSDEC, 1998, 2000a).

Channel observations were made during surveys of both Geddes Brook and Ninemile Creek. At each cross-section location, standard observations of channel patterns (straight, meandering, or braided), characterization of channel substrate (e.g., composed primarily of boulders, cobbles, or sand and silt, and the presence or absence of woody debris), presence and elevation of flood debris or other high-water marks, and proximity to known sources of contaminants were recorded by Honeywell.

Honeywell also collected stream channel data (cross-sectional representations of Ninemile Creek, including elevations for ground surface or channel bottom, areas of ineffective flow, and conveyance limits) as part of the supplemental RI/IRM sampling program in 2001 (BBL, 2001). These data are presented in the Geddes Brook/Ninemile Creek Sediment IRM Investigation Report (BBL, 2001), along with results of hydrologic modeling that was performed using the HEC-RAS computer program developed at the US Army Corps of Engineers (USACE) Hydrologic Engineering Center.

2.4 Surface Water, Sediment, and Floodplain Soil Sampling (1998)

2.4.1 Objectives

The objectives of Honeywell's surface water, sediment, and floodplain soil sampling were to determine concentrations of measured analytes in the Geddes Brook/Ninemile Creek site. The analytical results were used to define the distribution of substances in the various media and to relate substance distributions to potential sources. Additionally, the surface water and surficial sediment results were used in conjunction with the 1998 sediment toxicity results (see Section 2.5 below) to characterize the potential risks to ecological receptors. Sample intervals from sediment cores were analyzed to define the distribution of substances in the deeper sediment. Results of the surface water, sediment, and floodplain soil sampling are presented in Appendix A and discussed in Chapter 5.

2.4.2 Sampling Location and Frequency

Sampling locations for the various media were selected based on the proximity to potential sources and the locations of previous sampling efforts as well as the prior sampling results. All sampling locations were approved by a NYSDEC representative prior to sampling and were documented using a differential global positioning system (GPS). Surface water, sediment, and floodplain soil sampling are summarized as follows (locations are presented in Figure 2-1, and specifications and analyses are provided in Table 2-2):

- **Surface Water**: Surface water was collected during two separate dry-weather sampling events (July 15 through 20 and September 1 and 2, 1998) from four locations in Geddes Brook, seven locations in Ninemile Creek, and one location each in the West Flume and the unnamed tributary just upstream of the discharge points to Geddes Brook (see Figure 2-1).

- **Sediment**: Sediment was collected from the centers of the channels at six locations in Geddes Brook and ten locations in Ninemile Creek during the July 1998 sampling event (see Figure 2-1). Locations were selected to include areas of high sediment deposition.

- **Floodplain Soil:** Floodplain soil was collected from three locations along Geddes Brook and five locations along Ninemile Creek during the July 1998 sampling event (see Figure 2-1).

2.4.3 Field Methods

The following subsections briefly describe the procedures used by Honeywell for collecting surface water, sediment, and floodplain soil samples. More detailed information on the field methods are available in the RI/FS Work Plan (NYSDEC, 1998, 2000a). Modifications to the field collection methods described in the work plan are described in Section 2.4.5.

Pre-cleaned and appropriately preserved sample containers were provided by the analytical laboratories. All samples were clearly labeled and stored on ice in a cooler until they were transferred by overnight delivery service to the analytical laboratories. Samples were maintained under full chain-of-custody procedures at all times. Field procedures and observations were recorded by Exponent for Honeywell in bound field notebooks.

2.4.3.1 Surface Water

Surface water samples were collected using depth-integrating sampling techniques during low-flow, dry weather conditions. The reason for sampling during these weather conditions was to collect water samples that were indicative of base flow (groundwater seepage) conditions. In order to assure dry weather conditions, the National Oceanic and Atmospheric Administration (NOAA) was consulted prior to sampling in order to confirm that no major precipitation had occurred within the three-day period prior to sampling. During the July field effort, no rainfall occurred during the three days prior to sampling and 0.05 in (0.12 cm) of rain fell during the last day of sampling. During the September field effort, 0.11 in (0.25 cm) of rain fell three days prior to sampling and no rainfall occurred during sample collection (NOAA, 1998).

Low-flow conditions were confirmed by data from the USGS streamflow station in Ninemile Creek at Lakeland, New York (Station 04240300) (Figure 2-1). Data from this station were used to ascertain a monthly range of flow rates. Once this range was established, flow rates that occurred during sample collection were compared to the monthly ranges to confirm that samples were collected during low-flow periods. Sample collection in both July and September occurred during the low end of the flow-rate range for each month, as follows:

- Streamflow during July 1998 ranged from 54 to 520 cubic feet per second (cfs), and the streamflow during the July sampling event was 54 to 60 cfs.

- Streamflow during September 1998 ranged from 45 to 70 cfs, and the streamflow during the September sampling event was 48 cfs (USGS, 1999).

Further discussion of stream flow characteristics is provided in Chapter 3.

At each location, water quality measurements were obtained by Honeywell/Exponent using a Horiba Water Quality Checker 11-10. Water depth was measured to the nearest inch. Water samples were collected directly into appropriately preserved laboratory bottles at locations where water depths were 2 ft (0.6 m) or less. For water depths greater than 2 ft (0.6 m), a depth-integrated sampling device fitted with a 2-liter (L) Teflon bottle was employed to collect water. Water samples were transferred directly from the 2-L Teflon bottle to the appropriate sample bottles. Depth integration was achieved by raising and lowering the bottle through the full depth of the water column, avoiding both the water and sediment surfaces. Samples collected for mercury analysis were collected using USEPA's "clean hands" technique, in accordance with the standard operating procedures (SOPs) in the work plan. Samples were filtered in the laboratory through 0.45-μm pore size filters.

2.4.3.2 Sediment

Sediment cores were collected by manually pushing pre-cleaned Lexan tubes into the sediment to the point of refusal. Two or more cores were collected at each location. While the dense substrate at many sample locations resisted sediment penetration to the depth specified in the work plan (i.e., 3.3 ft [1 m]), several attempts to reach the maximum depth were made at such locations before a core with a less-than-specified depth was determined to be acceptable. Core depths are reported along with the data in Appendix A.

Cores were sectioned into the following sample intervals: 0 to 6 in (0 to 15 cm), 6 to 18 in (15 to 45 cm), 18 to 30 in (45 to 75 cm), and greater than 30 in (75 cm). USEPA considers the top 6 in (15 cm) of sediment to be representative of the biologically active zone. Below a depth of 6 in (15 cm), the next two intervals represent approximately 1 ft (0.3 m) thick slices, a standard unit for engineering analysis of sediment remediation alternatives. To obtain enough sample material, corresponding intervals from two or more cores collected from the same sample location were combined. No cores from greater than a 3.3 ft (1 m) depth were collected. The approximate locations of samples in relation to the banks of Geddes Brook and Ninemile Creek are presented in Figure 2-2.

2.4.3.3 Floodplain Soil

At each floodplain soil sample location, a transect was established perpendicular to the streambed that extended from the water's edge to the limit of the floodplain where the soil appeared to have recently been inundated, based on field observations. The edge of the floodplain sampling locations were determined based on landscape morphology and type of vegetation present. Soil was collected at a 0 to 6 in (0 to 15 cm) depth from three evenly spaced locations along this transect. Sample locations (i.e., distance from the water's edge) are provided along with the data in Appendix A; in addition, the approximate locations of samples in relation to the banks of Geddes Brook and Ninemile Creek are presented in Figure 2-2 and the contaminant concentration figures in Chapter 5.

Soil samples were collected at each location using a pre-cleaned trowel. A 6 in (15 cm) deep hole was dug, and sample material was collected from the walls of this hole to ensure that soils from the full length of the 0 to 6 in (0 to 15 cm) interval were equally represented in the sample. Samples were homogenized in a stainless-steel bowl before transfer to the appropriate sample containers.

2.4.4 Laboratory Methods

All analyses, with the exception of mercury and methylmercury, were performed by Honeywell's laboratory, Quanterra, Inc. (now part of Severn-Trent Laboratories) of Pittsburgh, Pennsylvania (New York State Department of Health [NYSDOH] certification number 11182). Mercury and methylmercury analyses in surface water, sediment, and floodplain soil were performed by Honeywell's analytical laboratory Frontier Geosciences (FGS) of Seattle, Washington. Quality assurance procedures and data quality objectives are provided in the revised QAPP (NYSDEC, 1998, 2000a).

2.4.5 Modifications to the Work Plan

Sampling was conducted according to the revised field sampling plan, which is a component of the RI/FS Work Plan (NYSDEC, 1998, 2000a), with the following exceptions:

- Water quality parameters (pH, conductivity, dissolved oxygen [DO], and temperature) were measured on the day following sample collection at Stations NM1, NM2, GB1, and GB2 during the July 1998 surface water sample event.

- At surface water locations with shallow water depths (<2 ft [0.6 m]), water samples were collected directly into laboratory sample bottles rather than using the depth-integrated sampling device. In all cases, water samples were collected using depth-integrating techniques.

- At Stations NM1 and NM2, during the second round of water sampling, no Teflon bottle was available to fit into the depth-integrated sampler. After consultation with FGS, the depth-integrated sampler was fitted with a pre-cleaned low-density polyethylene (LDPE) bottle. Two samples were collected for mercury analysis: one decanted from the LDPE bottle (used with the depth-integrated sampler) into a Teflon bottle, and a second sampled by hand from a depth of 1 ft (0.3 m) directly into a Teflon sample bottle. Both samples were analyzed for unfiltered and dissolved total mercury and dissolved methylmercury. Only the samples collected with the depth-integrated sampler were reported in Appendix A and used for risk assessment, because the grab samples do not represent the entire water column. The grab sample data are included as a footnote to Appendix A, Table A-9 for comparison purposes.

- The floodplain soil was collected from a depth of 0 to 6 in (0 to 15 cm), instead of 0 to 4 in (0 to 10 cm), as indicated in the work plan. This change was an oversight by field staff, but was consistent with the surface interval for sediment samples.

Other changes in the revised field sampling plan (NYSDEC, 1998, 2000a) were clarified in a July 16, 1998 communication to NYSDEC (E. Henry, pers. comm., 1998). The following modifications were addressed in this communication:

- All sediment samples were analyzed for methylmercury and grain size.
- All sediment, soil, tissue, and water samples were analyzed for Target Compound List (TCL) pesticides and polychlorinated biphenyls (PCBs).
- Analysis for hardness and chloride in water samples was performed on unfiltered samples.
- The holding time for TCL volatile organic compound (VOC) analysis in soil and sediment samples was seven days.
- The holding time for samples for cyanide analysis was 12 days.

2.5 Sediment Toxicity Testing and Benthic Macroinvertebrate Surveys (1998)

2.5.1 Objectives

The objective of the sediment toxicity testing was to evaluate the toxicity of surface sediment to sensitive and representative benthic organisms in Geddes Brook and Ninemile Creek. The objective of the BMI survey was to assess the abundance and richness of the communities. The results of the sediment toxicity testing and BMI surveys are presented in Appendices C and D. The sediment toxicity testing and BMI surveys, in conjunction with the 1998 sediment chemistry analyses (see Section 2.4), form a sediment triad analysis that was used in the ecological risk assessment to assess the extent of sediment contamination and to characterize the potential risk to biota. This analysis is discussed in detail in Chapter 9 of the BERA (TAMS, 2003a).

2.5.2 Sampling Location and Frequency

Surface sediment samples for toxicity testing and the BMI survey were co-located with samples collected for chemical analysis. Samples were collected by Honeywell/Exponent at three locations along Geddes Brook and five locations along Ninemile Creek during one sampling event from July 15 through 23, 1998 (see Figure 2-1). Stations where toxicity testing was conducted are also noted in Figure 2-1. Sampling specifications and analyses are summarized in Table 2-2.

2.5.3 Field Methods

Surface sediment samples were collected using a 225 cm^2 Ekman grab sampler. Samples collected at a depth of 4 to 6 in (10 to 15 cm) were considered acceptable and retained for toxicity testing and BMI surveys.

For each toxicity test sample, the overlying water was siphoned off and the sediment was removed from the Ekman grab sampler and placed into a 1 gallon (gal) (3.8 L) bucket lined with a Teflon bag. After collection of approximately 1 gal (3.8 L) of sediment, the sample was homogenized and placed on ice. For the BMI survey, five replicate grab samples were collected at each sample location. The contents of each Ekman grab sampler, including overlying water, were emptied into a 0.002 in (0.5 millimeter [mm]) brass mesh sieve and sieved with site water. All benthic macroinvertebrates and other particles retained in the sieve were carefully transferred from the sieve to a clean, high-density polyethylene (HDPE) jar and immediately placed on ice. After all five replicate samples from a sample location were sieved and the contents transferred to the sample jar, the BMI sample was preserved with 10 percent formalin.

2.5.4 Laboratory Methods

Springborn Laboratories, Inc. (Honeywell's laboratory), located in Wareham, Massachusetts, performed ten-day subchronic toxicity tests with midges (*Chironomus tentans*) and amphipods (*Hyalella azteca*). The laboratory procedures met the standard procedures described in Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates (American Society for Testing and Materials [ASTM], 1995). Each sediment sample was divided into 16 replicate samples (eight for *H. azteca* and eight for *C. tentans*), into which ten test organisms were introduced. The ten-day survival and growth of each replicate test sample was assessed and the environmental parameters monitored. Sediment toxicity was estimated by comparing the response of exposed organisms in the test sediment with both field and laboratory control samples.

EVS Consultants of Seattle, Washington, performed the benthic macroinvertebrate identification. Upon receipt in the laboratory, samples were re-screened and transferred to a solution of 70 percent ethanol. Samples were sorted into major taxonomic groups using a 10X dissecting microscope or a magnifying lamp. Sorting efficiency was monitored by having at least 20 percent of each sample resorted by someone other than the original sorter. Organisms were identified to the lowest taxonomic level possible (target = species) by experienced taxonomists using appropriate taxonomic literature. Taxonomic identifications were verified by taxonomists by comparisons with a reference collection.

2.5.5 Modifications to the Work Plan

The RI/FS Work Plan (NYSDEC, 1998, 2000a) indicated that sediment grab samples were to be collected from a depth of 6 in (15 cm). At many sample locations, this depth could not be achieved with the Ekman sampler and minimum depth of 4 in (10 cm) was determined to be acceptable by Exponent field staff (Exponent, 2001c) Penetration depths for all sediment grab samples are presented in Appendix A. One location for sediment toxicity testing was moved from Station NM10 to Station NM9 to correspond with fish sampling at Station NM9 (E. Henry, pers. comm., 1998).

2.6 Fish Sampling (1998)

2.6.1 Objectives

The objectives of the fish sampling were twofold:

- The first objective was to determine concentrations of measured analytes in YOY and adult fish in Geddes Brook and Ninemile Creek. The results were used in the BERA and HHRA to estimate potential exposure concentrations for wildlife and humans that consume fish from the study area.

- The second objective was to determine the species and age-class composition of the fish assemblage in Geddes Brook and Ninemile Creek. This information, in conjunction with the CDR (1991) data, was used in the ecological risk assessment to characterize the structure of the fish community in the study area. The fish sampling results are presented in Appendix A and discussed in Chapter 5. Fish data are also discussed in Chapter 9 of the BERA (TAMS, 2003a).

2.6.2 Sampling Location and Frequency

Fish were collected by Honeywell/Exponent during one sampling event from July 24 through 27, 1998. Adult fish were collected from two locations in Geddes Brook (Stations GB3 and GB8) and five locations in Ninemile Creek (Stations NM1, NM2, NM3, NM5, and NM9) (Figure 2-1). YOY fish were only collected at two locations in Ninemile Creek (Stations NM2 and NM3). The YOY fish were not sufficiently abundant at the other five stations sampled to meet the minimum sample volume requirement for any analysis. Sampling specifications and analyses are summarized in Table 2-2. Since the analysis of YOY fish samples collected in 1998 by Honeywell/Exponent was limited to YOY fish collected upstream of the major source of mercury, NYSDEC/TAMS collected and analyzed YOY fish in Ninemile Creek in 2002 downstream of Geddes Brook (see Section 2.12).

2.6.3 Field Methods

A NYSDEC fish collection permit (license number LCP98-467) was obtained by Honeywell/Exponent. Stream channel and substrate conditions dictated what types of fish-collection gear were used. Adult fish were caught using a variety of methods, including a backpack electroshocker at Station GB3, a boat-mounted electroshocker at Station NM9, trap nets at Stations NM1 and NM2, rods and reels at Stations GB8, NM3, and NM5, and a beach seine at Station GB8. YOY fish were caught with a beach seine at Stations NM2 and NM3.

Five adult fish samples from each of the seven sampling stations were retained for tissue chemical analysis. Six fish from Station GB8 were retained for chemical analysis, but two individuals were composited into a single sample (see Section 2.6.5). The species targeted for collection included brown trout, smallmouth bass, white sucker, and yellow perch (*Perca flavescens*). Three YOY composite samples were collected from Station NM2, and five were collected from Station NM3. The lengths and species of other fish captured but not retained for tissue chemical analysis were recorded to provide information on the species composition and age structure of the fish assemblage in the study area.

Prior to processing for tissue chemical analysis, adult fish were rinsed, weighed, measured, examined for lesions or other abnormalities, and identified to species. Prior to removing the scales from fish fillets, a subset of scales (10 to 20 scales) from each fish was retained for subsequent age determination. The body area from which scales were removed varied, but was consistent and appropriate for each species. The sex of the fish was determined prior to filleting.

Fillets from each side of the fish (with attached ribcages) were removed and placed in individual plastic bags. Skin, viscera, and remaining parts of the skeleton were combined and bagged separately from the fillet samples. Samples of both fillets and remainders were double-bagged and frozen prior to shipment.

YOY fish were counted and separated into samples according to species. The range of lengths for YOY fish was determined by measuring a representative set of individuals (up to approximately 200 fish) of each species. Composite YOY fish samples were weighed, double-bagged, and frozen.

All frozen tissue samples were packed on dry ice and shipped to the analytical laboratory by overnight delivery service. These procedures are in accordance with revised SOP 114, Fish Collection Procedures, and SOP 115, Fish Processing Procedures (NYSDEC, 1998, 2000a).

2.6.4 Laboratory Methods

Except for mercury, analysis of fish tissue was performed by Quanterra, Inc. (Honeywell's laboratory) of North Canton, Ohio. Mercury analysis in fish tissue was performed by Cebam Analytical (Honeywell's laboratory) of Seattle, Washington. The analytes determined for each sample are presented in Table 2-3.

At the Quanterra laboratory, samples were weighed, homogenized, and weighed again prior to analysis. A subsample of the homogenate tissue sample was shipped to Cebam for subsequent analysis. Adult fish and YOY tissue samples were analyzed for total mercury, PCBs, pesticides, polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs), total solids, semivolatile organic compounds (SVOCs), Target Analyte List (TAL) metals, and cyanide. Due to sample volume limitations, some fish samples were analyzed for a select number of analytes (Table 2-3). Quality assurance procedures and data quality objectives are provided in the QAPP (NYSDEC, 1998, 2000a).

2.6.5 Modifications to the Work Plan

Sampling was conducted according to the revised RI/FS Work Plan (NYSDEC, 1998, 2000a), with the following exceptions:

- The high conductivity of the surface water in Geddes Brook and Ninemile Creek greatly reduced the effectiveness of the backpack electroshocker. In portions of the channel that were too narrow and shallow for use of the boat electroshocker, field staff employed other techniques (i.e., rods and reels, trap nets, beach seines) to capture adult fish for tissue samples.

- One of the adult fish samples collected from Station GB8 consists of two fish rather than an individual fish. These two fish were composited into a single sample to meet the sample volume requirement, since an individual fish collected at this location alone would not have provided sufficient mass for analysis of all parameters.

- YOY fish were collected from only two stations in 1998 because fish in this age class were not sufficiently abundant to meet the minimum sample volume requirement for any analysis. Only one sample (CF0001) was greater than the 100 g minimum identified in the work plan. At Station NM3, two species of YOY or alternative forage fish (blacknose dace and longnose dace [*Rhinichthys cataractae*]) were composited into a single sample (CF0006) to obtain sufficient mass for analysis.

- Fish samples were placed in food-grade plastic bags (e.g., Ziploc®) rather than aluminum foil, as stated in the work plan.

- In the case of insufficient sample size for fish analysis, NYSDEC prioritized analytes for partial analysis. The tissue samples affected by low sample volume and the analyses performed on these samples are provided in Table 2-3.

An additional modification to the revised work plan resulted from an unintentional oversight by field staff and the analytical laboratory (Quanterra). Remainders from 12 adult fish samples were not weighed until after sample homogenization. Pre- and post-homogenized fillet weights from these 12 samples and fillets and remainders for all other fish samples were obtained. The estimation of missing sample weights and calculation of whole-body concentrations of substances is discussed in Chapter 8 of the BERA (TAMS, 2003a).

In addition to the analysis of fillets, the revised work plan (Table 6-1 in NYSDEC, 1998) also required the collection and analysis of whole-body fish samples of up to four of the most abundant species. These whole-body fish samples were not collected by Exponent's field staff.

2.7 Muskrat Sampling (1998)

2.7.1 Objectives

The objective of the muskrat sampling, as envisioned by Honeywell, was to characterize muskrat tissue near Geddes Brook and Ninemile Creek for use in the food-web models in the BERA. Muskrat sampling was not included in the work plan (NYSDEC, 1998, 2000a) since the state rejected Honeywell's proposal to include the muskrat sampling effort in the Geddes Brook/Ninemile Creek site field investigation (P. Bein, pers. comm., 1998) on the basis that it was inappropriate to use a herbivorous mammal to represent small mammals, inclusive of insectivores, based on differences in bioaccumulation related to feeding strategies. Data from the muskrat sampling are presented for information purposes only in Appendix A. Methylmercury data from the muskrat samples and co-located sediment samples were used in the BERA to derive a methylmercury small mammal uptake factor, due to the lack of other data for this purpose (TAMS, 2003a). However, muskrat data were not used directly in the food-web model in the BERA (TAMS, 2003a).

2.7.2 Sampling Location and Frequency

Twelve muskrat were collected in and upstream of the Geddes Brook/Ninemile Creek site between July and November 1998. Three muskrat were collected at Stations GB1 and NM1 and six were collected in downstream reaches of Geddes Brook (one each at Stations GB6, GB7, and GB8) and Ninemile Creek (one at Station NM6 and two at Station NM7). Sampling stations for muskrat collection are shown in Figure 2-1.

2.7.3 Field Methods

Muskrat were collected using 110-size Connebear traps placed near visible muskrat runs. Traps were checked at least every 24 hours. After the muskrat were euthanized, their carcasses were shipped on ice to the laboratories.

2.7.4 Laboratory Methods

Except for mercury, analyses were performed by Quanterra, Inc. (Honeywell's analytical laboratory) of Pittsburgh, Pennsylvania (NYSDOH certification number 11182). Mercury analyses were performed by Cebam Analytical (Honeywell's laboratory) of Seattle, Washington. Muskrat tissue samples were analyzed for total mercury, methylmercury, PCBs, and PCDD/PCDFs. Muskrat skin samples, including hair, were analyzed for total mercury and methylmercury.

2.8 Wetlands Delineation and Sampling (2000)

2.8.1 Objectives

Honeywell (Exponent) performed a federal wetland delineation for the area designated as Wetland SYW-18, which was determined to have been affected by Honeywell's contamination as per Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) guidance (USEPA, 1994d). The detailed results of the wetland delineation are presented in Appendix E of the BERA (TAMS, 2003a).

In 2000, in addition to the wetland delineation and as part of the Onondaga Lake RI, Honeywell (Exponent) also collected eight wetland sediment samples from four locations within Wetland SYW-10, east of I-690 (Stations S379, S380, S381, and S382; see Figure 2-2 for approximate locations). At each station, samples were collected from the 0 to 6 in (0 to 15 cm) and 6 to 12 in (15 to 30 cm) depth intervals and analyzed for TAL metals, VOCs, SVOCs, pesticides, PCBs, PCDD/PCDFs, TOC, grain size, and total solids.

2.8.2 Location of Delineation

Delineation of wetlands included the general area of Wetland SYW-18, which is located on both sides of Geddes Brook near the confluence with Ninemile Creek (see Figure 2-2). In addition, wetlands along Ninemile Creek upstream of Geddes Brook, from where the power lines cross the creek (Figure 2-1) down to State Fair Boulevard, including the islands downstream of Geddes Brook, were delineated. The areal extent of the wetland delineation was determined based on consultation with NYSDEC.

2.8.3 Field Method

The wetland delineation was performed by Exponent for Honeywell from July 17 to 21, 2000, in accordance with the USACE manual for identification of wetlands (USACE, 1987). Soil conditions were assessed by use of a soil auger; field observations of wetland vegetation and evidence of groundwater were recorded; photographs were taken; and boundaries were flagged and then surveyed to permit accurate preparation of a map depicting wetland areas (see Appendix E of the BERA [TAMS, 2003a]).

2.9 Sediment, Island Soil, and Floodplain Soil Sampling (2001)

2.9.1 Objectives

The objective of the 2001 Geddes Brook/Ninemile Creek supplemental RI sampling program was to further characterize sediment, island soil, and floodplain soil in Geddes Brook and Ninemile Creek. Sampling was performed in accordance with the sampling plan (BBL, 2000), an addendum, and a modification to the addendum approved by NYSDEC (T. Larson, pers. comm., 2001b). The sampling plan was designed to evaluate variability in chemical concentrations with respect to depth as well as longitudinal (along the length of the stream) and lateral (perpendicular to the stream) directions (BBL, 2000). The sampling was performed by BBL for Honeywell. Chemical concentration data are presented in Appendix E and are discussed in Chapters 5 and 6 of this report, in addition to being evaluated in the BERA and HHRA (TAMS, 2003a,b).

Besides fulfilling the NYSDEC request for additional data for this RI report (T. Larson and P. Bein, pers. comm., 2000), the purpose of the sampling program was to support the design of a proposed IRM for the Geddes Brook/Ninemile Creek site (note that the IRM is currently limited to the lower Geddes Brook portion of the site, as discussed in Chapter 4). Additional data collected during this 2001 sampling program, but not included in this RI report, include sediment probing/profiling data to estimate sediment volume and stream channel data to support hydrologic modeling. These data were submitted to NYSDEC by BBL in a separate report (BBL, 2001).

2.9.2 Sampling Location and Frequency

Sampling was conducted by Honeywell and BBL from February to April 2001 with a delay from March 23 to April 20 because of adverse weather conditions (i.e., high flows). Sample locations are shown in Figure 2-2. Sediment cores, numbers, and locations are as follows:

- **Geddes Brook transects:** Sediment cores were collected along five transects in Geddes Brook. Two cores were collected at four transects in Geddes Brook downstream of the West Flume (Transects TG-1 through TG-4), and three cores were collected at the fifth transect, just upstream of the West Flume (Transect TG-5).

- **Geddes Brook discrete locations:** Two sediment cores were collected at discrete locations in Geddes Brook, including Station GB-Culvt, situated at the mouth of the culvert that passes under the railroad tracks and part of the New York State Fairgrounds, and Station MN-3, which is approximately 25 ft (7.6 m) downstream of the culvert.

- **Ninemile Creek transects:** Sediment cores were collected along 18 transects in Ninemile Creek. Three cores were collected at each sediment transect location. Three of these transects (Transects TN-11, TN-13, and TN-14) crossed islands, and the middle core consisted of island soil. Transects 17 and 18 (not shown on Figure 2-2) are located above Amboy Dam, with Transect TN-17 just downstream of 1998 Station NM2 and Transect TN-18 just upstream of Station NM2.

- **Ninemile Creek discrete locations:** Sediment cores were collected at four discrete locations in Ninemile Creek. Two cores were collected in depositional areas created by artificial structures (Station MN-1 near State Fair Boulevard and Station MN-2 near the large island) and two cores were collected in sediment downstream of islands (Stations CN-1 and CN-2).

Floodplain soil cores were collected along two transects in Geddes Brook (Transects FG-1 and FG-2) and 13 transects in Ninemile Creek (Transects FN1 through FN13). With the exception of two transects (Transects FN-11 and FN-12), three cores were collected on each side of the brook or creek at distances of approximately 3, 10, and 15 ft (1, 3, and 5 m) from the shoreline. Transect FN-12 crossed an island in Ninemile Creek, so three cores were collected on each side of the island, in addition to each side of the creek (for a total of 12 cores). At Transect FN-11, three cores were collected on the left bank (facing downstream) and two cores were collected on the right bank (for a total of 11 cores).

2.9.3 Field Methods

Samples were collected in accordance with the sampling plan (BBL, 2000). Sampling specifications and analyses are summarized in Table 2-4. Sediment cores were collected by manually pushing pre-cleaned Lexan tubes into the sediment to the point of refusal. A hole-saw device was mounted to the Lexan tubing and used to advance the core when refusal appeared to be premature. All cores were sectioned into the following sample intervals: 0 to 6 in (0 to 15 cm), 6 to 18 in (15 to 45 cm),18 to 30 in (45 to 75 cm), and 30 to 41 in (75 to 105 cm). Some cores that were sampled to greater depth were analyzed if the total concentration of mercury exceeded 0.15 mg/kg in the sample obtained from the 30 to 41 in (75 to 105 cm) interval.

Floodplain soil cores were collected with Lexan tubes, as described above. Cores were sectioned into 0 to 6 in (0 to 15 cm) and 6 to 12 in (15 to 30 cm) sample intervals.

2.9.4 Laboratory Methods

Honeywell's analytical laboratory, FGS of Seattle, Washington, performed the methylmercury analysis, and Columbia Analytical Services (CAS) of Rochester, New York performed the total mercury, total organic carbon (TOC), total suspended solids (TSS), and PCDD/PCDFs analyses. Honeywell's analytical laboratory, O'Brien & Gere of Syracuse, New York, performed analyses for TAL metals (including total mercury and cyanide), TCL VOCs and SVOCs, PCBs plus hexachlorobenzene, and pesticides.

All samples were analyzed for mercury and TOC. A subset of samples was analyzed for methylmercury, and a separate subset was analyzed for TAL metals (plus cyanide), VOCs, SVOCs, pesticides, PCBs including Aroclor 1268, and PCDD/PCDFs. Identification of specific analyses conducted for each sample is presented in Appendix F, Quality Assurance Review Summaries for Analytical Data (2001).

2.9.5 Modifications to the Sampling Plan

Modifications to the sampling plan included not collecting some of the proposed samples due to obstructions or unacceptable substrate (i.e., rock) (see Table 1 in BBL, 2001) and the addition of analytical testing parameters to several sediment and floodplain soil transects (BBL, 2001).

2.10 Laboratory Analyses and Data Quality (1998 and 2001)

Laboratories, methods of analysis, and data quality are summarized in this section for the 1998 RI and the 2001 supplemental RI/IRM programs. Details are provided in Appendix B, Quality Assurance Review Summaries for Analytical Data (1998) and Appendix F, Quality Assurance Review Summaries for Analytical Data (2001) of this RI report.

2.10.1 Remedial Investigation (1998)

The water, soil, sediment, and tissue samples for the 1998 RI were analyzed by three laboratories chosen by Honeywell and/or their consultant, as follows:

- Quanterra, Inc., headquartered in Pittsburgh, Pennsylvania, conducted the analyses for TAL and TCL analytes (except mercury), PCDD/PCDFs, and conventional wet chemistry in all sample types.

- FGS, located in Seattle, Washington, conducted the analyses for total mercury and methylmercury in water, sediment and soil samples and for TSS in water samples.

- Cebam Analytical, also located in Seattle, conducted the analyses for total mercury and methylmercury in the fish and muskrat tissue samples.

In addition, Springborn Laboratories, Inc., located in Wareham, Massachusetts, performed the sediment toxicity testing, and EVS Consultants of Seattle performed the taxonomic identification of benthic macroinvertebrates in sediment samples.

2.10.1.1 Laboratory Methods

All samples for the 1998 RI were analyzed using USEPA Contract Laboratory Program (CLP) methods (USEPA, 1995a) or other methods approved or recommended by USEPA, when necessary (Table 2-5). The analyses included all quality assurance and quality control (QA/QC) procedures specified for each CLP or other approved or recommended method. Summary descriptions of the analytical procedures are provided in the QAPP (NYSDEC, 1998, 2000a).

2.10.1.2 Data Validation Procedures

All data were subjected to a quality assurance review to verify that the laboratory QA/QC procedures were completed and documented as required, and that the quality of the data was sufficiently high to support its use in the risk assessments, RI, and FS. QA/QC Solutions, LLC, completed the data validation for Honeywell/Exponent, with the exception of metals in fish tissue, toxicity testing, and benthic invertebrate enumeration. These data were validated by Exponent.

Data validation was completed according to USEPA's national functional guidelines for evaluating inorganic and organic analyses (USEPA, 1994a,b), as specified in the QAPP (NYSDEC, 1998, 2000a). Modifications to the validation procedures were made as appropriate to accommodate QC requirements for methods that are not specifically addressed by the functional guidelines (i.e., conventional analyses and low-level mercury and methylmercury analyses). Data for PCDD/PCDFs were validated according to USEPA Region 2 SOP No. HW-19 (USEPA, 1994c). Data qualifiers were assigned during the QA reviews if control limits were not met, in accordance with validation guidelines (USEPA, 1994a,b,c), QC requirements stated in the methods, and the data quality objectives established for the project (NYSDEC, 1998, 2000a), as applicable. In addition, all reported laboratory data were compared with electronic data imported or hand-entered into the project database, and all discrepancies were resolved.

Results of the QA chemical data review are provided in Appendix B of this report. Results of the QA review for the sediment toxicity data and the BMI identification data are included in Appendices C and D of this report.

2.10.1.3 Data Quality and Usability

The RI chemical data are of good quality. Only one result for one field blank was of unacceptable quality and rejected (i.e., labeled with an "*R*" in the data package and flagged as unreportable in the database). Rejected data are unusable for any purpose. The rejected field blank result was for total mercury and the field blank was for water sample collection and filtration. No data for field samples were rejected. Details are provided in Appendix B.

All of the RI data are of acceptable quality for use in the risk assessments, RI, and FS. Reported detection limits generally met the data quality objective for sensitivity. The actual detection limits reported for some samples were elevated with respect to analytical method detection limits. These elevated method detection limits or method reporting limits were reported when dilutions were necessary to conduct an analysis because the sample contained high concentrations of target analytes, matrix interferences, or both, preventing reliable identification and quantification of the target analytes in undiluted samples. Reported detection limits were additionally elevated when results were restated as undetected due to contamination of laboratory or field blanks. Detailed descriptions of restated data are provided in Appendix B.

2.10.2 Supplemental RI/IRM Investigation (2001)

Sediment, island soil, and floodplain soil samples collected during the 2001 investigation were analyzed for Honeywell by three laboratories, as follows:

- O'Brien & Gere of Syracuse, New York analyzed the samples for TAL and TCL analytes except VOCs.

- CAS of Rochester, New York performed analyses for TCL VOCs, mercury, PCDD/PCDFs, and TOC.

- FGS of Seattle, Washington analyzed sediment samples for methylmercury.

2.10.2.1 Laboratory Methods

Laboratory procedures for the 2001 investigation were generally completed as specified in the Onondaga Lake RI/FS Supplemental Data Phase 2A Work Plan (Exponent, 2000d). The following methods were used:

- Kahn (1986) for TOC.
- USEPA Methods 6010B, 7470A, and 9014 for TAL metals, mercury, and cyanide, respectively.
- USEPA Method 8260B for TCL VOCs.
- USEPA Method 8270C for TCL SVOCs.
- NYSDEC Analytical Services Protocol (ASP) Method 95-3 for TCL pesticides.
- USEPA Method 8082 for TCL PCBs, Aroclor 1268, and hexachlorobenzene.
- USEPA Method 8290 for PCDD/PCDFs.

In addition to the QA/QC procedures specified in each of these methods, the QC procedures specified in Exhibit E of the NYSDEC ASP (NYSDEC, 1995) were completed for metals, SVOCs, and PCBs. Methods were modified to improve detection limits and to mitigate matrix interferences. Results for detected organic compounds and mercury were reported as estimates when reported at levels below the practical quantification limit but above the detection limit. In addition, the concentration of the lowest calibration standard was decreased for key SVOCs to extend the calibration range downward. The analyte list for TCL PCBs was modified to include Aroclor 1268 and, for improved detection limits, hexachlorobenzene. Details are provided in Section 1.2 of Appendix F of this RI report.

2.10.2.2 Data Validation Procedures

Data validation procedures and qualifier assignments were completed according to SOPs prepared by USEPA Region 2. Methylmercury data were validated according to general procedures described in USEPA Region 2's SOP HW-2 (USEPA, 1992), with modifications made to comply with QA/QC procedures and control limits provided in the descriptions for USEPA Method 1630 (USEPA, 1998a). Validation procedures for conventional analyses were based on SOP HW-2 and on national functional guidelines for inorganic data review (USEPA, 1994a), when applicable.

2.10.2.3 Data Quality and Usability

Over 40,000 results were produced by the 2001 investigation. The data were generally of acceptable quality. Only 51 results were rejected (*R*), and most of these were for pesticides, which were difficult to analyze due to interferences in the samples that could not be removed with routine cleanup procedures. Detailed descriptions of the data validation results and reasons for data qualification are provided in Appendix F of this RI report.

The overall data set, without the rejected data, is adequate to support the analyses performed in and the objectives of this RI.

2.11 Ninemile Creek Supplemental RI Floodplain Investigation (2002)

2.11.1 Objectives

The objective of the Ninemile Creek supplemental floodplain soil sampling program was to further characterize the nature and extent of contaminants in floodplain soil along Ninemile Creek. Sampling was performed by O'Brien & Gere for Honeywell in accordance with the sampling and analysis work plan (O'Brien & Gere, 2002a) and the addendum (T. Larson, pers. comm., 2002b). The sampling plan was designed to evaluate variability in chemical concentrations with respect to depth as well as longitudinal and lateral directions within the pre-defined floodplain, as depicted on Federal Emergency Management Agency (FEMA) maps. Chemical concentration data are presented in Appendix G1, Floodplain Soils Data (2002), and are discussed in Chapters 5 and 6 of this report, in addition to being evaluated in the BERA and HHRA (TAMS, 2003a,b).

2.11.2 Sampling Location and Frequency

Floodplain soil sample collection was conducted from September 5 to 16, 2002. Samples were collected at 64 locations within 12 transects along Ninemile Creek between Geddes Brook and Onondaga Lake, at depth intervals of 0 to 6 in (0 to 15 cm), 6 to 12 in (15 to 30 cm), 12 to 24 in (30 to 60 cm), and 24 to 36 in (60 to 90 cm). Given the irregular shape and topography of the floodplain area, it was not practical to follow a systematic sampling grid. At some locations, in order to further define the extent of lateral contamination from the 1998 and 2001 sampling events, the transects were extended farther from the banks on both sides of the channel from what was previously sampled.

Transects were selected to provide reasonable coverage of the defined floodplain area, specifically in low-lying areas where sediments, and possibly waste streams, would have historically settled. In addition, transects were located in areas that, based on data from the prior investigations, exhibited elevated levels of mercury.

Some of these samples were collected in Wetlands SYW-10 and SYW-18, as well as other adjacent floodplain areas exhibiting wetland characteristics. The other soil samples were collected in upland (i.e., non-wetland) areas. Sample locations are shown in Figure 2-2.

It should be noted that samples were labeled using O'Brien & Gere's convention; for example, if the sample identification (ID) number is NMFP-T-10-25R, the sample ID is broken down as follows: NMFP (Ninemile Floodplain) - T (transect) - 10 (transect number) - 25R (distance, in feet, from the right [R] or left bank, facing upstream). Note that the "L" or "R" designations are only used when the transect extends from both banks of the creek (see Figure 2-2).

All of the locations were marked and surveyed using a hand-held GPS unit. The sampling specifications for the Ninemile Creek supplemental floodplain soil sampling are summarized in Table 2-6.

2.11.3 Field Methods

Sampling was conducted in accordance with the sampling and analysis work plan (O'Brien & Gere, 2002a). Soil samples were collected using a split-spoon sampler driven by a 40-lb hammer or hand auger. If obstructions were encountered, the sampling was typically moved to a nearby, representative location, with the concurrence of NYSDEC field personnel.

2.11.4 Laboratory Methods

Laboratory procedures were generally completed as specified in the sampling and analysis work plan (O'Brien & Gere, 2002a), using the following methods:

- Kahn (1986) for TOC.
- USEPA Method 7471 for mercury.
- USEPA Method 8270C for TCL SVOCs (PAHs and hexachlorobenzene only).
- USEPA Method 8290 for PCDD/PCDFs.

The analytical results are presented in Appendix G1 of this report.

2.11.5 Modifications to the Work Plan

In general, all of the sampling activities were completed in conformance with the floodplain sampling and analysis work plan (O'Brien & Gere, 2002a) and addendum (T. Larson, pers. comm., 2002b). However, due to obstructions, not all depth intervals at all locations could be collected.

Fourteen floodplain samples could not be collected at intervals below 1 ft (0.3 m) due to obstructions. Only the top two depth intervals (i.e., 0 to 6 and 6 to 12 in) were collected at 12 locations (i.e., NMFP-T-01-5; NMFP-T-01-150; NMFP-T-02-25; NMFP-T-02-50; NMFP-T-02-180; NMFP-T-03-330; NMFP-T-06-50; NMFP-T-07-25; NMFP-T-07-50; NMFP-T-08-60L; NMFP-T-10-25R; NMFP-T-10-60R; NMFP-T-11-50R), and only the top three depth intervals (i.e., 0 to 6, 6 to 12, and 12 to 24 in) were collected at location NMFP-T-08-30R.

2.11.6 Data Validation Procedures

Data validation procedures and qualifier assignments were completed according to SOPs for data validation prepared by USEPA Region 2 (USEPA, 1999, 2002). The data validation is summarized in the Ninemile Creek Supplemental Sampling Program Data Validation Report (O'Brien & Gere, 2002b), included in Appendix G1 of this report. According to the data validation report, the mercury, SVOC, TOC, and percent solids data were determined to be usable for qualitative and quantitative purposes (O'Brien & Gere, 2002b).

2.12 Ninemile Creek Supplemental Young-of-Year Fish Sampling (2002)

2.12.1 Objectives

From October 1 to 3, 2002, NYSDEC and TAMS conducted a supplemental fish sampling program in the lower reaches of Ninemile Creek in order to collect data on concentrations of contaminants in YOY fish tissue. Although required to by the RI/FS Work Plan (NYSDEC, 1998, 2000a), Honeywell was not able to collect the required mass of YOY fish tissue in the lower reach of Ninemile Creek as part of the 1998 RI, as discussed in Section 2.6. Young-of-year fish typically exhibit a higher degree of site fidelity than older fish, and thus are more likely to bioaccumulate mercury and other chemicals based on local contaminant concentrations. In addition, some ecological receptors (e.g, belted kingfisher [*Ceryle alcyon*] and mink [*Mustela vison*]) feed primarily on small fish. Thus, another attempt was made and YOY fish were collected by NYSDEC/TAMS in 2002 in Ninemile Creek downstream of Geddes Brook (see Figure 2-2). This supplements the 1998 YOY fish data collected by Honeywell upstream of Ninemile Creek, and allows YOY fish data to be used in food-web modeling in the BERA.

Analytical results of this additional YOY sampling are presented in Appendix G2, YOY Fish Data (2002). A summary of the sampling specifications is presented in Table 2-7. These data are used in the BERA (TAMS, 2003a) to estimate potential exposure concentrations for ecological receptors (e.g., birds and mammals) that feed on fish.

2.12.2 Sampling Location and Frequency

YOY fish were collected from three stations in Ninemile Creek during the 2002 supplemental sampling, as follows:

- **Station NMC:** Bluegill (*Lepomis macrochirus*) (three composite samples), killifish (*Fundulus diaphanous*) (one composite sample), four individual largemouth bass (*Micropterus salmoides*), and tessellated darter (one composite sample) were collected and analyzed in this reach between the confluence with Geddes Brook and the upstream end of the large island. Blacknose dace was also collected at Station NMC. However, this species was archived as an alternate species and not analyzed, as it was not a target species (TAMS, 2002d).

- **Station NM5:** Bluegill (three composite samples), killifish (one composite sample), and tessellated darter (one composite sample) were collected and analyzed in this reach in the area of 1998 Station NM5 around the large island. White sucker was also collected at Station NM5. However, this species was archived as an alternate species and not analyzed, as it was not a target species (TAMS, 2002d).

- **Station NM9:** Bluegill (three composite samples) were collected and analyzed in this reach in the area of 1998 Station NM9, just downstream of I-690.

These stations are shown on Figure 2-2, and sampling specifications and analyses for the 2002 YOY fish sampling program are summarized in Table 2-7.

2.12.3 Field Methods

All fish were caught in compliance with a NYSDEC fish collection permit (license number LC02-590467). YOY fish were collected using a backpack electrofishing unit, baited minnow traps, or a combination of these techniques.

Fish were identified as YOY based on their size at capture. The sizes of individual fish selected for analysis were less than or equal to the species-specific maximum values identified in the Onondaga Lake RI/FS Supplemental Data Phase 2A Work Plan (Exponent, 2000d) and the Work Plan for YOY Fish Collection in Ninemile Creek (TAMS, 2002d).

Fish were collected, sorted by species and size, and stored on ice until all locations were sampled. Each composite sample was comprised of a single species and weighed at least 75 g. Samples were collected to ensure that one species (i.e., bluegill) was represented at all locations. YOY fish samples were weighed, double-bagged, and frozen, and the frozen tissue samples were packed on dry ice and shipped to the analytical laboratory by overnight delivery service. These procedures were carried out in accordance with revised SOP 114, Fish Collection Procedures, and SOP 115, Fish Processing Procedures (NYSDEC, 1998, 2000a).

2.12.4 Laboratory Methods

Analysis of fish tissue was performed by NYSDEC's contract analytical laboratories, EnChem, Inc. of Green Bay, Wisconsin and Wright State University of Dayton, Ohio. Both laboratories were under contract with NYSDEC. The compounds analyzed for each fish sample are shown in Table 2-7.

At the EnChem laboratory, samples were weighed, homogenized, and weighed again prior to analysis. A subsample (20 g) of the homogenate tissue sample was shipped to Wright State University for PCDD/PCDF analysis. The remainder of the samples were analyzed by EnChem for PCBs, pesticides, total solids, SVOCs, and TAL metals. Due to sample volume limitations, some fish samples were analyzed for a select number of analytes (Table 2-7). Quality assurance procedures and data quality objectives are provided in the QAPP for the Geddes Brook/Ninemile Creek RI (NYSDEC, 1998, 2000a).

2.12.5 Modifications to the Work Plan

Sampling was conducted according to the Work Plan for YOY Fish Collection in Ninemile Creek (TAMS, 2002d). The following modifications were approved in the field by a NYSDEC representative:

- The high conductivity of the surface water in Ninemile Creek greatly reduced the effectiveness of the backpack electroshocker. The field staff mainly employed minnow traps and nets to capture YOY fish for tissue samples.

- In the case of insufficient sample size for fish analysis, metals (including mercury) were not analyzed for one of the bluegill at Station NM5 and the single tessellated darter composite samples at Stations NMC and NM5.

- In addition to the minimum requirements of the work plan, additional composite and individual YOY fish samples were collected and analyzed for TAL metals, including mercury, on each of four largemouth bass collected from Station NMC; a full suite of analysis (excluding metals) on the composite sample of tessellated darter from Station NMC; and a full suite of analysis for the tessellated darter composite sample from Station NM5.

2.12.6 Data Validation Procedures

The results of the supplemental 2002 YOY fish sampling are presented in Appendix G2 of this report. The data provided by EnChem (i.e., for SVOCs, TAL metals, pesticides, PCBs, total percent solids, and total percent lipids) and Wright State University (for PCDD/PCDFs) were validated by Analytical Assurance Associates of Downingtown, Pennsylvania. Data validation reports are provided in Appendix G2.

2.13 Summary of Previous Investigations in Geddes Brook/Ninemile Creek

This Geddes Brook/Ninemile Creek RI was designed to be more comprehensive than previous studies in terms of sample locations and analytes. Nevertheless, historical chemical data are useful for assessing the nature and extent of contamination and for determining trends in contaminant levels. Therefore, a summary of previous investigations in Geddes Brook and Ninemile Creek, conducted independently of the Geddes Brook/Ninemile Creek RI/FS, is presented in this section, which includes the following studies:

- Engineering Investigations at Inactive Hazardous Waste Sites in the State of New York: Phase II Investigation, Mercury Sediments – Onondaga Lake, Onondaga County (NYSDEC, 1989).

- Rotating Intensive Basin Studies (RIBS) (NYSDEC, 1992).

- Environmental Assessment of Lower Reaches of Ninemile Creek and Geddes Brook (CDR [for Honeywell], 1991).

- Onondaga Lake RI/FS Mercury and Calcite Mass Balance Investigation Data Report (PTI [for Honeywell], 1993).

- Onondaga Lake RI/FS, West Flume and Ninemile Creek Supplemental Sampling (PTI [for Honeywell],1996).

- Concentrations and Fluxes of Total and Methyl Mercury to Onondaga Lake (Gbondo-Tugbawa, 1997).

- Onondaga County Surface Water Sampling Program, 1999 – 2001 (K. Murphy, pers. comm., 2002).

Previous biological sampling programs that have been conducted in Geddes Brook and/or Ninemile Creek and that are not discussed in this section include: Fish Community – Habitat Relations in a Central New York Stream (Finger, 1982); A Macroinvertebrate Study of Ninemile Creek (Cooper, 1974); and Biological Stream Assessment: Tributaries to Onondaga Lake (Bode et al., 1989; CDR, 1991).

Data from the investigations discussed below were considered for use in supplementing the RI data collected from 1998 to 2002 by Honeywell and NYSDEC to evaluate the nature and extent of contamination and the fate and transport of contaminants. Any data collected independently of this RI and used for this purpose are presented, as appropriate, in Chapters 5 and 6.

2.13.1 NYSDEC Investigations

In 1987, NYSDEC conducted surface water and sediment sampling in Geddes Brook and Ninemile Creek as part of the Engineering Investigations at Inactive Hazardous Waste Sites in New York: Phase II (NYSDEC, 1989). NYSDEC collected surface water at two stations and sediment from three stations, as follows:

- The two surface water samples were collected from lower Geddes Brook (Station W9; see Figure 2-3) and from Ninemile Creek just upstream of Geddes Brook (Station W7; see Figure 2-3), and were analyzed for mercury and other metals, VOCs, SVOCs, PCBs, and pesticides. The surface water samples were not analyzed using low-level mercury techniques.

- The three sediment samples were grab samples collected from lower Geddes Brook (Station S48; see Figure 2-3), lower Ninemile Creek (Station S44; see Figure 2-3), and upper Ninemile Creek (near the Amboy Dam; station not shown in Figure 2-3), and were also analyzed for mercury and other metals, VOCs, SVOCs, PCBs, and pesticides.

In 1989 and 1990, as part of RIBS, NYSDEC collected sediment samples from a single station at the Route 48 bridge (Station 7024301; see Figure 2-3) (NYSDEC, 1989, 1992). These sediment samples were analyzed for metals, pesticides, and PCBs. In addition, a total of 21 water column samples were collected at this station: 10 in 1989 (between March 29 and November 6) and 11 in 1990 (between March 26 and September 13). Times and flows were reported for each sample. These surface water samples were analyzed for conventional field parameters, nutrients, solids, metals, select VOCs, and total/fecal coliform. These surface water samples were not analyzed using low-level mercury techniques.

In 1996, 1997, and 2000, as part of the Onondaga Lake National Priorities List (NPL) investigation, NYSDEC collected sediment samples from tributaries of the lake, including Geddes Brook and Ninemile Creek. These studies were intended to gather additional information to evaluate the impact of upland sites on tributaries of Onondaga Lake.

The data collected during the above-listed NYSDEC studies were not used to supplement existing RI data for the analyses presented in this report since the water sampling did not use low-level mercury techniques and more recent and more extensive sediment data are now available for the site.

2.13.2 Honeywell/CDR Environmental Specialists Assessment

In 1990, CDR collected sediment, surface water, and fish samples from Geddes Brook and Ninemile Creek for Honeywell (CDR, 1991). Sample locations are shown in Figure 2-3 and are designated with “CDR” as part of the sample ID.

CDR collected sediment samples in 1990 from 16 locations in Geddes Brook and Ninemile Creek at a 0 to 4 in (0 to 10 cm) depth interval. The samples were analyzed for total chloride, TOC, total mercury, calcium, sodium, and percent silt and clay (CDR, 1991).

Surface water samples were collected at 22 stations in Geddes Brook and Ninemile Creek, as well as tributaries (i.e., the West Flume, Beaver Meadow Brook, and the unnamed tributary), on nine different dates for analysis of conventional parameters, calcium, sodium, chloride, TSS, turbidity, and ammonia. Samples were collected for low-level mercury and methylmercury analysis from these stations on only two dates: July 26 and October 4, 1990.

Twenty fish samples (bluegill, brown trout, largemouth bass, northern pike, smallmouth bass, and white sucker) were collected from Ninemile Creek at its confluence with Geddes Brook, and from its upper and lower channels. These samples were analyzed for mercury and methylmercury in all samples and PCBs in four samples. Soft-substrate and hard-substrate invertebrates were also collected for a benthic organism study.

The sediment data from this study were not used to supplement existing RI data, since more recent and extensive sediment data are available. However, surface water and fish data are used in this RI and the risk assessments. The surface water data are discussed in Chapters 5 and 6 of this RI report, and the fish and benthic data are discussed in the BERA (TAMS, 2003a). Fish fillet data from this investigation were used in the HHRA (TAMS, 2003b).

2.13.3 Honeywell/PTI Environmental Services Tributary Loading Investigation

In 1992, PTI Environmental Services (PTI; now Exponent) sampled surface water in Geddes Brook and Ninemile Creek during base-flow and higher-stage flow conditions, but did not collect samples during a high-flow event (PTI, 1993) as part of the Onondaga Lake RI (TAMS, 2002c). Between April 24 and December 16, 1992, a total of 42 surface water samples were collected from three stations (14 from each): upper Ninemile Creek at the Amboy Dam (Station W14), lower Ninemile Creek (Station W10), and lower Geddes Brook (Station W13). The samples were analyzed for conventional water quality parameters, metals, chlorinated benzenes, and benzene, toluene, ethylbenzene, and xylenes (BTEX).

PTI also sampled Geddes Brook and Ninemile Creek in 1994 and 1995 for a study of mercury loading under high-flow conditions (PTI, 1996) as part of Honeywell's Onondaga Lake RI (TAMS, 2002c). A total of 46 surface water samples were collected: 16 from Geddes Brook and 29 from Ninemile Creek in 1995, and one sample collected from Ninemile Creek in 1994. These stations include Ninemile Creek just above the confluence with Geddes Brook (Station SW01), the mouth of Geddes Brook (Station SW02), and lower Ninemile Creek (Station SW03). Samples were analyzed for TSS, total mercury, and methylmercury.

The objective of the PTI studies was to evaluate the Geddes Brook/Ninemile Creek site as a source of mercury and other select contaminants to Onondaga Lake, and the sampling was, therefore, limited in geographic coverage relevant to this report. These 1995 high-flow surface water sampling data are used in this RI to assess stream loads, as discussed in Chapter 6.

2.13.4 Syracuse University Total Mercury and Methylmercury Fluxes to Onondaga Lake

Surface water samples were collected by Syracuse University (Gbondo-Tugbawa, 1997) as part of this investigation from two stations in Ninemile Creek (one at Amboy Dam and one at the USGS gauging station at Lakeland). Fifteen samples were collected at each station from October 1995 to September 1996 and analyzed for total mercury and total methylmercury (unfiltered). Sampling was performed once a month, with three additional samples taken in March 1996.

The objective of this study was to evaluate Ninemile Creek as a source of mercury to Onondaga Lake. Data from this study were not used to supplement existing RI data, since only one station in lower Ninemile Creek was sampled.

2.13.5 Onondaga County Surface Water Data

From 1999 to 2001, Onondaga County collected 12 surface water samples on ten different dates from the West Flume and upper and lower Geddes Brook for a total of 36 samples, and eight samples (including two duplicates) on six dates in lower Ninemile Creek (K. Murphy, pers. comm., 2002).

These samples were analyzed for mercury, methylmercury, and TSS. On one of the sampling dates (June 21, 2000), samples were collected at the beginning of a storm event and at two and four hours into the event (except at the lower Ninemile Creek location). The county's sample locations are provided in Figure 2-2.

These data are used to complement existing RI data and are presented and discussed in Chapters 5 and 6 of this report.

2.14 Summary of Investigations at Relevant Upland Sites

Honeywell conducted investigations at upland sites and disposal areas adjacent to the Geddes Brook/Ninemile Creek site (i.e., the LCP Bridge Street site, the Solvay Wastebeds, and the Mathews Avenue Landfill site). A summary of these investigations and their relevance to the Geddes Brook/Ninemile Creek site is discussed in more detail in Chapter 4.

2.14.1 Summary of the LCP Bridge Street Site Remedial Investigation

Geddes Brook has been primarily affected by contaminants from Honeywell's former LCP Bridge Street facility that reached the brook via the West Flume. A detailed history of ownership, manufacturing processes, and waste management at the LCP Bridge Street site is presented in the RI report (NYSDEC/TAMS, 1998).

The RI for the LCP Bridge Street site, which includes the West Flume, involved a two-part site characterization conducted in 1995 (Phase 1) and 1996 (Phase 2). The characterization included sampling the following media:

- Surface water (chemistry and toxicity).
- Sediment (chemistry and toxicity).
- Fish and benthic invertebrate tissue.
- Benthic invertebrate community.
- Groundwater.
- Surface soil.
- Deep soil.
- Air.
- Sewer bedding.
- The building floor.

Complete analytical results for surface water, sediment, groundwater, soil, air, fish tissue samples, and bioassays are presented in the LCP Bridge Street RI report (NYSDEC/TAMS, 1998).

The mercury content of sediment from the West Flume and in the water samples collected during storm events (PTI, 1996) indicates that mercury-contaminated sediments from the LCP Bridge Street site have been discharged from the West Flume to Geddes Brook (NYSDEC/TAMS, 1998). Additional discussion of contaminant loading from the West Flume to Geddes Brook and Ninemile Creek is provided in Chapter 6.

2.14.2 Summary of Solvay Wastebeds Investigations

In the study area, Geddes Brook and Ninemile Creek have been affected by Wastebeds 1 to 8 and 9 to 15 (Chapter 1, Figure 1-3) and by the former LCP Bridge Street facility via the West Flume, as described above. The history of the wastebeds is described in Blasland & Bouck (1989), BBL (1999), and PTI (1991, 1992) and is summarized here, with the exception of Wastebeds A to M, which are located near the south end of Onondaga Lake and do not appear to have affected the Geddes Brook/Ninemile Creek site.

As part of Honeywell's hydrogeologic assessment of the wastebeds, BBL collected surface water samples at 27 locations in December 1987 (Blasland and Bouck, 1989). The sampling locations were in and around upper and lower Geddes Brook and upper and lower Ninemile Creek.

In 1995, for NYSDEC, TAMS sampled groundwater wells, outfalls, seeps, waste, and sediment associated with Wastebeds 1 to 8 (TAMS, 1995). Outfall samples were also collected from Honeywell's Main Plant, the Semet Residue Ponds, the Willis Avenue site, and from Wastebeds 9 to 15. Also in 1995, for Honeywell, BBL prepared a data summary report compiling data from 11 studies of Wastebeds 9 to 15 and their surrounding areas (BBL, 1995). Samples of surface water, air, and wastebed solids were collected for analysis as part of the FS for the Solvay Wastebeds (BBL, 1990).

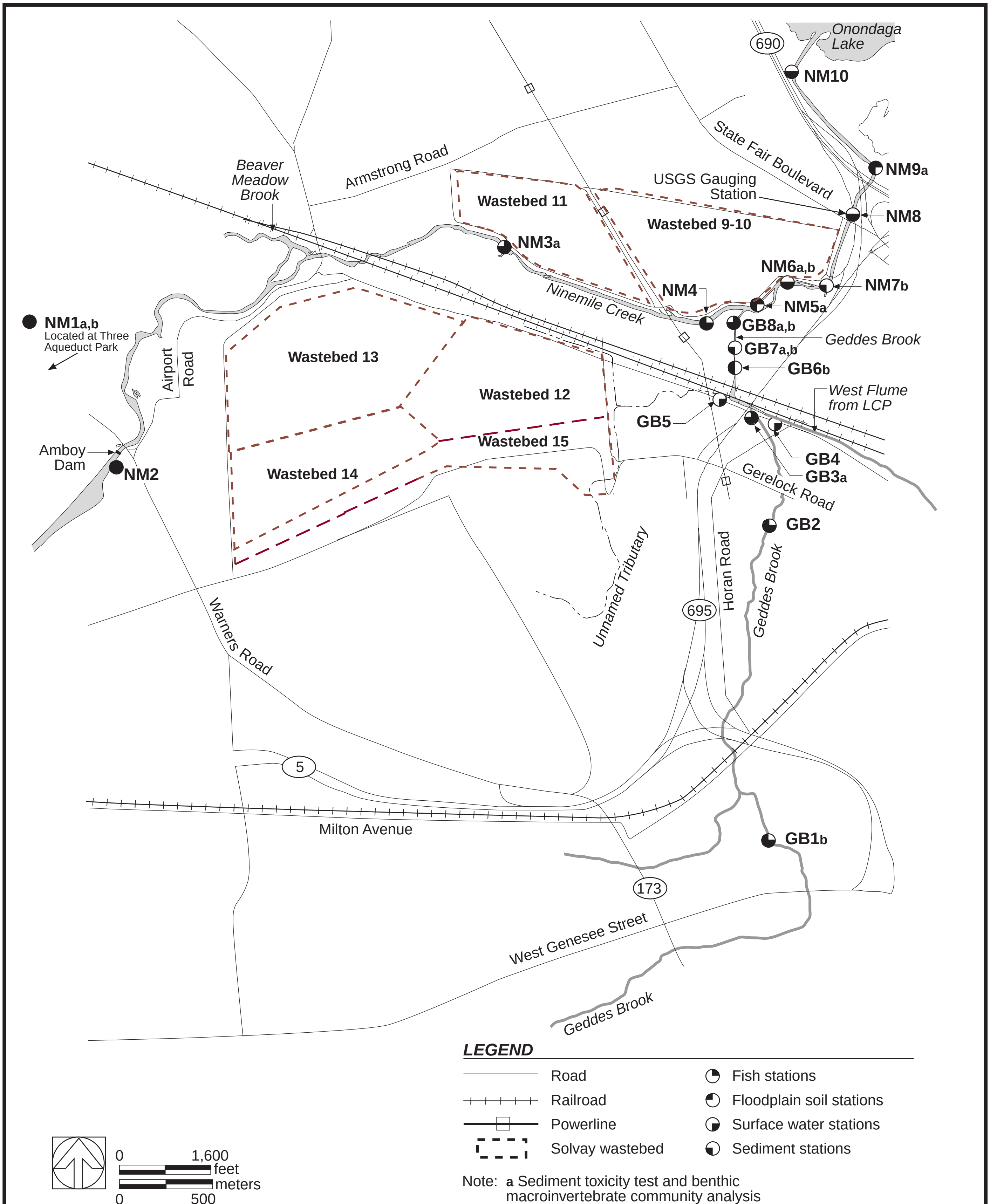
Between 1997 and 1999, BBL (for Honeywell) conducted a supplemental site investigation of Wastebeds 9 to 15, and collected additional groundwater, surface water, and sediment samples for chemical analysis (BBL, 1999). In 1997, BBL completed a supplemental wastebed investigation during which three sediment stations and three surface water stations in Ninemile Creek were sampled. Groundwater samples, in which cations/anions were analyzed, were collected from 22 wells in December 1997 from the vicinity of Wastebeds 9 to 15, Geddes Brook, and Ninemile Creek. In 1999, BBL collected samples at four sediment stations, one floodplain soil station, and five surface water stations in Ninemile Creek (BBL, 1999). Sediment and surface water samples were analyzed for metals, PCBs, SVOCs, and VOCs. The results from the 1997, 1998, and 1999 studies are summarized in the Supplemental Site Investigation Report: Wastebeds 9 to 15, Onondaga County, New York (BBL, 1999).

BBL conducted a quarterly monitoring program for Honeywell in Ninemile Creek from 1986 to 2000. In 2001, O'Brien & Gere took over the monitoring program. Monitoring is still being conducted by O'Brien & Gere as part of Honeywell's overall operation and maintenance (O&M) tasks. Chloride, total dissolved solids (TDS), pH, conductivity, and temperature are measured four times each year in 11 surface water stations and four groundwater stations (monitoring wells). In addition, streamflow measurements are made at one station in Geddes Brook and two stations in Ninemile Creek on the same quarterly basis. The streamflow data for 1989 through 2000 are presented and discussed in Chapter 3 of this RI report. Additional discussion of contaminant loading from the wastebeds to Ninemile Creek is provided in Chapters 4 and 5.

2.14.3 Summary of Mathews Avenue Landfill Site Investigation

An additional waste disposal area adjacent to Geddes Brook that was used by Honeywell is the currently inactive Mathews Avenue Landfill. The Mathews Avenue Landfill site is bordered by the Old Erie Canal on the north and Geddes Brook to the west (see Chapter 1, Figures 1-2 and 1-3). Honeywell entered into an Order on Consent (NYS index # D07-0007-01-01) in September 2002 for implementation of a preliminary site assessment (PSA) at the Mathews Avenue Landfill site and, if warranted, an RI/FS. The landfill was operated by Honeywell as a 6 NYCRR Part 360 construction and demolition (C&D) debris disposal site and may have received debris from the LCP Bridge Street site (Montgomery Watson Harza [MWH], 2002). Honeywell applied for closure of the landfill in 1988 under Part 360, and environmental sampling was performed by Honeywell at the landfill (MWH, 2002). Additional information can be found in Chapter 4.

In 1989, Blasland and Bouck on behalf of Honeywell excavated seven test pits at the landfill (Blasland & Bouck, 1990). Soil samples were collected from the walls of the test pits. Eight soil samples were analyzed for volatile petroleum hydrocarbons (e.g., chlorinated benzenes, BTEX, methyltertbutylether [MTBE], and total hydrocarbons), select metals (i.e., barium, chromium, mercury, silver), and percent solids.



Source: Modified from Exponent, 2001c

Figure 2-1. Sampling Stations for the Geddes Brook/Ninemile Creek RI/FS (1998)

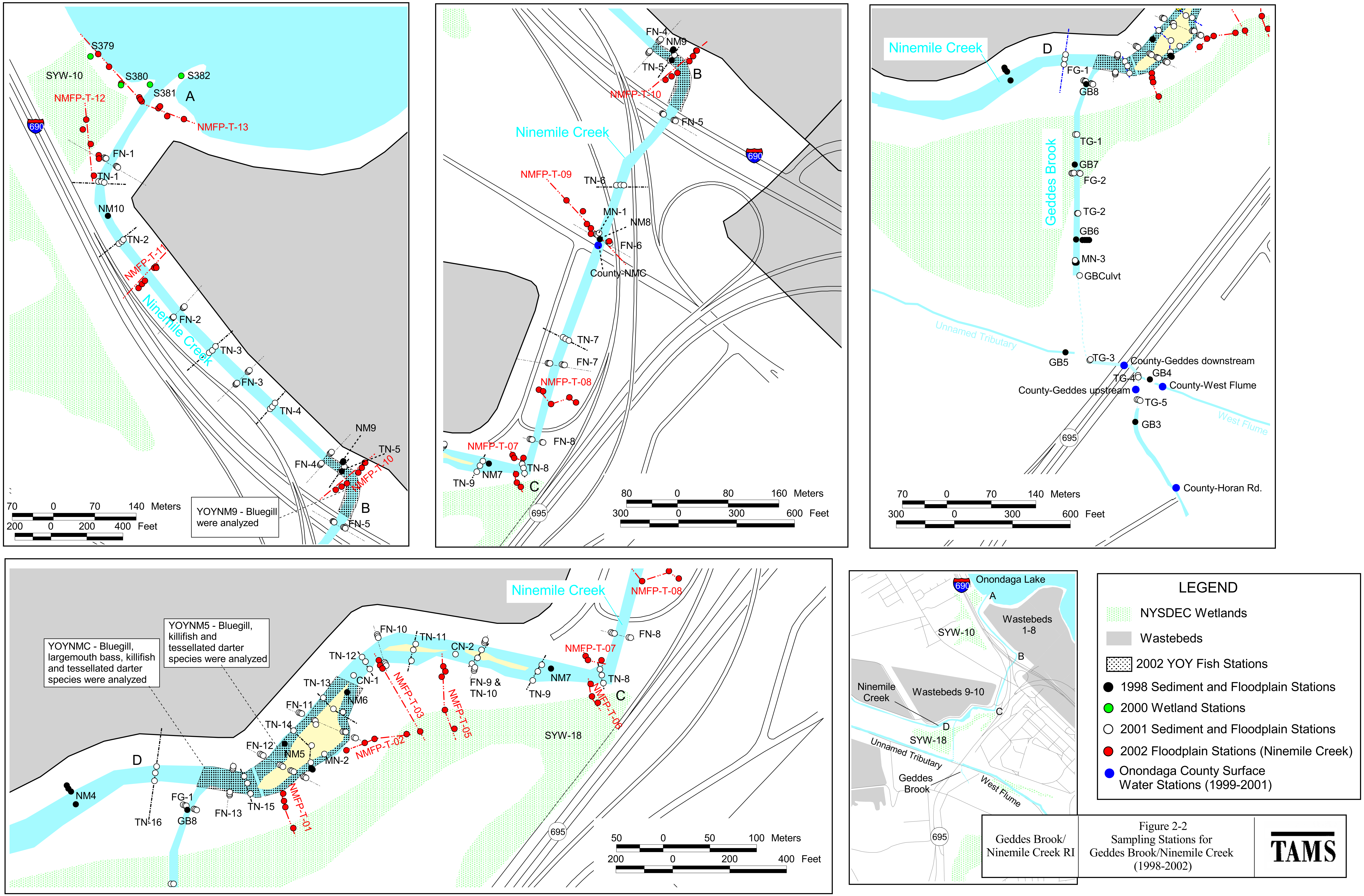
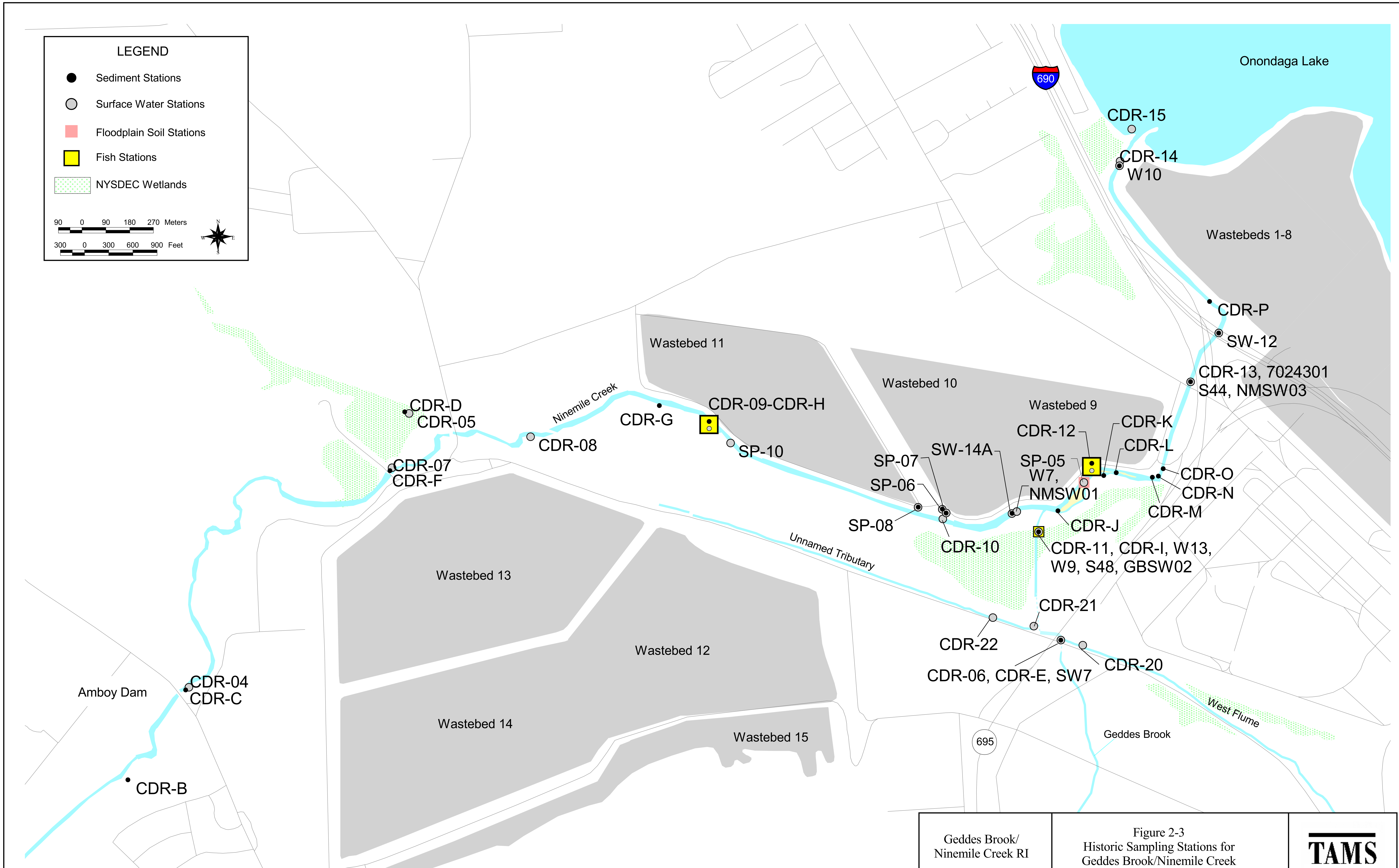


Figure 2-2
Sampling Stations for Geddes Brook/Ninemile Creek (1998-2002)



Geddes Brook/
Ninemile Creek RI

Figure 2-3
Historic Sampling Stations for
Geddes Brook/Ninemile Creek

TAMS

Source: Modified from Exponent, 2001c.

Table 2-1. Investigations In and Adjacent to the Geddes Brook/Ninemile Creek Site

Document Title	Sampled Area	Year(s)	Topic of Investigation
Previous Investigations (Performed Independently of Geddes Brook/Ninemile Creek RI/FS)			
Fish Community – Habitat Relations (Finger, 1982)	Geddes Brook/Ninemile Creek	1973	Fish
Macroinvertebrate Study of Ninemile Creek (Cooper et al., 1974)	Geddes Brook/Ninemile Creek	1974	Benthic macroinvertebrates
Biological Stream Assessment of Tributaries to Onondaga Lake (Bode et al., 1989, as cited in CDR, 1991)	Geddes Brook/Ninemile Creek	1989	Surface water, sediment
Engineering Investigations at Inactive Hazardous Waste Sites in the State of New York: Phase II Mercury Sediments – Onondaga Lake, Onondaga County (NYSDEC, 1989)	Onondaga Lake, East Flume, Geddes Brook, Tributary 5A, Ninemile Creek	1986–1987	Chemical analysis of surface water and sediment
Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area (Blasland & Bouck, 1989)	Allied wastebeds	1988–1989	Hydrogeologic assessment
Wastebed Feasibility Study (BBL, 1990)	Allied wastebeds	1990	Feasibility study based on 1988 and 1989 studies
Environmental Assessment of Lower Reaches of Ninemile Creek and Geddes Brook (CDR, 1991)	Geddes Brook/Ninemile Creek	1990	Chemical analysis of surface water, sediment, and biota; toxicity and community analysis of fish and macroinvertebrates
Honeywell's Mathews Avenue Landfill Closure Investigation (Blasland & Bouck, 1990)	Mathews Avenue Landfill	1990	Soil, sediment
Onondaga Lake RI/FS Mercury and Calcite Mass Balance Investigation Data Report (PTI, 1993)	Onondaga Lake, tributaries (all but West Flume)	1992	Chemical analysis of surface water and sediment
Rotating Intensive Basin Studies (NYSDEC, 1992)	Ninemile Creek	1989–1990	Chemical analysis of surface water and sediment

Table 2-1. (cont.)

Document Title	Sampled Area	Year(s)	Topic of Investigation
Previous Investigations (cont.)			
Wastebeds Investigation Report (NYSDEC and TAMS, 1995)	Wastebeds 1 to 8	1995	Chemical analysis of groundwater, surface water, sediment, and waste
Allied Wastebeds 9 to 15 and lower Ninemile Creek Valley Summary Data Report (Blasland &Bouck, July 1995)	Wastebeds 9 to 15	1995	Summary of available analytical analyses completed on samples of groundwater, surface water, seeps, sediments, and soils
Onondaga Lake RI/FS West Flume Mercury Investigation and Supplemental Sampling and Ninemile Creek Supplemental Sampling Data Report (PTI, 1996a)	West Flume, Geddes Brook, and Ninemile Creek	1994–1995	Analysis of total mercury and methylmercury in groundwater, sediments, and surface water
Concentrations and Fluxes of Total and Methyl Mercury to Onondaga Lake, Syracuse, New York (Gbondo-Tugbawa, 1997)	Tributaries	1995–1996	Analysis of total mercury and methylmercury in water
Remedial Investigation Report, LCP Bridge Street Facility, Solvay, New York (NYSDEC and TAMS, 1998c)	Bridge Street Facility and West Flume	1996–1997	Chemical analysis of air, soil, sediment, groundwater, surface water, biota
Supplemental Site Investigation Report: Waste Beds 9 to 15, Onondaga County, New York (BBL, 1999)	Wastebeds 9 to 15, Ninemile Creek	1997–1999	Chemical analysis of groundwater, surface water, sediment, and seeps
Onondaga County Surface Water Sampling Program (K. Murphy, pers. comm., 2002)	West Flume, Geddes Brook, Ninemile Creek	1999–2001	Surface water
NYSDEC/TAMS Onondaga Lake Database, Onondaga Lake Project Tributary Sampling (NYSDEC/TAMS, 2002)	Geddes Brook/Ninemile Creek NYSDEC sediment data	1996, 1997, 2000	Sediment in tributaries

Table 2-1. (cont.)

Document Title	Sampled Area	Year(s)	Topic of Investigation
Field and Laboratory Investigations Conducted for the Geddes Brook/Ninemile Creek RI/FS			
Geddes Brook/Ninemile Creek Remedial Investigation Report (Exponent, 2001)	Geddes Brook/Ninemile Creek	1998	Sediment, surface water, floodplain soil, fish, sediment toxicity, benthic community analysis
Geddes Brook/Ninemile Creek Supplemental RI Sampling (BBL, 2001)	Geddes Brook/Ninemile Creek	2001	Sediment, floodplain soil
Ninemile Creek Supplemental Floodplain Soil Sampling (O'Brien and Gere, 2002)	Ninemile Creek	2002	Floodplain soil
Ninemile Creek Young-of-Year (YOY) Fish Sampling Program (TAMS, 2002d)	Ninemile Creek	2002	Young-of-year fish

Table 2-2. Summary of Sampling Specifications Achieved for the Geddes Brook/Ninemile Creek Remedial Investigation (1998)

Task	Number of Sampling Locations	Sampling Period	Field Replicates	Total Number of Samples	Analyses
Surface Water Sampling					
One depth-integrated grab sample under dry conditions at each location	13	7/98, 9/98	1/event	28	Field measurements: pH, conductivity, dissolved oxygen, temperature, water depth Laboratory analyses: TAL substances (unfiltered and filtered); TCL VOCs, SVOCs and TSS (unfiltered); PCDD/PCDFs, methylmercury, chloride, TDS, hardness, other TCL, PCBs and pesticides (filtered)
Sediment Sampling					
One sediment core to approximately 1 m at each location; 0–15 cm, 15–45 cm, 45–75 cm, and 75–100 cm intervals were sampled, conditions permitting	16	7/98	2	39 [a]	Laboratory analyses: TAL and TCL substances, PCDD/PCDFs, chloride, TOC, percent solids, methylmercury, and grain-size distribution
Floodplain Soil Sampling					
Three discrete soil samples in each floodplain area; 0-15 cm at each location	8	7/98	2	26	Laboratory analyses: TAL and TCL substances, PCDD/PCDFs, methylmercury, chloride, TOC, percent solids
Sediment Toxicity Testing					
Additional surface sediment (0–15 cm) from the sediment sampling stations	8	7/98	0	8	Laboratory analyses: chironomid and amphipod bioassays, benthic macroinvertebrate survey
Fish Sampling[b]					
Fish by electroshock or seine at each location	7	7/98	0	7	Field measurements: species abundance, individual length, biomass
Three young-of-the-year composite samples from one location; five such samples from the other	2 [c]	7/98	0	8	Laboratory analyses:[d] TCL SVOCs, TCL pesticides/PCBs, TAL substances, total solids, lipid content
Five legal-size fish at each location	7	7/98	0	35	Laboratory analyses of fillet and remainder:[d] TCL SVOCs, TCL pesticides/PCBs, TAL substances, total solids, lipid content

Footnotes on next page.

Table 2-2. (cont.)

Notes:	PCB	-	polychlorinated biphenyl
	PCDD/PCDF	-	polychlorinated dibenzo-*p* -dioxin and polychlorinated dibenzofuran
	SVOC	-	semivolatile organic compound
	TAL	-	Target Analyte List
	TCL	-	Target Compound List
	TDS	-	total dissolved solids
	TOC	-	total organic carbon
	TSS	-	total suspended solids
	VOC	-	volatile organic compound

[a] Sample penetration was less than 100 cm at several stations resulting in fewer samples than anticipated.

[b] Collection and analysis of whole body samples specified in the work plan was inadvertently omitted by Honeywell/Exponent.

[c] Young-of-year fish were only found in sufficient quantity for analysis at two locations.

[d] See Table 2-3. In some cases, sample size limited analysis.

Source: Modified from Exponent, 2001c.

Table 2-3. Summary of Chemical Analyses in Fish Tissue (1998)

Sample Number[a]	Sample Location	Total Mercury	TCL Pesticides/ PCBs[b]	PCDD/ PCDFs	Total Solids	TCL SVOCs	TAL Metals	Cyanide	Lipids
WF0001	NM9	*	*	*	*	*	*	*	*
FF0001	NM9	*	*	*	*	*	*	*	*
WF0002	NM9	*	*	*	*	*	*	*	*
FF0002	NM9	*	*	*	*	*	*	*	*
WF0003	NM9	*	*	*	*	*	*	*	*
FF0003	NM9	*	*	*	*	*	*	*	*
WF0004	NM9	*	*	*	*	*	*		*
FF0004	NM9	*	*	*	*	*	*	*	*
WF0005	NM9	*	*	*	*	*	*		*
FF0005	NM9	*	*	*	*	*	*	*	*
WF0006	GB3	*	*	*	*	*	*	*	*
FF0006	GB3	*	*	*	*	*	*	*	*
WF0007	GB3	*	*	*	*		*	*	*
FF0007	GB3	*	*	*	*		*	*	*
WF0008	GB3	*	*	*	*		*	*	*
FF0008	GB3	*	*	*	*		*	*	*
WF0009	GB3	*	*	*	*	*	*	*	*
FF0009	GB3	*	*	*	*	*	*	*	*
WF0010	GB3	*	*	*	*	*	*	*	*
FF0010	GB3	*	*	*	*	*	*		*
WF0011	NM2	*	*	*	*	*	*	*	*
FF0011	NM2	*	*	*	*	*	*	*	*
WF0012	NM2	*	*	*	*	*	*	*	*
FF0012	NM2	*	*	*	*	*	*	*	*
WF0013	NM2	*	*	*	*	*	*	*	*
FF0013	NM2	*	*	*	*	*	*	*	*
WF0014	NM2	*	*	*	*	*	*	*	*
FF0014	NM2	*	*	*	*	*	*	*	*
WF0015	NM2	*	*	*	*	*	*	*	*
FF0015	NM2	*	*	*	*	*	*	*	*
WF0016	NM5	*	*	*	*	*	*	*	*
FF0016	NM5	*	*	*	*	*	*	*	*
WF0017	NM5	*	*	*	*	*	*	*	*
FF0017	NM5	*	*	*	*	*	*	*	*
WF0018	NM5	*	*	*	*	*	*	*	*
FF0018	NM5	*	*	*	*	*	*	*	*
WF0019	NM5	*	*	*	*	*	*	*	*
FF0019	NM5	*	*	*	*	*	*	*	*
WF0020	NM5	*	*	*	*		*		*
FF0020	NM5	*	*	*	*		*	*	*
WF0021	NM3	*	*	*	*	*	*	*	*
FF0021	NM3	*	*	*	*	*	*	*	*
WF0022	NM3	*	*	*	*	*	*	*	*
FF0022	NM3	*	*	*	*	*	*	*	*
WF0023	NM3	*	*	*	*		*	*	*
FF0023	NM3	*	*	*	*		*	*	*
WF0024	NM3	*	*	*	*	*	*	*	*
FF0024	NM3	*	*	*	*	*	*	*	*
WF0025	NM3	*	*	*	*		*	*	*
FF0025	NM3	*	*	*	*		*	*	*

Table 2-3. (cont.)

Sample Number[a]	Sample Location	Total Mercury	TCL Pesticides/ PCBs[b]	PCDD/Fs	Total Solids	TCL SVOCs	TAL Metals	Cyanide	Lipids
WF0026	NM1	*	*	*	*	*	*	*	*
FF0026	NM1	*	*	*	*	*	*	*	*
WF0027	NM1	*	*	*	*	*	*	*	*
FF0027	NM1	*	*	*	*	*	*	*	*
WF0028	NM1	*	*	*	*	*	*	*	*
FF0028	NM1	*	*	*	*	*	*	*	*
WF0029	NM1	*	*	*	*	*	*	*	*
FF0029	NM1	*	*	*	*	*	*	*	*
WF0030	NM1	*	*	*	*	*	*	*	*
FF0030	NM1	*	*	*	*	*	*	*	*
WF0031	GB8	*	*	*	*	*	*	*	*
FF0031	GB8	*	*	*	*	*	*	*	*
WF0032	GB8	*	*	*	*	*	*	*	*
FF0032	GB8	*	*	*	*	*	*	*	*
WF0033	GB8	*	*	*	*	*	*	*	*
FF0033	GB8	*	*	*	*	*	*	*	*
WF0034	GB8	*	*	*	*		*	*	*
FF0034	GB8	*	*	*	*	*	*	*	*
WF0035[c]	GB8	*			*	*	*		*
FF0035[d]	GB8	*			*	*	*	*	
WF0036[c]	GB8	*			*	*	*		*
FF0036[d]	GB8	*			*	*	*	*	
CF0001	NM2	*	*	*	*	*	*	*	*
CF0002	NM2	*	*		*				*
CF0003	NM2	*		*					*
CF0004	NM3	*		*	*				*
CF0005	NM3	*	*	*	*		*	*	*
CF0006[e]	NM3	*	*	*	*		*	*	*
CF0007[e]	NM3	*	*	*	*		*	*	*
CF0008	NM3	*		*	*	*	*	*	*

Notes: PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
SVOC - semivolatile organic compound
TAL - Target Analyte List
TCL - Target Compound List

[a] FF - fish fillet
WF - remainder of fish (after filleting)
CF - whole-body composite (young-of-year fish)
FF and WF samples with the same number are from the same fish.

[b] Hexachlorobenzene was analyzed in the PCBs/pesticides extract.

[c] WF0035 and WF0036 were composited.

[d] FF0035 and FF0036 were composited.

[e] CF0006 and CF0007 were composited.

Source: Modified from Exponent, 2001c.

Table 2-4. Summary of Sampling Specifications Achieved for the Geddes Brook/Ninemile Creek Supplemental RI Sampling (2001)

Task	Number of Sampling Locations	Sampling Period	Field Replicates	Total Number of Samples	Analyses [a]
Floodplain Soil Sampling					
Six cores along each of 13 transects; 12 cores along two transects; 0–15 cm and 15–30 cm intervals were sampled, conditions permitting.	102	2/01, 3/01	11	207	Laboratory analyses: TAL and TCL substances, PCDD/PCDFs, TOC, percent solids, and methylmercury
Sediment Sampling (transects)					
Three sediment cores to approximately 1 m along 16 transects; two sediment cores to approximately 1 m along 7 transects; 0–15 cm, 15–45 cm, 45–75 cm, and 75–105 cm intervals were sampled, conditions permitting.[c]	62	3/01, 04/01	13	276 [b]	Laboratory analyses: TAL and TCL substances, PCDD/PCDFs, TOC, percent solids, and methylmercury
Sediment Sampling (discrete)					
One sediment core to approximately 1 m at each location; 0–15 cm, 15–45 cm, 45–75 cm, and 75–105 cm intervals were sampled, conditions permitting.	6	3/01, 04/01	2	21	Laboratory analyses: Total mercury, TOC, percent solids
Island Soil Sampling	3	3/01	0	12	Laboratory analyses: TAL and TCL substances, PCDD/PCDFs, TOC, percent solids, and methylmercury
One core to approximately 1 m at each location; 0–15 cm, 15–45 cm, 45–75 cm, and 75–105 cm intervals were sampled, conditions permitting.					

Notes:

PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
SVOC - semivolatile organic compound
TAL - Target Analyte List (includes metals + cyanide)
TCL - Target Compound List (includes SVOCs, VOCs, pesticides, PCBs + Aroclor 1268)
TDS - total dissolved solids
TOC - total organic carbon
TSS - total suspended solids
VOC - volatile organic compound

[a] All samples were analyzed for total mercury and TOC. Subsets were analyzed for other analytes according to the sampling plan. See Appendices E and F for analyses conducted for each interval.

[b] Sample penetration was less than 100 cm at several stations resulting in fewer samples than anticipated.

[c] Some cores were sampled at intervals greater than 105 cm according to the sampling plan.

Source: Modified from Exponent, 2001c.

Table 2-5. Summary of Laboratory Methods for Analysis of Samples from the Geddes Brook/ Ninemile Creek Remedial Investigation (1998)

Task	Laboratory Method	Number of Sampling Locations	Field Replicates	Total Number of Samples
Surface Water Sampling		13	1/event	28
TAL metals (except mercury)	EPA CLP SOW ILM04.0			
TCL VOCs, SVOCs, pesticides, PCBs[a]	EPA CLP SOW OLM03.1			
PCDD/PCDFs	SW-846 Method 8290			
Total mercury	EPA Method 1631			
Methylmercury	Bloom (1989) and Liang et al. (1994)			
Chloride	EPA Method 325.3			
TDS	EPA Method 160.1			
Hardness	EPA Method 130.2			
TSS	EPA Method 160.2 (modified)			
Sediment Sampling		16	2	39
TAL metals	EPA CLP SOW ILM04.0			
TCL VOCs, SVOCs, pesticides, PCBs[a]	EPA CLP SOW OLM03.1			
PCDD/PCDFs	SW-846 Method 8290			
Total mercury	EPA Method 1631			
Methylmercury	Bloom (1989) and Liang et al. (1994)			
Chloride	EPA Method 325.3			
TOC	ASTM Method E1391-93			
Percent solids	EPA 160.3 (modified)			
Grain size distribution	ASTM Method D422-63			
Floodplain Soil Sampling		8	2	26
TAL metals	EPA CLP SOW ILM04.0			
TCL VOCs, SVOCs, pesticides, PCBs[a]	EPA CLP SOW OLM03.1			
PCDD/PCDFs	SW-846 Method 8290			
Total mercury	EPA Method 1631			
Methylmercury	Bloom (1989) and Liang et al. (1994)			
Chloride	EPA Method 325.3			
TOC	ASTM Method E1391-93			
Percent solids	EPA 160.3 (modified)			
Sediment Toxicity Testing		8	0	8
Midge bioassay	ASTM Method E1706-95b			
Amphipod bioassay	ASTM Method E1706-95b			
BMI survey	taxonomic identification			
Fish Sampling		7	0	35 adult fish
TAL metals	EPA CLP SOW ILM04.0			7 young-of-year
TCL VOCs, SVOCs, pesticides, PCBs[a]	EPA CLP SOW OLM03.1			composites
PCDD/PCDFs	SW-846 Method 8290			
Total mercury	Bloom (1989)			
Total solids	EPA 160.3 (modified)			
Lipid content	AOAC 17.016			

Notes:
PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
TAL - Target Analyte List
TCL - Target Compound List
TDS - total dissolved solids
TOC - total organic carbon
TSS - total suspended solids

[a] Hexachlorobenzene was analyzed twice for each sample: with the SVOC and PCB analytes. Both results are reported in data tables in Appendix A.

Source: Modified from Exponent 2001c.

Table 2-6. Summary of Sampling Specifications Achieved for the Ninemile Creek Supplemental Floodplain Soil Investigation (2002)

Task	Number of Sampling Locations	Sampling Period	Field Replicates	Total Number of Samples	Analyses / Method [a]
Floodplain Soil Sampling Location					
12 transects; four depth intervals; 0 - 6 inches (0 - 15 cm); 6 - 12 inches (15 - 30 cm); 12 - 24 inches (30 - 60 cm); and 24 - 36 inches (60 - 90 cm) All depth intervals were not collected at all locations.[b] Number of cores per transect varied from 3 to 10.	64	9/5 - 9/16	13	235	Laboratory Analysis: Mercury / USEPA Method 7471A, SVOCs (PAHs) / USEPA Methods 3550B/8270C PCDD/PCDFs/ USEPA Method 8290 Percent Total Solids / 2540-G, TOC/ Lloyd Kahn

Notes:

PCDD/PCDF	-	polychlorinated dibenzo-*p* -dioxin and polychlorinated dibenzofuran
PAHs	-	polycyclic aromatic hydrocarbons
SVOC	-	semivolatile organic compound
TOC	-	total organic carbon

[a] All samples were analyzed for total mercury and TOC. Samples collected from transects 1, 3, 6, 7, 8 (L) and (R), 9 (R), 10 (L) and (R) were also analyzed for PAHs (including hexachlorobenzene) and PCDD/PCDFs. The 2002 soil data are presented in Appendix G1.

[b] Due to field obstructions only the top two intervals were collected at 12 locations including:

NMFP-T-01-5; NMFP-T-01-150; NMFP-T-02-25; NMFP-T-02-50; NMFP-T-02-180; NMFP-T-03-330; NMFP-T-06-50; NMFP-T-07-25; NMFP-T-07-50;

NMFP-T-08-60L; NMFP-T-10-25R (right bank facing upstream); NMFP-T-10-60R; and NMFP-T-11-50R.

Only the top three intervals were collected at NMFP-T-08-30R (right bank facing upstream). Data are presented in Appendix G1.

Table 2-7. Summary of Sampling Specifications Achieved for the Supplemental Ninemile Creek Young-of-Year (YOY) Fish Investigation (2002)

Task	Number of Sampling Locations	Sampling Period	Field Replicates	Total Number of Samples	Analyses/Method
Fish Sampling					
Three young-of-year bluegill composite samples from three locations (Figure 2-2: Stations NMC, NM5, and NM9)	3 [a]	10/1 through 10/3	0	9	Individual length TAL metals/ SW- 846 6010B, SW-846 7471A (mercury) PCDD/PCDFs/SW-846 8090 SVOCs/SW-846 8270C PCBs/ SW-846 8082
One young-of-year killifish composite sample from two locations (Figure 2-2: Stations NMC and NM5)	2 [b]	10/1 through 10/3	0	1	Pesticide/SW-846 8081A Total Percent Solids Lipids
One young-of-year tessellated darter composite sample from two locations (Figure 2-2: Stations NMC and NM5)	2 [a,b]	10/1 through 10/3	0	1	
Individual largemouth bass samples from Station NMC	4	10/1 through 10/3	0	4	Individual length TAL metals including mercury

Notes:
PCB - polychlorinated biphenyl
PCDD/PCDF - polychlorinated dibenzo-*p* -dioxin and polychlorinated dibenzofuran
SVOC - semivolatile organic compound
TAL - target analyte list
TCL - target compound list

[a] Sample size limited analyses; metals (including mercury) were not analyzed for one of the bluegill composites (S2) and the tessellated darter composite at Station NM5.

[b] The composite samples of killifish and tessellated darter collected from Station NMC were composited with the samples of the same species from Station NM5 in the laboratory. The sample results were reported as NM5-killifish-S1 and NM5-tessdarter-S1.

[c] The 2002 YOY fish data are presented in Appendix G2.

Table 2-8. Sediment, Soil, Surface Water, and Fish Tissue Stations Used in the Geddes Brook/Ninemile Creek HHRA and BERA

Survey	Location of Data in RI Appendices	Sediment		Soil		Surface Water		Fish Tissue		Comments
		BERA	HHRA	BERA	HHRA	BERA	HHRA	BERA	HHRA	
BBL 2001	Appendix E	CN-1	CN-1	FG-1-1	FG-1-1					
	Appendix E	CN-2	CN-2	FG-1-2	FG-1-2					
	Appendix E	GBCULVT1	GBCULVT1	FG-1-3	FG-1-3					
	Appendix E	MN-1	MN-1	FG-1-4	FG-1-4					
	Appendix E	MN-2	MN-2	FG-1-5	FG-1-5					
	Appendix E	MN-3	MN-3	FG-1-6	FG-1-6					
	Appendix E	TG-1-1	TG-1-1	FG-2-1	FG-2-1					
	Appendix E	TG-1-2	TG-1-2	FG-2-2	FG-2-2					
	Appendix E	TG-2-1	TG-2-1	FG-2-3	FG-2-3					
	Appendix E	TG-2-2	TG-2-2	FG-2-4	FG-2-4					
	Appendix E	TG-3-1	TG-3-1	FG-2-5	FG-2-5					
	Appendix E	TG-3-2	TG-3-2	FN-1-1	FN-1-1					
	Appendix E	TG-4-1	TG-4-1	FN-1-2	FN-1-2					
	Appendix E	TG-4-2	TG-4-2	FN-1-3	FN-1-3					
	Appendix E	TG-5-1	TG-5-1	FN-1-4	FN-1-4					
	Appendix E	TG-5-2	TG-5-2	FN-1-5	FN-1-5					
	Appendix E	TG-5-3	TG-5-3	FN-1-6	FN-1-6					
	Appendix E	TN-1-1		FN-2-1	FN-2-1					HHRA excludes due to water depth
	Appendix E	TN-1-2		FN-2-2	FN-2-2					HHRA excludes due to water depth
	Appendix E	TN-1-3		FN-2-3	FN-2-3					HHRA excludes due to water depth
	Appendix E	TN-2-1	TN-2-1	FN-2-4	FN-2-4					
	Appendix E	TN-2-2		FN-2-5	FN-2-5					HHRA excludes due to water depth
	Appendix E	TN-2-3		FN-2-6	FN-2-6					HHRA excludes due to water depth
	Appendix E	TN-3-1	TN-3-1	FN-3-1	FN-3-1					
	Appendix E	TN-3-2	TN-3-2	FN-3-2	FN-3-2					
	Appendix E	TN-3-3	TN-3-3	FN-3-3	FN-3-3					
	Appendix E	TN-4-1	TN-4-1	FN-3-4	FN-3-4					
	Appendix E	TN-4-2	TN-4-2	FN-3-5	FN-3-5					
	Appendix E	TN-4-3	TN-4-3	FN-3-6	FN-3-6					
	Appendix E	TN-5-1	TN-5-1	FN-4-1	FN-4-1					
	Appendix E	TN-5-2		FN-4-2	FN-4-2					HHRA excludes due to water depth
	Appendix E	TN-5-3		FN-4-3	FN-4-3					HHRA excludes due to water depth
	Appendix E	TN-6-1	TN-6-1	FN-4-4	FN-4-4					
	Appendix E	TN-6-2	TN-6-2	FN-4-5	FN-4-5					
	Appendix E	TN-6-3	TN-6-3	FN-4-6	FN-4-6					
	Appendix E	TN-7-1	TN-7-1	FN-5-1	FN-5-1					
	Appendix E	TN-7-2	TN-7-2	FN-5-2	FN-5-2					
	Appendix E	TN-7-3	TN-7-3	FN-5-3	FN-5-3					
	Appendix E	TN-8-1	TN-8-1	FN-5-4	FN-5-4					
	Appendix E	TN-8-2	TN-8-2	FN-5-5	FN-5-5					
	Appendix E	TN-8-3	TN-8-3	FN-5-6	FN-5-6					
	Appendix E	TN-9-1	TN-9-1	FN-6-1	FN-6-1					
	Appendix E	TN-9-2	TN-9-2	FN-6-2	FN-6-2					
	Appendix E	TN-9-3		FN-6-3	FN-6-3					HHRA excludes due to water depth
	Appendix E	TN-10-1	TN-10-1	FN-6-4	FN-6-4					
	Appendix E	TN-10-2	TN-10-2	FN-6-5	FN-6-5					
	Appendix E	TN-10-3	TN-10-3	FN-6-6	FN-6-6					
	Appendix E	TN-11-1	TN-11-1	FN-7-1	FN-7-1					
	Appendix E	TN-11-3	TN-11-3	FN-7-2	FN-7-2					
	Appendix E	TN-12-1	TN-12-1	FN-7-3	FN-7-3					
	Appendix E	TN-12-2	TN-12-2	FN-7-4	FN-7-4					
	Appendix E	TN-12-3	TN-12-3	FN-7-5	FN-7-5					
	Appendix E	TN-13-1	TN-13-1	FN-7-6	FN-7-6					
	Appendix E	TN-13-3	TN-13-3	FN-8-1	FN-8-1					
	Appendix E	TN-14-1	TN-14-1	FN-8-2	FN-8-2					
	Appendix E	TN-14-3	TN-14-3	FN-8-3	FN-8-3					

Table 2-8. (cont.)

Survey	Location of Data in RI Appendices	Sediment		Soil		Surface Water		Fish Tissue		Comments
		BERA	HHRA	BERA	HHRA	BERA	HHRA	BERA	HHRA	
BBL 2001 cont.	Appendix E	TN-15-1	TN-15-1	FN-8-4	FN-8-4					
	Appendix E	TN-15-2	TN-15-2	FN-8-5	FN-8-5					
	Appendix E	TN-15-3	TN-15-3	FN-9-1	FN-9-1					
	Appendix E	TN-16-1	TN-16-1	FN-9-2	FN-9-2					
	Appendix E	TN-16-2	TN-16-2	FN-9-3	FN-9-3					
	Appendix E	TN-16-3	TN-16-3	FN-9-4	FN-9-4					
	Appendix E	*TN-17-1*	*TN-17-1*	FN-9-5	FN-9-5					*Reference Station, excluding "A" depth*
	Appendix E	*TN-17-2*	*TN-17-2*	FN-9-6	FN-9-6					*Reference Station*
	Appendix E	*TN-17-3*	*TN-17-3*	FN-10-1	FN-10-1					*Reference Station*
	Appendix E	*TN-18-1*	*TN-18-1*	FN-10-2	FN-10-2					*Reference Station, excluding "A" depth*
	Appendix E	*TN-18-2*	*TN-18-2*	FN-10-3	FN-10-3					*Reference Station*
	Appendix E	*TN-18-3*	*TN-18-3*	FN-10-4	FN-10-4					*Reference Station*
	Appendix E			FN-10-5	FN-10-5					
	Appendix E			FN-10-6	FN-10-6					
	Appendix E			FN-11-1	FN-11-1					
	Appendix E			FN-11-2	FN-11-2					
	Appendix E			FN-11-3	FN-11-3					
	Appendix E			FN-11-4	FN-11-4					
	Appendix E			FN-11-5	FN-11-5					
	Appendix E			FN-11-6	FN-11-6					
	Appendix E			FN-11-7	FN-11-7					
	Appendix E			FN-11-8	FN-11-8					
	Appendix E			FN-11-9	FN-11-9					
	Appendix E			FN-11-10	FN-11-10					
	Appendix E			FN-11-11	FN-11-11					
	Appendix E			FN-12-1	FN-12-1					
	Appendix E			FN-12-2	FN-12-2					
	Appendix E			FN-12-3	FN-12-3					
	Appendix E			FN-12-4	FN-12-4					
	Appendix E			FN-12-5	FN-12-5					
	Appendix E			FN-12-6	FN-12-6					
	Appendix E			FN-12-7	FN-12-7					
	Appendix E			FN-12-8	FN-12-8					
	Appendix E			FN-12-9	FN-12-9					
	Appendix E			FN-12-10	FN-12-10					
	Appendix E			FN-12-11	FN-12-11					
	Appendix E			FN-12-12	FN-12-12					
	Appendix E			FN-13-1	FN-13-1					
	Appendix E			FN-13-2	FN-13-2					
	Appendix E			FN-13-3	FN-13-3					
	Appendix E			FN-13-4	FN-13-4					
	Appendix E			FN-13-5	FN-13-5					
	Appendix E			FN-13-6	FN-13-6					
	Appendix E			TN-11-2	TN-11-2					Island soil
	Appendix E			TN-13-2	TN-13-2					Island soil
	Appendix E			TN-14-2	TN-14-2					Island soil
Exponent 2000	Appendix E			S379	S379					
	Appendix E			S380	S380					
	Appendix E			S381	S381					
	Appendix E			S382	S382					
	Appendix L							MNMC		HHRA used fish from this station in Onondaga Lake HHRA
	Appendix L							NMC	NMC	
BBL 1997	Appendix L	SP-05				SP-10				
	Appendix L	SW-12	SW-12			SW-12				
	Appendix L	SW-14A	SW-14A			SW-14A				

Table 2-8. (cont.)

Survey	Location of Data in RI Appendices	Sediment		Soil		Surface Water		Fish Tissue		Comments
		BERA	HHRA	BERA	HHRA	BERA	HHRA	BERA	HHRA	
Exponent 1998	Appendix A	*GB2*	GB2	*GB2*	GB2	*GB2*	GB2	GB3	GB3	*Reference Station (GB2-BERA)*
	Appendix A	GB3	GB3	GB6	GB6	GB3	GB3	GB8	GB8	
	Appendix A	GB6	GB6		*NM1*	GB4			*NM1*	*Reference Station (NM1-HHRA);* Water - GB4 in West Flume (not used in HHRA)
	Appendix A	GB7	GB7	*NM2*	*NM2*	GB5		*NM2*	*NM2*	*Reference Station (NM2-both);* Water - GB5 in Unnamed Trib (not used in HHRA)
	Appendix A	GB8	GB8	NM4	NM4	GB8	GB8	NM3	NM3	
	Appendix A		*NM1*	NM5	NM5	*NM2*	*NM2*	NM5	NM5	*Reference Station (NM1-HHRA, NM2-both)*
	Appendix A	*NM2*	*NM2*	NM9	NM9	NM3	NM3	NM9	NM9	
	Appendix A	NM3	NM3			NM4	NM4			
	Appendix A	NM4	NM4			NM6	NM6			
	Appendix A	NM5	NM5			NM8	NM8			
	Appendix A	NM6	NM6			NM10	NM10			
	Appendix A	NM7	NM7							
	Appendix A	NM8	NM8							
	Appendix A	NM9	NM9							
	Appendix A	NM10	NM10							
PTI 1992-1995	Appendix L					GBSW2	GBSW2			
	Appendix L					GBSW7	GBSW7			
	Appendix L					NMSW1	NMSW1			
	Appendix L					NMSW3	NMSW3			
	Appendix L					W10	W10			
	Appendix L					W13	W13			
	Appendix L					W14	W14			
CDR 1990	Appendix L	CDR-D				CDR04		CDR09	CDR09	
	Appendix L	CDR-E				CDR05		CDR11		
	Appendix L	CDR-F				CDR06		CDR12	CDR12	
	Appendix L	CDR-I				CDR07				
	Appendix L	CDR-G				CDR08				
	Appendix L	CDR-K				CDR09				
	Appendix L	CDR-L				CDR10				
	Appendix L	CDR-M				CDR11				
	Appendix L	CDR-O				CDR12				
	Appendix L	CDR-P				CDR13				
	Appendix L					CDR14				
	Appendix L					CDR15				
	Appendix L					CDR21				
NYSDEC RIBS 1987, 1989, and 1990	Appendix L	7024301				7024301				
	Appendix L	S44				W7				
	Appendix L	S48				W9				
Onondaga County 1999-2001	Appendix L					Geddes Brook (Downstream)				Only used for BERA screening
	Appendix L					Geddes Brook (above W. Flume)				Only used for BERA screening
	Appendix L					Ninemile Creek (USGS on Rt 48)				Only used for BERA screening
NYSDEC Trib Monitoring (1996-1997)	Appendix L	G3	G3							Stations from 2000 not included since not in Geddes Brook or Ninemile Creek
	Appendix L	G4	G4							
	Appendix L	G5	G5							
	Appendix L	N103	N103							
	Appendix L	N104	N104							
NYSDEC/TAMS YOY 2002	Appendix G2							NMC		YOY fish not used in HHRA
	Appendix G2							NM5		
	Appendix G2							NM9		

Table 2-8. (cont.)

Survey	Location of Data in RI Appendices	Sediment		Soil		Surface Water		Fish Tissue		Comments
		BERA	HHRA	BERA	HHRA	BERA	HHRA	BERA	HHRA	
OBG 2002	Appendix G1			NMFP-T-01-150	NMFP-T-01-150					
	Appendix G1			NMFP-T-01-25	NMFP-T-01-25					
	Appendix G1			NMFP-T-01-5	NMFP-T-01-5					
	Appendix G1			NMFP-T-01-50	NMFP-T-01-50					
	Appendix G1			NMFP-T-02-180	NMFP-T-02-180					
	Appendix G1			NMFP-T-02-25	NMFP-T-02-25					
	Appendix G1			NMFP-T-02-5	NMFP-T-02-5					
	Appendix G1			NMFP-T-02-50	NMFP-T-02-50					
	Appendix G1			NMFP-T-03-25	NMFP-T-03-25					
	Appendix G1			NMFP-T-03-330	NMFP-T-03-330					
	Appendix G1			NMFP-T-03-5	NMFP-T-03-5					
	Appendix G1			NMFP-T-03-50	NMFP-T-03-50					
	Appendix G1			NMFP-T-05-150	NMFP-T-05-150					
	Appendix G1			NMFP-T-05-200	NMFP-T-05-200					
	Appendix G1			NMFP-T-05-25	NMFP-T-05-25					
	Appendix G1			NMFP-T-05-5	NMFP-T-05-5					
	Appendix G1			NMFP-T-05-50	NMFP-T-05-50					
	Appendix G1			NMFP-T-06-25	NMFP-T-06-25					
	Appendix G1			NMFP-T-06-5	NMFP-T-06-5					
	Appendix G1			NMFP-T-06-50	NMFP-T-06-50					
	Appendix G1			NMFP-T-07-25	NMFP-T-07-25					
	Appendix G1			NMFP-T-07-5	NMFP-T-07-5					
	Appendix G1			NMFP-T-07-50	NMFP-T-07-50					
	Appendix G1			NMFP-T-08-25L	NMFP-T-08-25L					
	Appendix G1			NMFP-T-08-30R	NMFP-T-08-30R					
	Appendix G1			NMFP-T-08-5L	NMFP-T-08-5L					
	Appendix G1			NMFP-T-08-5R	NMFP-T-08-5R					
	Appendix G1			NMFP-T-08-60L	NMFP-T-08-60L					
	Appendix G1			NMFP-T-09-150R	NMFP-T-09-150R					
	Appendix G1			NMFP-T-09-25R	NMFP-T-09-25R					
	Appendix G1			NMFP-T-09-260R	NMFP-T-09-260R					
	Appendix G1			NMFP-T-09-50R	NMFP-T-09-50R					
	Appendix G1			NMFP-T-09-5L	NMFP-T-09-5L					
	Appendix G1			NMFP-T-09-5R	NMFP-T-09-5R					
	Appendix G1			NMFP-T-10-100L	NMFP-T-10-100L					
	Appendix G1			NMFP-T-10-25L	NMFP-T-10-25L					
	Appendix G1			NMFP-T-10-25R	NMFP-T-10-25R					
	Appendix G1			NMFP-T-10-50L	NMFP-T-10-50L					
	Appendix G1			NMFP-T-10-5L	NMFP-T-10-5L					
	Appendix G1			NMFP-T-10-5R	NMFP-T-10-5R					
	Appendix G1			NMFP-T-10-60R	NMFP-T-10-60R					
	Appendix G1			NMFP-T-11-25L	NMFP-T-11-25L					
	Appendix G1			NMFP-T-11-25R	NMFP-T-11-25R					
	Appendix G1			NMFP-T-11-40L	NMFP-T-11-40L					
	Appendix G1			NMFP-T-11-50R	NMFP-T-11-50R					
	Appendix G1			NMFP-T-11-5L	NMFP-T-11-5L					
	Appendix G1			NMFP-T-11-5R	NMFP-T-11-5R					
	Appendix G1			NMFP-T-12-150	NMFP-T-12-150					
	Appendix G1			NMFP-T-12-25	NMFP-T-12-25					
	Appendix G1			NMFP-T-12-250	NMFP-T-12-250					
	Appendix G1			NMFP-T-12-350	NMFP-T-12-350					
	Appendix G1			NMFP-T-12-5	NMFP-T-12-5					
	Appendix G1			NMFP-T-12-50	NMFP-T-12-50					
	Appendix G1			NMFP-T-13-150L	NMFP-T-13-150L					
	Appendix G1			NMFP-T-13-150R	NMFP-T-13-150R					
	Appendix G1			NMFP-T-13-250R	NMFP-T-13-250R					

Table 2-8. (cont.)

Survey	Location of Data in RI Appendices	Sediment		Soil		Surface Water		Fish Tissue		Comments
		BERA	HHRA	BERA	HHRA	BERA	HHRA	BERA	HHRA	
OBG 2002 cont.	Appendix G1			NMFP-T-13-25L	NMFP-T-13-25L					
	Appendix G1			NMFP-T-13-25R	NMFP-T-13-25R					
	Appendix G1			NMFP-T-13-260L	NMFP-T-13-260L					
	Appendix G1			NMFP-T-13-390R	NMFP-T-13-390R					
	Appendix G1			NMFP-T-13-50L	NMFP-T-13-50L					
	Appendix G1			NMFP-T-13-50R	NMFP-T-13-50R					
	Appendix G1			NMFP-T-13-5L	NMFP-T-13-5L					
	Appendix G1			NMFP-T-13-5R	NMFP-T-13-5R					

Note: Stations in italics were used as reference stations.

3. SITE HISTORY AND PHYSICAL CHARACTERISTICS

This chapter describes the history of Geddes Brook and Ninemile Creek (Section 3.1), as well as the physical characteristics of the site, including topography and surface features (Section 3.2), climate and meteorology (Section 3.3), geologic setting (Section 3.4), surface soils (Section 3.5), surface water hydrology and sediment transport (Section 3.6), hydrogeology (Section 3.7), and demography and land use (Section 3.8). A summary of the chapter is presented in Section 3.9. Much of this information was obtained from the scientific literature and previous reports for sites in the vicinity of Geddes Brook and Ninemile Creek. Biological characteristics of the site are discussed in the Geddes Brook/Ninemile Creek Baseline Ecological Risk Assessment (BERA) (TAMS, 2003a).

3.1 History of Geddes Brook and Ninemile Creek

The history of the Geddes Brook/Ninemile Creek site was explored through evaluation of a series of aerial photographs, New York State Department of Transportation (NYSDOT) and National Oceanic and Atmospheric Administration (NOAA) maps, and written reference materials. Historical photographs and maps depicting the paths of Geddes Brook and Ninemile Creek from 1923 to 1978 are presented in Figures 3-1 through 3-8. An interpretation of these photographs and summary of relevant literature are presented in chronological order in this section.

The 1923 map of the Erie Canal (Figure 3-1) (NOAA, 2003), while not detailed, clearly shows the mouth of Ninemile Creek near Lakeview Point approximately 1,600 ft (500 m) east of its present location (as shown on Figure 1-2 in Chapter 1, Introduction).

The photograph in Figure 3-2 (M. Clements, pers. comm., 2002), taken in 1938, has hand-drawn markings on it that show the former route of the Ninemile Creek channel prior to its rerouting in 1926 (Blasland & Bouck, 1989). (Note that this image is actually a negative, so that the Solvay Wastebeds are shown as black, not white.) Prior to 1926, the mouth of Ninemile Creek was located roughly halfway between the current location of the mouth of the creek and Lakeview Point (the current location of Wastebeds 1 to 8), which is consistent with the map from 1923.The creek proceeded, in an upstream direction, from its mouth at Onondaga Lake due south with slight meanders until it almost reached the New York State Fairgrounds. At this point, Ninemile Creek turned westward with a series of acute meanders (eight major turns) before crossing under a set of railroad tracks. The confluence of Geddes Brook and Ninemile Creek occurred at the third major bend in Ninemile Creek, shown south of State Fair Boulevard.

Also as shown in Figure 3-2, Geddes Brook, in an upstream direction, is aligned almost directly south, crossing under the railroad tracks, after which it turned more to the southeast until it crossed under the Erie Canal. After crossing under the canal, Geddes Brook continued roughly southeast until it became indistinct in the photograph. The West Flume was in existence at this time as a very linear feature at an industrial facility (the Atmospheric Nitrogen Company site, which later was demolished and the property became Honeywell's LCP Bridge Street facility [NYSDEC/TAMS, 1998]). The West Flume flowed in a northwest direction until it reached the railroad tracks southwest of the race track at the New York State Fairgrounds, from which point the flume paralleled the tracks until it discharged to Geddes Brook. In 1938, there was relatively little urban development in the general area of Geddes Brook and Ninemile Creek, with most of the land devoted to farming.

A date was not specified on the photograph in Figure 3-3 (M. Clements, pers. comm., 2002). However, the photograph shows that Wastebeds 1 to 8 (and of particular importance, Wastebeds 7 and 8) are in full use, and Wastebeds 9 to 11 are not open. In this context, and by referencing the Onondaga Lake Site History Report (PTI, 1992), it is assumed that this photograph was taken after 1939 and before 1944. The most significant change from pre-1926 conditions is that the mouth of Ninemile Creek has moved about 1,600 ft (500 m) to the west. The lower reach of Ninemile Creek was moved to accommodate the construction of Wastebeds 1 to 8 (shown as white Solvay waste in the photograph) (Blasland & Bouck, 1989). The mouth of Ninemile Creek, as shown in this photograph, is at or close to its present location. The first segment of the new channel of the lower reach of Ninemile Creek (shown in the photograph) is oriented northeast/southwest. The second segment of the new channel is oriented northwest/southeast and joins the natural channel at the second large bend in the creek. The photograph shows some disturbance of the ground surface east of that bend. Although the edges of Wastebeds 1 to 8 are very close to this new section of Ninemile Creek, no groundwater or surface water seeps into the creek are apparent in this photograph. The watershed for lower Ninemile Creek is still primarily rural, with farms bordering the creek. An early phase of the Syracuse Municipal Airport is shown south of the creek and north of the Erie Canal.

It should be noted that during the 1940s the operations at Honeywell's Willis Avenue facility changed, as discussed below. The Honeywell chlor-alkali plant at the Willis Avenue facility operated from 1918 until 1977, producing chlorine and other chemicals. The plant utilized both diaphragm and mercury cells for chlorine production. The 102 mercury cells originally part of this operation were designed in the 1930s and started with sodium chloride brine. In 1947 and 1948, the plant was redeveloped and a new process was installed. The number of mercury cells was reduced to 59, and the plant converted to potassium chloride brine (O'Brien & Gere, 1990). Thus, significant mercury use by Honeywell began sometime after 1930, but before 1947. Honeywell's Main Plant was discharging wastes to the West Flume and Solvay Wastebeds in the 1940s. Wastes from the Willis Avenue plant were also incorporated into those discharges from the Main Plant (PTI, 1992), and thus these wastes represented a potential source of mercury to Geddes Brook and Ninemile Creek at that time.

The photograph taken on October 5, 1951 (Figure 3-4) (D. Ayers, pers. comm., 2002) shows further changes to the watershed of lower Ninemile Creek. Wastebeds 1 to 8 appear as darker grey, which indicates that they are not in use, as recently deposited Solvay waste appears white in photographs. Wastebeds 9 to 11 appear to be in use and appear as bright white in the photograph (typical of newly placed Solvay waste). An elevated structure is shown crossing the triangle of land between Geddes Brook and Ninemile Creek. Wastebeds 12 to 15 are under construction at the former airport site. Ninemile Creek has been rerouted in the section between the confluence with Geddes Brook (Point D) and the point where Ninemile Creek crosses under the railroad tracks roughly 10,000 ft (3,000 m) upstream (Point E). As compared to the 1938 photo, the creek appears to have been straightened south of State Fair Boulevard, while maintaining the first three large bends south of this roadway. Within this section between State Fair Boulevard and Geddes Brook (between Points B and D), the photograph shows two major channels (more obvious in later photographs): one channel runs very close to the foot of the wastebeds, and the other runs farther south close to the current location of the creek. A series of islands separates the channels.

Upstream of the confluence with Geddes Brook, Ninemile Creek (between Points D and E) is shown to have been moved a significant distance southwest from the original channel into a straight stretch parallel to the railroad tracks. The color of Ninemile Creek in this photograph changes from a dark grey to white near the southern end of Wastebed 11, indicating that this point is apparently where the wastebed overflows first entered the creek at this time. In Wastebed 12, there are areas of white, which could be the first placement of Solvay waste in this wastebed. Additionally, there is a long, thin, white, linear feature, which runs parallel to the railroad tracks, apparently between Wastebed 12 and Geddes Brook. This is likely a drainage ditch (also referred to as the "unnamed tributary") that is carrying Solvay waste from Wastebeds 12 to 15 to Geddes Brook. The unnamed tributary appears as white with apparent Solvay waste from that point down to Geddes Brook. There is some urban development with an increased number of homes, larger buildings, and side roads in the watershed. This photograph shows the first indication of a disturbance (i.e., possible start of disposal activity at the Mathews Avenue Landfill) between Mathews Avenue and the Erie Canal.

It should be noted that the Honeywell chlor-alkali facility at the LCP Bridge Street plant first started operations, including the use of mercury cells, in 1953. This represents the first year that confirmed mercury discharges into the Ninemile Creek watershed (via the West Flume and Geddes Brook) occurred. However, as indicated above, it is possible that the wastes containing mercury from the Willis Avenue plant reached Ninemile Creek, along with wastes from the Main Plant, prior to this time.

As-built drawings dated December 1955 obtained from the NYSDOT (N. Zingarow, pers. comm., 2002) provide details of the construction of Interstate 690 (I-690). The construction in this area took place in 1954. Part of the construction of I-690 involved the excavation and slight relocation of part of Ninemile Creek. The section of the creek that was excavated and relocated extends from approximately 50 ft (15 m) north of the northbound lane to about 100 ft (30 m) south of the southbound lane of I-690. The drawings show that the creek was straightened and the banks were relocated on the order of 5 to 10 ft (2 to 3 m) in places. The Ninemile Creek relocation is apparent by comparing the 1951 and the 1959 photos (between Points B and C in Figures 3-4 and 3-5, respectively).

The photograph taken on June 15, 1959 (Figure 3-5) (D. Ayers, pers. comm., 2002) shows that Wastebeds 9 to 11 were still in use at that time. The first apparent point of discharge of Solvay waste into Ninemile Creek is the interbed area between Wastebeds 10 and 11. The construction of I-690 is complete. There is a disturbance in the form of a series of linear white features on the triangle of land between Geddes Brook and Ninemile Creek. This suggests disposal of material that is consistent with the description in Hutton and Rice (1977) that this area is "made land" and with the notations in the Wetlands Delineation Report (Geddes Brook/Ninemile Creek BERA, Appendix E [TAMS, 2003a]) that a layer of ash was found in this area. The Wetlands Delineation Report also states that berms in this area suggest that the area was used as a disposal site. The morphology of Geddes Brook in this area suggests that it was artificially modified at some time, and it would be reasonable to suggest a connection between the extremely straight and deeply cut channel of lower Geddes Brook with the mounds identified adjacent to the brook. The structure (elevated pipeline) crossing the triangle of land is still evident in the aerial photograph. The more southern channel of lower Ninemile Creek (between State Fair Boulevard and Point D) is clearly seen in this photograph. The plume of Solvay waste entering Onondaga Lake is clearly shown (Point A), and the relic of the delta at the former location of the mouth of Ninemile Creek is also shown. Wastebed 12 is shown to be in use in this photograph. There appears to be a large amount of white Solvay waste flowing in the ditch from Wastebed 12 to Geddes Brook, as well as in the surrounding wetlands. Solvay waste also appears to be in the West Flume from its origin as well as in its associated wetland (i.e., Wetland SYW-14). Geddes Brook appears to be white with Solvay waste from its confluence with the West Flume down to its confluence with Ninemile Creek. The Honeywell LCP Bridge Street site is in operation in this photograph. During this time frame, the LCP Bridge Street site was discharging mercury and other contaminants (NYSDEC/TAMS, 1998). The disposal area(s) between Mathews Avenue and the Erie Canal has expanded greatly since 1951. Further urban development can be seen, compared to the 1951 photograph.

The photograph taken on June 22, 1966 (Figure 3-6) (D. Ayers, pers. comm., 2002), shows little change from the 1959 photograph, with respect to Ninemile Creek characteristics. There is still evidence of the discharge of Solvay waste from the wastebeds starting at the interbed area, as well as from the unnamed tributary and the West Flume. The Solvay waste plume into Onondaga Lake and both channels of lower Ninemile Creek are clearly evident. There is evidence of disturbance on the triangle of land between Geddes Brook and Ninemile Creek, and new disturbance on the land east of the confluence of Geddes Brook and Ninemile Creek, consistent with the notations in the Wetlands Delineation Report (BERA, Appendix E [TAMS, 2003a]), which notes that debris including metal fragments, empty steel drums, and concrete fragments were commonly observed in the area east of Ninemile Creek. Wastebeds 1 to 8 appear to be supporting more vegetation than in earlier photographs. The disposal areas(s) between Mathews Avenue and the Erie Canal is still evident, with portions of the disposal area appearing to be covered and supporting vegetation.

The April 28, 1967 photograph (Figure 3-7) (D. Ayers, pers. comm., 2001), shows several changes compared to the 1966 photo. West of the mouth of Ninemile Creek a series of bermed areas are shown, which were built as dewatering/disposal cells as part of the operation for dredging the mouth of Ninemile Creek (USEPA, 1973; *Syracuse Herald-Journal*, 1967). (See discussion below on this joint Honeywell/Onondaga County project.) The first two cells appear to contain water. Farther upstream there is evidence of some construction activity east of Ninemile Creek (between Points B and C). There is a linear white feature running north to south that is likely the start of the construction of Route 695. Slightly south of this feature, there is further disturbance in the area east of the confluence of Geddes Brook and Ninemile Creek. This area is the location of the State Fair Landfill. Wastebed 15 is under construction; however, Ninemile Creek becomes white just upstream of the railroad tracks (Point F), indicating that this appears to be the most upstream discharge point of Solvay waste from the Wastebeds 12 to 15 area on that date. The unnamed tributary and the West Flume continue to be white apparently with Solvay waste. The disposal area(s) between Mathews Avenue and the Old Erie Canal is still evident, with portions of the disposal area appearing to be covered and supporting vegetation.

Route 695 was constructed in the late 1960s, based on the apparent start of construction seen in the 1967 photograph and the as-built drawings of the interstate project dated December 1970 (N. Zingarow, pers. comm., 2002). The NYSDOT as-built drawings indicate that Ninemile Creek was excavated and/or rerouted from just north of the westbound lane of I-690 to the second large bend in Ninemile Creek, below the confluence with Geddes Brook (Reach BC). The as-built drawings indicate that the new channel includes about 600 ft (183 m) of the creek and is located immediately south of the railroad tracks about 100 ft (30 m) west of the former eastern channel. The western channel for the entire 1,200 ft (366 m) between the railroad bridge and the second large bend below Geddes Brook has been eliminated. The 200 ft (61 m) of Geddes Brook above the confluence with the West Flume was rerouted to a location approximately 200 ft (61 m) eastward.

USEPA (1973) indicated that Honeywell and Onondaga County, in a cooperative project, dredged the mouth of Ninemile Creek. An article in the *Syracuse Herald-Journal* from May 16, 1967 indicated that this dredging project was to start on May 18, 1967, and was expected to take three years. According to the Onondaga Lake RI (TAMS, 2002c), the spoils from this dredging, which were disposed of in basins along the lakeshore just north of the mouth of Ninemile Creek (the "bermed area" shown on Figure 3-7), contained elevated levels of mercury. These sources do not describe how far up Ninemile Creek the dredging took place. It is possible that the operation went as far as the second major bend (Figure 3-7; Point B) in the creek (just north of I-690), because this section is straight, has no bridges, and was not dredged for any other reason (such as highway construction) yet has a deep and well defined channel relative to other parts of Ninemile Creek. This is consistent with the sediment probing/bathymetry study conducted by Honeywell (BBL, 2001) that indicated a sharp shelf cut into the calcite deposits along the right-hand bank (facing downstream) from near the mouth to the second major bend (Point B). Such a shelf most likely was cut by a dredging operation. It is unlikely that natural flow created this cut.

In 1970, the mercury discharge from Honeywell's chlor-alkali plants (i.e., Willis Avenue and LCP Bridge Street) was reduced by more than 97 percent (USEPA, 1973). USEPA (1973) cites an AlliedChemical letter dated July 21, 1970 to the New York Department of Health stating that, "prior to May 9, 1970, the mercury discharged to Geddes Brook (tributary to Ninemile Creek) averaged 22 pounds per day [10 kg/day]." In 1972, the total suspended solids (TSS) discharges to the Geddes Brook/Ninemile Creek site from Honeywell totaled 33,000 pounds per day (lbs/day) (15,000 kilograms per day [kg/day]) (USEPA, 1973). Samples collected in September 1948 (CSDE, 1948) in Ninemile Creek suggested that the TSS concentrations in Ninemile Creek at State Fair Boulevard were higher than in 1972, and thus the TSS loads were likely higher. The Willis Avenue and LCP Bridge Street chlor-alkali facilities closed in 1977 and 1988, respectively (PTI, 1992).

The photograph taken on September 13, 1978 (Figure 3-8) (D. Ayers, pers. comm., 2002), shows that the construction of Route 695 is complete. The reach of Ninemile Creek from the second major bend in the creek below the Geddes Brook confluence (Point C) to State Fair Boulevard (approximately half way between Points B and C) that previously contained two channels (Figures 3-6 and 3-7) now contains only a single channel (Figure 3-8). A white plume of apparent Solvay waste can be seen entering the lake from the mouth of Ninemile Creek. The creek and its tributaries (Geddes Brook, the West Flume, and the unnamed tributary) are white with apparent Solvay waste.

The disposal area(s) between Mathews Avenue and the Old Erie Canal is still shown. However, most of the disposal area appears covered with vegetation.

In 1980, the Honeywell discharges from the Main Plant to the West Flume were diverted to the East Flume (PTI, 1992). In 1981, about 10 cubic feet per second (cfs) (0.3 cubic meters per second [m^3/s]) of the discharge from the Solvay Wastebeds was diverted to the Metropolitan Syracuse Sewage Treatment Plant (Metro) as part of their tertiary treatment for removal of phosphorus. This practice continued until closure of Honeywell's Main Plant (Solvay Process) in 1986 (Effler and Harnett, 1996). The relative size of the Honeywell discharges can be seen in the annual mean daily flow of Ninemile Creek before and after diversion of the discharges in 1980 (Table 3-1). The average annual flows dropped from an average of 264 cfs (7.5 m^3/s) between 1971 and 1979 to 154 cfs (4.4 m^3/s) between 1980 and 2000 (Table 3-1).

The LCP Bridge Street chlor-alkali plant was closed in 1988 (PTI, 1992), ending active discharges to the West Flume and, thus, the Geddes Brook/Ninemile Creek site. Interim remedial measures (IRMs), including the plugging of sewers and the razing of most of the buildings, were conducted at the LCP Bridge Street site in 2000 and 2001 (NYSDEC, 2001).

3.2 Topography and Surface Features

Geddes Brook and Ninemile Creek are located in Onondaga County, central New York State, in the Oswego River drainage basin on the southern end of Onondaga Lake. At roughly 43°4′ north latitude and 76°15′ west longitude, the Geddes Brook/Ninemile Creek site is located in the Ontario Lowland lake plain physiographic province. Wisconsin Glaciation (12,000 to 14,500 years ago) molded the pre-glacial topography in the site area by glacial scouring, producing a pronounced northwest-southeast orientation of valleys and hills in the vicinity of Onondaga Lake. The study area is located within a north-northeast-draining stream valley with a surface expression of primarily alluvium, manmade fill, and urban development. The valley is bordered to the north and west by the Ontario Lowland drumlin fields, to the south by the Appalachian Upland border scarp province, and to the east by Onondaga Lake, into which it drains.

3.3 Climate and Meteorology

The climate in the Syracuse area can be described as "temperate continental" (Trewartha, 1968) and somewhat humid. The area's geographic proximity to Lake Ontario results in moderated extremes in air temperature relative to areas at the same latitude that are farther east and are less subject to the "lake effect" (Effler and Harnett, 1996). The mean annual temperature is 48°F (8.8°C), with a mean July temperature of 71°F (22°C) and a mean January temperature of 23°F (−4.9°C) (National Oceanic and Atmospheric Administration [NOAA], 2001). Record temperatures range from 102°F (39°C) in July to −26°F (−32°C) in January, February, and December. Based on data from the period of 1971 to 2000, the average first occurrence of freezing temperatures (daily low of 32°F [0°C]) in the fall is November 15, and the average last occurrence of freezing temperatures in the spring is April 8 (NOAA, 2001).

Moisture enters the area primarily via low-pressure systems that move through the St. Lawrence valley toward the Atlantic Ocean. Monthly precipitation averages approximately 3.2 inches (8.2 cm) and is relatively evenly distributed throughout the year, ranging from 2.5 inches (6.4 cm) in February to 3.7 inches (9.4 cm) in July (National Climatic Data Center [NCDC], 1995).

Winds in the Syracuse area are predominantly from the west and northwest. The predominant wind directions remain relatively constant throughout the year, although minor variations occur during different months. Most of the strongest winds (20 to 23 m/sec, 44 to 51 mph) occur between November and April (NCDC, 1998).

3.4 Geologic Setting

3.4.1 Regional Geology

The Geddes Brook/Ninemile Creek site is located in the Onondaga Lake drainage basin in the Ontario Lowland Lake Plain physiographic province. This province is bordered by the Ontario Lowland drumlin fields to the west and the Appalachian Upland border scarp province to the south (Winkley, 1989). The axis of the lake is aligned along the northward-draining Onondaga glacial trough. The trough was formed by glacial scouring and glaciofluvial erosion of bedrock. The trough is now filled with up to almost 300 ft (91 m) of unconsolidated sediment, including glacial deposits, post-glacial deposits (marl and peat), and artificial fill (Winkley, 1989).

Most of the Onondaga Lake drainage basin, including Geddes Brook and Ninemile Creek, is located within the Limestone Belt of central New York State (Berg, 1963). This geologic province extends from Buffalo eastward to Albany (Figure 3-9), with the southern part of the drainage basin lying on the Northern Appalachian Plateau. The surfaces of some areas in the Limestone Belt consist of exposures of glacial till and lacustrine deposits, whereas outcrops of limestone (particularly Onondaga Limestone) and alkaline shales are exposed at other locations.

Since water flowing into Geddes Brook and Ninemile Creek is derived primarily from the Limestone Belt, soils within that belt play a major role in influencing the characteristics of the water. Calcium, magnesium, bicarbonate, and alkalinity concentrations all tend to be much higher in streams and lakes influenced by the Limestone Belt, when compared to streams and lakes influenced by the Northern Allegheny Plateau to the south (e.g., the Finger Lakes) or the Ontario-Oneida-Champlain Lake Plain to the north (e.g., Oneida Lake), and such is the case in Onondaga Lake. In addition to these natural sources, concentrations of calcium and other ionic waste constituents in Geddes Brook, Ninemile Creek, and Onondaga Lake have been heavily influenced primarily by Honeywell's (formerly AlliedSignal) generation of Solvay waste since 1890. The current major source of industrially contaminated surface water, high in calcium, entering Onondaga Lake is Ninemile Creek. Ninemile Creek receives much of its calcium loading, among other contaminants, from Honeywell Wastebeds 1 to 15.

3.4.2 Site Geology

3.4.2.1 Bedrock Geology

The Upper Silurian Vernon Shale underlies the portion of Ninemile Creek addressed in this study, and all but the uppermost reaches of Geddes Brook (Figure 3-10). The Vernon Shale is approximately 500 to 600 ft (150 to 180 m) in thickness (Luetze, 1964) and consists primarily of thick-bedded red and green shale beds replaced westwardly by gray argillaceous dolostones and green dolomitic shale (Winkley, 1989).

The upper reaches of Geddes Brook are underlain by the Upper Silurian Syracuse Formation. The Syracuse Formation overlies the older Vernon Formation to the south of Onondaga Lake at an elevation of about 500 ft (150 m) above mean sea level (amsl). It is approximately 600 ft (180 m) thick and is comprised of interbedded shales, argillaceous dolostones, clays, and evaporites (gypsum and salt) (Winkley, 1989).

3.4.2.2 Sedimentary Geology

The glaciation that produced most of the existing topography in the area also deposited a thin veneer of glacial till over the bedrock surface throughout most of the area. Till is typically a compact, poorly sorted mixture of clays, silts, sands, and boulders deposited directly by glacial ice. Along some areas of the Ninemile Creek valley margins, this till is exposed at the surface (Blasland & Bouck, 1989).

Traveling easterly along Ninemile Creek downstream toward Onondaga Lake from the west margin of the study area, the creek runs through a steep bedrock-walled valley approximately 0.5 mi (0.8 km) in width. The depth to bedrock in the middle of the valley in this area is approximately 50 ft (15 m) below the top of the valley fill. Typical of the area, glacial till overlies the bedrock with general thicknesses ranging from 10 to 15 ft (3 to 5 m). Overlying the till are glaciolacustrine deposits. These sediments are comprised primarily of clays, silts, and sands, with gravels being present at increasing depth (Onondaga County, 1971). Near-surface sediments in this area consist primarily of alluvium from Ninemile Creek.

Farther downstream near Wastebeds 12 to 15, the valley widens to almost 1 mi (1.6 km), and the subsurface bedrock valley becomes less steep (Blasland & Bouck, 1989). In this area, glaciolacustrine and alluvial sediments were deposited similarly to upstream sections of the valley, with sediment grain sizes increasing with depth (Blasland & Bouck, 1989). From this point downstream, depths to bedrock increase as the valley continues to widen until reaching Onondaga Lake.

Minimal subsurface exploration has occurred along Geddes Brook. However, available data suggest a subsurface structure similar to that of Ninemile Creek, with a steep subsurface bedrock valley progressively widening downstream as it approaches Onondaga Lake (Blasland & Bouck, 1989). Likewise, sediment type and distribution can be reasonably assumed to be similar to that of Ninemile Creek.

3.5 Surface Soils

The surface soils of the Onondaga Lake watershed consist of deposits of glacial origin, including till, outwash, alluvial, and glacio-lacustrine sediments. The soils tend to be medium-textured, well drained, and high in lime (NYSDEC, 1989; Hutton and Rice, 1977). Above the unconsolidated sediments in many upland areas near the site are fill deposits composed of peat, cinders, ash, and Solvay wastes. As mentioned earlier, the drainage basin of the lake is in the northern portion of a region characterized by drumlins with narrow, steep-sided valleys. Significant amounts of soil erode into the valley streams during rainstorm events (Lincoln, 1982; Murphy, 1978; NYSDEC, 1989).

Remaining surface soils in the study area overlying bedrock and glacial material include more recent post-glacial sediments. These sediments include alluvial deposits along Geddes Brook and Ninemile Creek, organic-rich sediments deposited in post-glacial marshes and swamps, and lacustrine deposits in the Onondaga Lake basin. The lacustrine deposits are composed primarily of marl with varying amounts of silts and fine sand (Blasland & Bouck 1989).

Within the Ninemile Creek valley, large amounts of Solvay Process wastes were placed in Wastebeds 9 to 15, both north (Wastebeds 9 to 11) and south (Wastebeds 12 to 15) of Ninemile Creek (Figure 3-11). Wastebeds 9 to 15 occupy approximately 662 acres and range in thickness from approximately 3 to 69 ft (1 to 21 m) (Effler and Harnett, 1996). As noted in Section 3.1, Ninemile Creek was historically diverted to accommodate accumulations of these wastes. Wastebeds 9 and 10 are separated from Wastebed 11 by a low interbed area that is the original ground surface prior to construction of the wastebeds (Figure 3-11). Remnants of the original Ninemile Creek channel are present within this interbed area. Drainage from the area, prior to construction of the wastebeds, had discharged south toward Ninemile Creek.

3.6 Surface Water Hydrology and Sediment Transport Regimes

3.6.1 Surface Water Hydrology

The major surface water features at the site are Geddes Brook and Ninemile Creek. Onondaga Lake receives the discharges from the site. The minor surface water features are the West Flume and an unnamed tributary that flow into Geddes Brook, and Beaver Meadow Brook that flows into Ninemile Creek upstream of the Geddes Brook confluence with Ninemile Creek. Surface-water flow patterns are shown in Chapter 3, Figure 3-2 of the Geddes Brook/Ninemile Creek BERA (TAMS, 2003a).

In general, Geddes Brook and Ninemile Creek serve as major drainage features in the region. Flow rates can range dramatically under the influence of storm events. The US Geological Survey (USGS) operates two stream gauges on lower Ninemile Creek: one is located at Camillus, upstream of the site, and one is located in Lakeland at State Fair Boulevard approximately 2,500 ft (760 m) upstream from the mouth of the creek at Onondaga Lake. Daily flow data for Ninemile Creek at the downstream gauge (i.e., Lakeland) from 1989 to 1999 is presented in Figure 3-12, and the annual mean flow for Ninemile Creek at the Lakeland gauge from 1971 to 2000 is presented in Table 3-1. Flows in Ninemile Creek ranged from about 50 cfs to over 1,000 cfs. Note that in Table 3-1, the annual mean stream flow dropped from an average of 264 cfs (7.5 m^3/s) from 1971 to 1979 to 154 cfs (4.4 m^3/s) from 1980 to 2000. This approximately 40 percent drop in flow coincided with the diversion of Honeywell discharges to other receiving waters, and represents a change in the hydraulic regime in Geddes Brook and Ninemile Creek that affected patterns of deposition (sediment accumulation) and erosion (sediment removal by water flow).

The two major tributaries to Ninemile Creek in the study area (i.e., Beaver Meadow Brook and Geddes Brook) are not gauged. However, BBL collected flow data from lower Geddes Brook and from Ninemile Creek at Lakeland on a quarterly basis on behalf of Honeywell (G. Thomas, pers. comm., 2000). Figure 3-13 presents the flow data obtained by BBL during their quarterly monitoring in Geddes Brook. As can be seen, flows in lower Geddes Brook during this period ranged from less than 10 cfs (0.3 m^3/s) to approximately 60 cfs (1.7 m^3/s). The flow data collected by BBL in Ninemile Creek are not presented here, since USGS data are used in this report.

Figure 3-14 shows both the 100-year and 500-year floodplains estimated by the Federal Emergency Management Agency (FEMA) and the measured historical high-water mark from 1972. In June 1972, tropical storm Agnes caused severe flooding in New York. The floods on many major streams were the highest known since the river valleys were settled. Levels of all of the Finger Lakes were higher than any previously recorded. The extent of flooding shown on Figure 3-14 was delineated by the USGS from field surveys made immediately after the flood (Shindel, 1972). The 100-year floodplain from FEMA is estimated based on statistical analysis of rainfall, stream flow, and other factors, which are used to construct a model showing areas of potential flooding. These estimates do not represent the boundaries of an actual flood, whereas the measurements from 1972 do represent the extent of the largest flood recorded at Ninemile Creek. Thus, for the purpose of assessing the extent of CPOI contamination due to previous flooding on the site, the 1972 historic high-water mark is the more accurate tool on which to define the floodplain for sampling and mapping.

As required under Executive Order 11988, “Floodplain Management,” a floodplain assessment will be required in the feasibility study (FS). During the FS, the 100-year and 500-year floodplains in the project area will be delineated, and a floodplain assessment will address: a description of the proposed action; the effects of the proposed action on the floodplain; a description of the other remedial alternatives considered and their effects on the floodplain; and measures to mitigate potential harm to the floodplain if there is no practicable alternative to locating in or affecting the floodplain, including impacts to the proposed remedial action from flooding events.

In addition, if remedial actions will take place within the delineated 100-year and 500-year floodplains, a Statement of Findings will be needed to document this decision in the Record of Decision (ROD). The Statement of Findings may be included in the ROD support document or attached as a separate appendix. It should include: the reasons why the proposed action must be located on or affect the floodplain; a description of significant facts considered in making the decision to locate in or affect the floodplain; a statement indicating whether the proposed action conforms to applicable state or local floodplains protection standards; a description of the steps taken to design or modify the proposed act to minimize potential harm to or within the floodplain; and a statement indicating how the proposed action affects the natural or beneficial values of the floodplain.

In addition to discharge (flow) rates, the amount of TSS in a stream influences its sediment transport characteristics. The average TSS concentration in Ninemile Creek (1988 to 1990) was 24.7 milligrams per liter (mg/L) and the median was 22 mg/L (Effler and Whitehead, 1996), which agrees well with the median of data from CDR (1991) of 22 mg/L at the USGS gauging station. The estimate of annual TSS loads to Onondaga Lake from Ninemile Creek (1988 to 1990) was 25,100 lbs/day (11,400 kg/day) (Effler and Whitehead, 1996). This estimate represents the TSS load without any active discharge from the Honeywell facilities. According to USEPA (1973), the TSS load solely from the wastebed overflows and the West Flume totaled 33,000 lbs/day (15,000 kg/day) in 1972. Thus, the discharges from the Honeywell facilities alone (wastebed overflow and the West Flume), prior to their closure, were approximately 30 percent greater than the current TSS loads in Ninemile Creek. This suggests that the TSS loads in Ninemile Creek prior to Honeywell's closures were more than twice the current loads in Ninemile Creek, which suggests that the depositional regime has changed greatly since Honeywell ceased operations.

3.6.2 Sediment Transport and Stream Channel Characteristics

A survey of Ninemile Creek performed for Honeywell in 1990 mapped in-channel features and collected data on the depth of specific pools and average low-flow velocity as part of a larger habitat assessment (CDR, 1991). Honeywell also conducted a hydrological evaluation in 1998 (presented in Appendix H, Hydrological Investigation [1998], of this RI), in which qualitative observations of channel morphology, slope, and sediment depth were used to define erosional and depositional reaches (Figure 3-15). These observations were supported by calculation of unit stream power, as described in Appendix H. The hydrological field investigation conducted by Honeywell in October 1998 was designed to confirm the channel features in Ninemile Creek and provide a reconnaissance of Geddes Brook from Milton Avenue to the mouth, for purposes of delineating the sediment transport regime of these locations. Other than rearrangement of smaller pieces of woody debris and localized bank erosion, few changes in Ninemile Creek were observed in 1998 relative to 1990.

Ninemile Creek was divided into relatively internally homogeneous reaches by CDR (1991). These reaches provided a framework for describing channel characteristics. As part of this RI, typical cross sections were surveyed in the reaches adjacent to or downstream of the Solvay Wastebeds. Cross-section survey data are presented in Appendix H and are summarized in Table H-2. Each reach is described qualitatively for erosional/depositional regime and contamination history as follows, proceeding from Amboy Dam downstream to Onondaga Lake (Figure 3-15):

- The short reach of Ninemile Creek located between Amboy Dam and the Warners Road bridge is steep (0.03 ft/ft, or 3 percent slope), multi-threaded, has a bouldery substrate, and is erosional. The slope of the creek bed minimizes sediment deposition and the bouldery substrate confirms the lack of deposition. This reach is located upstream of any known Honeywell disposal/industrial sites.

- The reach of Ninemile Creek located between the Warners Road bridge and the point in the creek immediately adjacent to Airport Road where the road makes a turn to the east (where a recycling facility and an old gravel pit are located) is the least disturbed reach of the creek, and is erosional for most of its length. Substrate ranges from sand to cobbles, woody debris is common, a pool-riffle sequence is present, channel complexity is high, and riparian vegetation is well established. Average slope in this reach is 0.004 ft/ft. This reach is upstream of the influence of the Solvay Wastebeds.

- The reach of Ninemile Creek located along Airport Road in front of Wastebed 13, and continuing downstream to the western boundary of Wastebed 11, has been channelized at the upstream and downstream ends and in the vicinity of the Conrail tracks so that most of the reach is an oversized, low-gradient canal, and is depositional at the lower end of the reach. There are relatively intact riparian vegetation, locally cobbly substrate, and a complex channel in the center of the reach. Substrate in the channelized section ranges from gravel to silt; substrate in the more morphologically complex portions of the reach is coarser. Grade control – morphologic features that maintain the bed elevation – is present at the Conrail bridge. Culverts in the next downstream reach (described below)act as grade control for the lower portion of this reach. Beaver Meadow Brook and an unnamed tributary enter Ninemile Creek in the middle of the reach. This is the most upstream reach which is adjacent to, and influenced by, the Solvay Wastebeds.

- The reach of Ninemile Creek located near the western edge of Wastebed 11 is short and relatively steep, and is depositional in some deep holes at the very upper portion of the reach. A failed road crossing, located at the remnants of large metal culverts, appears to be controlling the stream gradient in this location. The channel has flanked the culverts, and several deep pools have been scoured in the process. The substrate and the water depth are highly variable: fine-grained, unconsolidated sediment up to 4 ft (1.2 m) thick is present in one of the deeper pools, while gravel bars are present downstream of the culverts. This reach is located within the influence of the Solvay Wastebeds, but is upstream of the confluence with Geddes Brook.

- The reach of Ninemile Creek located in front of Wastebed 11 just below a riffle island, and extending down to the confluence with Geddes Brook, consists of a generally straight, uniform, low-gradient, over-excavated canal. The substrate is gravelly, consisting of a thin veneer of unconsolidated sediment overlying hardpan, which appears to extend across the full width of the channel. This suggests that the hardpan consists of glacial-lacustrine silts and clays rather than calcite crusts. Outcrops of glacial-lacustrine silts and clays at the head of the next downstream reach act as grade control for this reach. This reach is generally upstream of the influence of Geddes Brook. However, it is possible that flooding and backwater effects could cause some contamination from Geddes Brook to enter the extreme lower end of this reach.

- The reach of Ninemile Creek located from the mouth of Geddes Brook downstream to the second major bend below the brook (from Points D to C, as shown on Figure 3-8), is characterized by mid-channel islands, short riffles, and several deep scour holes, and is strongly erosional. The creek channel is wider and shallower in this reach than in any other. The islands and the streambed are dominated by glacial-lacustrine silts and clays, and are erosional features. However, this reach also contains features consistent with historical deposition, including pockets of unconsolidated sediments and calcite crusts present on the right bank. This reach is influenced by both the Solvay Wastebeds and Geddes Brook. Geddes Brook has been and continues to be a source of additional (in addition to those already in Ninemile Creek) TSS and total dissolved solids (TDS), which originate primarily from the wastebeds, as well as mercury and other contaminants from the LCP Bridge Street site. This reach does not appear to have undergone any excavation or other artificial changes to the stream bed, and any deposits which collected during the time of Honeywell operations would be expected to be relatively intact, except for the effects of erosion.

- The reach of Ninemile Creek located from the second bend in Ninemile Creek below the confluence with Geddes Brook to the bend north of I-690 (from Points C to B, as shown on Figure 3-8) is completely channelized around the wastebeds and under road and highway interchanges, and is depositional. With the exception of very few riffles under the State Fair Boulevard and Route 695 bridges, the channel is deep and wide, presenting a depositional regime for most of the reach. Unconsolidated sediments are deep along the channel margins, though less so in the center of the channel. Calcite crusts are present on the west side of the channel upstream of the State Fair Boulevard bridge and on the east and north sides of the channel downstream from the Route 695 bridge. Channel slope in this reach was negligible at the time of the field visit, and the reach appears to be a backwater during periods of high lake levels. While this reach is clearly depositional, it was channelized/relocated during the 1950s construction of I-690 and the late 1960s construction of Route 695. Thus, a portion of the sediments that accumulated during Honeywell's operation prior to the 1970 reduction in mercury discharges would have been disturbed (e.g., removed from the channel or covered at the time of channelization or relocation), although sediment would have been able to accumulate in the new channel since 1970.

- The most downstream reach of Ninemile Creek, located from the bend north of I-690 to the mouth of Ninemile Creek (from Points B to A, as shown on Figure 3-8), is deep and wide, presenting a strongly depositional regime.

Channel slope in this reach was negligible at the time of the field visit, and the reach appears to be a backwater during periods of high lake levels. This reach was likely channelized in the late 1960s as part of the joint Honeywell/Onondaga County dredging project, leaving a deep center channel. Thus, a portion of the sediments that accumulated during Honeywell's operation prior to the 1970 reduction in mercury discharges may have been removed from the channel at the time of channelization, although sediment has been able to accumulate in the channel since 1970.

Geddes Brook, except in its lowest reaches, was studied less intensively. A walking survey and review of aerial photographs were used to divide Geddes Brook into five reaches. Because most of Geddes Brook has not been channelized, morphology in these reaches is less uniform than in Ninemile Creek. As with Ninemile Creek, cross section survey data for Geddes Brook are presented in Appendix H and are summarized in Table H-2. Each reach of Geddes Brook from West Genesee Street downstream to Ninemile Creek is described qualitatively, as follows:

- The reach of Geddes Brook located from West Genesee Street to the culverts at Milton Street/Conrail/Route 695 is the most heavily urbanized reach of the creek, with several homes adjacent to the creek and storm sewer outlets present at the end of streets. The mid-section of this reach is erosional. At the downstream end of the reach, an intermittent tributary enters the creek from the west. The channel has four prominent bends in this reach, but is relatively straight between them. It is locally entrenched (i.e., downcut) over 5 ft (1.5 m) in the upstream portions of the reach, decreasing to 2 ft (0.5 m) in the downstream portions of the reach. Pools and riffles are well developed, although there is little woody debris. Substrate ranges from gravels to glacial-lacustrine silts and clays; the veneer of unconsolidated sediments is thin. Until a tree-clearing operation in October 1998, there was a well established riparian overstory along the entire length of this reach. This reach is upstream of any known Honeywell disposal sites or industrial facilities, although influences from the nearby urban area are likely.

- The reach of Geddes Brook located from the culvert at the Milton Street/Conrail/Route 695 complex downstream to the culverts at the Old Erie Canal and Gerelock Road is predominantly sand and gravel, becoming finer and highly depositional in the downstream end of the reach, but is erosional in the upper end of the reach. The creek is entrenched in the upstream half of the reach as it meanders past a cattail marsh. Riparian vegetation in this portion of the channel is shrubby (dominated by red-osier dogwood [*Cornus stolonifera*]), and undercut banks are common. In the downstream half of the reach, the channel flows through hardwoods, and riparian vegetation is well developed. The culverts at the downstream end of the reach act as grade control, and have caused backwater conditions to develop such that the channel widens and becomes multi-threaded. Woody debris is common in this reach. Several landfills, including Honeywell's inactive Mathews Avenue

Landfill, are located in the area, and surface water flowing from those sites enters Geddes Brook in this reach. The majority of that surface water probably enters the brook just above the culverts marking the end of the reach.

- The reach of Geddes Brook extending from Gerelock Road to the West Flume is relatively undisturbed, and is strongly depositional for most of its length. It is low-gradient, shallow, and is multi-threaded where it flows through hardwoods. The substrate is fine-grained (predominantly sand), and thick accumulations of unconsolidated sediments are common.

- The reach of Geddes Brook extending from the West Flume to the culverts underneath the Conrail tracks near the New York State Fairgrounds is straight, relatively steep, and is erosional, with coarse substrate. The unnamed tributary draining Wastebeds 12 to 15 enters Geddes Brook just before the culverts. Therefore, this reach receives the influences/contamination from both the LCP Bridge Street site (West Flume) and Wastebeds 12 to 15, including Solvay waste (both as TSS and TDS), mercury, and other potential contaminants. This reach appears to have been channelized at some time.

- The most downstream reach of Geddes Brook, extending from the culverts underneath the Conrail tracks near the New York State Fairgrounds to the confluence with Ninemile Creek, is characterized by steep vertical banks maintained on the west side by a thick stand of common reed (*Phragmites australis*). The channel, which is strongly depositional, is entrenched 3 to 5 ft (0.9 to 1.5 m) below the floodplain, and deepens rapidly in the downstream direction. This reach appears to have been channelized at some time. Fine-grained unconsolidated sediments are up to 60 inches (152 cm) thick in the middle portions of the reach, becoming thinner immediately upstream of the confluence with Ninemile Creek.

The regime of stream erosion/deposition is dynamic. While some areas are almost always erosional or depositional, most of a stream can be either, depending on the amount of water flowing in the stream. As flow increases, more of the stream will become erosional, and increased amounts of suspended sediments will be expected to be transported downstream. Furthermore, as the flow increases at a given location, the width of the stream increases, and additional areas (e.g., floodplain) become entrained in the regime, with some areas eroding and others accumulating sediments, or perhaps both, at different times.

The most erosive section of Geddes Brook is in the region where the West Flume and the unnamed tributary enter the brook. This region is narrow and steep and consequently has high stream power. Deeper sediment in lower Geddes Brook reflects a more depositional environment. Ninemile Creek is primarily depositional, with the exception of the reach just below the point where Geddes Brook joins the creek. In this reach, Ninemile Creek has both erosional and depositional areas downstream of the Geddes Brook entry, as water flow moves from one bank to the other and around islands.

The current distribution of sediments in Ninemile Creek are the result of historical depositional and erosional patterns, historical anthropomorphic modifications to the stream, and the current depositional and erosional regime. Overall, the historical discharges by Honeywell have resulted in two effects, as follows:

- First, the large amounts of TSS discharged into the streams, along with the potential for the TDS to precipitate out as additional solids, caused much more of lower Geddes Brook and lower Ninemile Creek to be depositional during Honeywell's operations than is currently the case.

- The other effect was that deposition rates during Honeywell's operations were much greater than those currently experienced, as evidenced by the accumulation of several feet of Solvay waste. A prime example of this change between historical and current regimes is the section of Ninemile Creek immediately below the confluence with Geddes Brook (Reach CD), which is currently erosional even at low flow, yet in the past accumulated large deposits of calcite-contaminated material.

The rerouting of the streams would produce different hydrologic conditions with respect to width, depth, and gradient. The alteration of the stream bed, on the other hand, would generally reduce the amount of sediment in a particular reach. Most alteration activities involved removal of material from the stream bed, whether it was dredging a completely new channel during rerouting, or dredging the sediments as part of channelization efforts. In particular, the 1954 channelization of Ninemile Creek for I-690 and the 1968 dredging of the mouth of Ninemile Creek (Reach AB, as shown on Figure 3-8) would have removed contaminated sediments in the stream. The movement of the stream bed for the 1960s construction of Route 695 also would have had the effect of producing presumably cleaner sediments in that reach (Reach BC, as shown on Figure 3-8), whether by actual removal of the contaminated sediments or by burial of contaminated sediments in the old stream channel.

3.7 Hydrogeologic Setting

3.7.1 General Hydrogeology of the Ninemile Creek Valley

Regionally, groundwater flow in the area is from south to north, with many small localized groundwater systems caused by mounding associated with topographic relief. Groundwater flow within the Geddes Brook/Ninemile Creek study area is comprised of several components:

- Flow in the bedrock.
- Flow in the unconsolidated valley fill deposits.
- Flow between the bedrock and the unconsolidated valley fill deposits.

As referenced in previous sections, unconsolidated fill materials in the study area are generally heterogeneous, with a relatively less-permeable layer closer to the ground surface. Groundwater flow within the unconsolidated materials varies greatly, depending upon the specific material through which the flow occurs. Groundwater is recharged to the subsurface primarily along the Ninemile Creek valley walls. However, in the lower reaches of the Ninemile Creek valley near Onondaga Lake, deeper flow systems discharge from bedrock into the overlying materials and toward the center of the valley (Blasland & Bouck, 1989). Discharge from bedrock is limited to areas that have little or no overlying glacial till. Groundwater discharge to the streams in this area likely originates from regional groundwater discharge and groundwater mounding beneath the wastebeds (Effler and Whitehead, 1996).

3.7.2 Hydrogeology of Bedrock Underlying Ninemile Creek Valley

The Vernon Shale hydrostratigraphic unit, which underlies most of the valley fill in the study area, is a fairly consistent water producer. The median reported yield of the Vernon unit is 12 gallons per minute (gpm), with yields ranging from 1 to 450 gpm (Winkley, 1989). Locally, the hydraulic conductivity of the Vernon unit approaches 4×10^{-4} centimeters per second (cm/s) (Stearns & Wheler, 1987). The permeability in the unit is largely attributed to weathering and fracturing in shallow zones, as well as the solution of the evaporites commonly found in the formation.

The Syracuse Formation, which underlies the upper reaches of Geddes Brook and overlies the Vernon Shale, is grouped into the Post-Vernon Evaporitic hydrostratigraphic unit. The median yield of this unit is 30 gpm; much higher than that of the underlying Vernon Shale. Significant secondary porosity is present in the Syracuse unit due to its highly soluble gypsum and halite deposits, bedding plane openings, solution-collapse breccias, and subsidence-related fractures. Hydraulic conductivities in this unit have been measured as high as 8.1×10^{-3} to 2×10^{-2} cm/s (Staubitz and Miller, 1987). Groundwater flows up-dip to the north in the Syracuse Formation and is the mechanism for the transport of brines to the Ninemile Creek valley (Blasland & Bouck,1989).

3.7.3 Hydrogeology of the Ninemile Creek Valley Fill and Wastebeds 1 to 15

Groundwater flow in the Ninemile Creek valley fill is driven largely by topography. Blasland & Bouck (1989) identified two distinct groundwater flow systems in the valley: shallow and deep. The shallow (upper) flow system is distinguished by the considerable groundwater mounding in the vicinity of the wastebeds, which provide multiple groundwater flow components. This mounding is attributable to the relatively low permeability of the waste materials. The degree of mounding is dependent on the characteristics of the wastebeds, such as size, age, surface drainage characteristics, and amount of time since it last received waste material. Excluding this mounding, groundwater migration direction in the shallow (upper) flow system is generally towards the creek. Based on surface water and groundwater elevations, Ninemile Creek is a gaining stream (groundwater normally flows upward, discharging into the stream) in the study area below Amboy Dam, as is Geddes Brook. The groundwater migration direction in the deep (lower) flow system is more consistent with the valley's orientation, flowing toward the northeast (Blasland & Bouck, 1989; BBL, 1999).

The largest and youngest of the Honeywell wastebeds, Wastebeds 9 to 15, are located adjacent to Geddes Brook and Ninemile Creek and received Solvay Process wastes from 1944 through 1986. Historical information pertaining to Wastebeds 9 to 15 is documented in the following reports:

Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area (Blasland & Bouck, 1989), and Supplemental Site Investigation Report, Waste Beds 9 to 15, Onondaga County, New York, Volume I (BBL, 1999). A brief history of these wastebeds is presented in Chapter 4, Sources and Potential Sources of Chemical Parameters of Interest, of this RI report.

Wastebeds 9 to 15 are the largest factor in determining the ionic waste content of Ninemile Creek at the USGS gauging station at Lakeland. Perkins and Romanowicz (1996) state that:

> *"The Ninemile Creek surface water ion ratios before and after closure of the soda ash/chlor-alkali plant equals that of the wastebed overflow. Concentrations of calcium, chloride, and sodium in the Ninemile Creek surface waters are less than concentrations in the wastebed overflow, indicating that the waters are diluted with less ionically enriched waters. Further, substantial decreases in the concentrations of these ions occurred following closure of the facilities. Despite the lower concentrations of calcium, chloride, and sodium found in Ninemile Creek and the decreased loadings to the surface waters of Ninemile Creek since the closure of the soda ash/chlor-alkali facility, the unchanged ionic ratios establish that the continuing ionic loading originates from the waste-bed overflow. A piper plot indicates that the composition of the Ninemile Creek surface water and waste-bed overflow are essentially the same; both are composed of the same unique combination of ions."*

Starting at Station CDR-08, downstream of where Ninemile Creek passes near Wastebed 13 (see Figure 2-3 of Chapter 2, Field and Laboratory Investigations), the ionic content of the creek's surface water increases (CDR, 1991). This station represents the first measurement location where groundwater from the Solvay Wastebeds significantly impacts Ninemile Creek. The ionic content continues to increase downstream to the USGS gauging station at Lakeland (State Fair Boulevard), after which the concentrations remain stable (see further discussion in Chapters 5 [Nature and Extent of Contamination] and 6 [Transport and Fate of Chemical Parameters of Interest]).

Chloride contributions from these wastebeds were anticipated by Honeywell to decrease with time (BBL, 1999), as a result of the leaching of available chloride from the wastebeds and natural revegetation of the wastebeds. A 1998 linear regression analysis of chloride concentrations measured in Ninemile Creek surface water between May 1989 and November 1997 indicated that chloride loading to Ninemile Creek decreased by 24 percent over this period (BBL, 1999). Because chloride releases by wastebeds are expected to decrease with wastebed age, this downward trend is consistent with the concept that a significant portion of the ionic waste loading to Ninemile Creek originates from the wastebeds.

Wastebeds 1 to 8 are located along Onondaga Lake southeast of the mouth of Ninemile Creek, with only Wastebed 5 directly bordering Ninemile Creek. According to Blasland & Bouck (1989), the mounded groundwater at these beds would produce radial (in all directions) flow. The amount of groundwater from Wastebeds 1 to 8 reaching Ninemile Creek is relatively small compared to the flow from Ninemile Creek, based on the observed minor increases in TDS through this section of the creek.

3.7.4 Groundwater Usage

Groundwater at the southwestern end of Onondaga Lake is not currently (nor was it historically) used for drinking water (O'Brien & Gere, 1999). The high chloride and TDS concentrations in the groundwater from the surface aquifer preclude its use as potable water, and it does not meet the regulatory definition of fresh groundwater. However, it should be noted that the groundwater in this area is designated as Class GA under 6 NYCRR Part 701.15. In addition, the soils in this area (silt, marl, and Solvay waste materials) have low hydraulic conductivity and would not yield sufficient water to be a supply source (O'Brien & Gere, 1999).

In a search of water wells along Geddes Brook and Ninemile Creek, no potable water wells were identified within the site as defined in Chapter 1. The Onondaga County Health Department did identify three properties on Thompson Road north of Ninemile Creek and upstream of Amboy Dam (i.e., beyond the limits of the Ninemile Creek portion of the site) that are believed to be using private wells (R. Burdick, pers. comm., 2001).

3.8 Demography and Land Use

Geddes Brook and Ninemile Creek flow through residential, agricultural, and highly industrialized areas. Upstream (south) of West Genesee Street, Geddes Brook flows near residential areas and alongside a large shopping mall before passing under West Genesee Street. Geddes Brook then flows through residential areas north of West Genesee Street before passing through culverts under the intersections of State Highway 5 and Route 695. After exiting the culverts, Geddes Brook flows through agricultural and residential areas until its confluence with the West Flume.

In addition to agricultural and residential areas, land use in the general area between the State Highway 5 and Route 695 culverts and the West Flume includes an intact portion of the Old Erie Canal that parallels Gerelock Road and several landfills. South of the canal are industrial landfills (Pass & Seymour, Frazer & Jones, and Stanton Foundry), Honeywell's currently inactive construction and demolition (C&D) debris landfill (Mathews Avenue), and a municipal landfill (Village of Solvay). From the West Flume confluence to its mouth at Ninemile Creek, Geddes Brook passes under several sets of railroad tracks and flows along the edge of the New York State Fairgrounds. The inactive State Fair Landfill is on fairgrounds property adjacent to Geddes Brook and Ninemile Creek.

Ninemile Creek flows through mostly agricultural land upstream of Amboy Dam and a small residential area along Airport Road before traveling along the north side of Wastebeds 12 to 15, the south side of Wastebeds 9 to 11, along or under highways (i.e., I-690 and Route 695), and past Wastebeds 1 to 8 to reach Onondaga Lake. Land immediately adjacent to Ninemile Creek for much of this distance is floodplain forest or reedgrass marsh. The mouth of Ninemile Creek is bordered on the south by Wastebeds 1 to 8 and on the north by a dredge-spoils area and parkland belonging to Onondaga County.

3.9 Summary

Geddes Brook and Ninemile Creek underwent significant changes in their flow and sediment regimes during the period of Honeywell operations. The large discharges by Honeywell caused significantly greater flows in Ninemile Creek, and the large quantities of suspended sediment and dissolved solids discharged by Honeywell caused deposits of Solvay waste and associated calcite to build up in sediments of both streams and to deposit within the floodplain areas. These deposits in Ninemile Creek were noted by CDR (1991) and BBL (2001) in Reach CD below the confluence with Geddes Brook, and the remnants of these deposits were evident in the calcite shelf in Reach AB between State Fair Boulevard and the mouth of Ninemile Creek. The thickness of some of these deposits can be seen in the fact that elevated mercury concentrations are found at depths greater than 3 ft (1 m) in the sediments and floodplain soils, and in some areas, as much as 6 ft (2 m) deep (see Chapter 5).

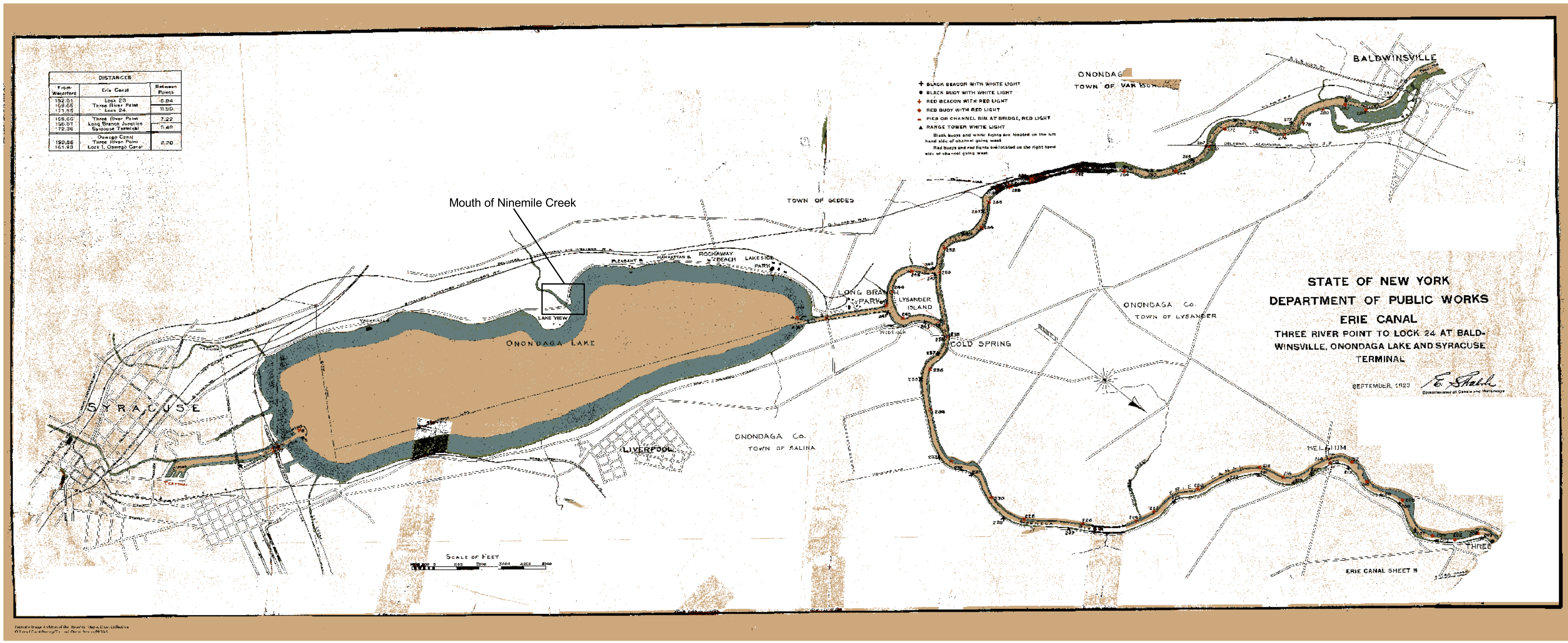
Subsequent artificial modification of the stream beds, changes in the stream flow caused by the cessation of Honeywell discharges, and natural processes resulted in distinct physical characteristics of individual reaches of Ninemile Creek, as described below:

- Upper Ninemile Creek (above the confluence with Geddes Brook) – This reach is relatively unaltered since 1944 when disposal began at Wastebeds 9 to 11. There is potential for CPOIs to have been deposited from wastebed overflows in this reach; however, it appears that the bulk of the discharges were below this reach.

- Reach CD (from the confluence with Geddes Brook to the large bend downstream of the islands) – This reach is unaltered since the 1930s, contains extensive Solvay waste and associated calcite deposits, and appears overall to be erosional. The deposits in this area may be eroding as Geddes Brook and Ninemile Creek attempt to achieve an equilibrium under the new (post-1980) flow and solids regime.

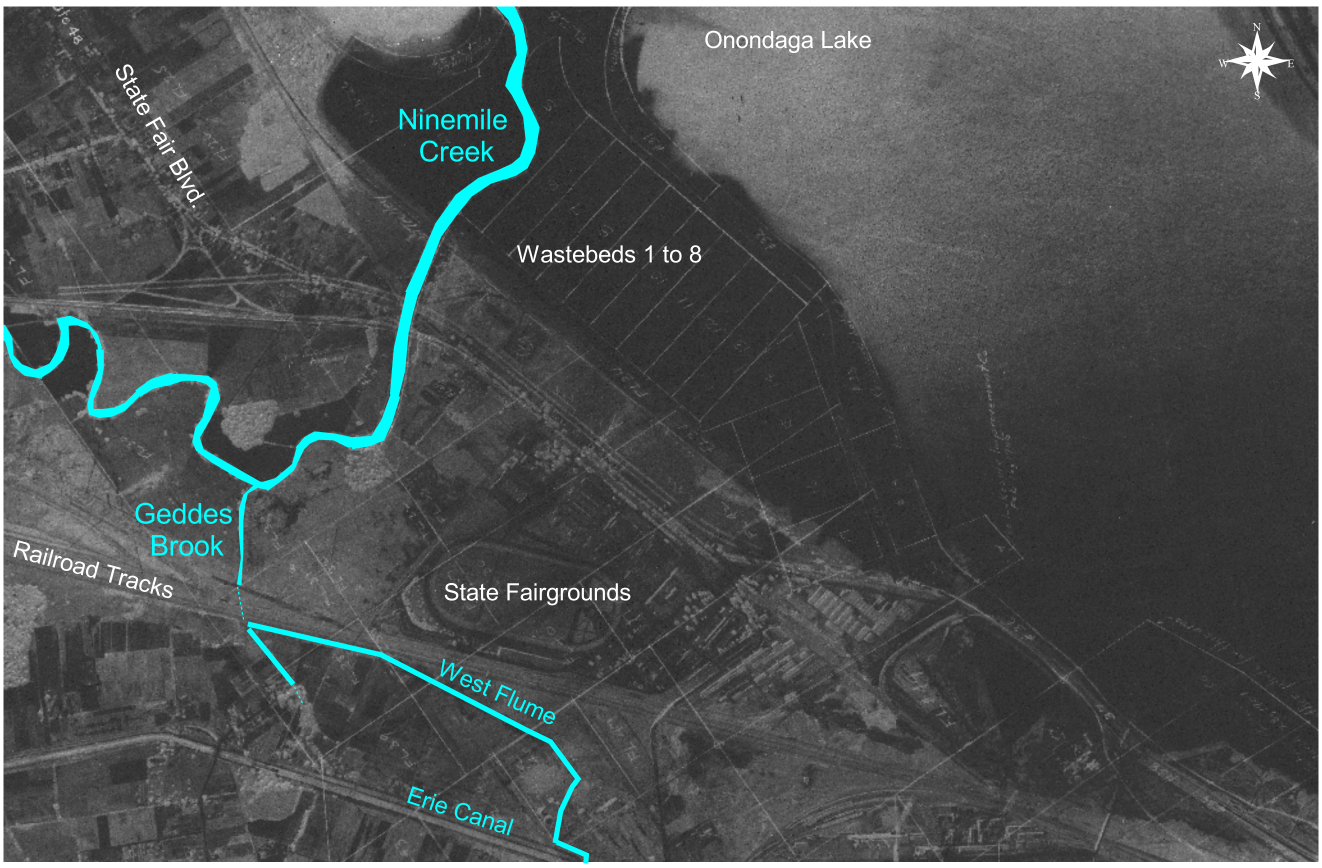
- Reach BC (from the bend downstream of the islands to the bend downstream of I-690) – This reach was rerouted in the late 1960s, and this rerouting may be why little evidence of Solvay waste and associated calcite deposits has been found, despite the fact that Reach BC appears to be primarily depositional.

- Reach AB (from the bend below I-690 to the mouth of Ninemile Creek) – This reach appears to have been channelized in the late 1960s, with remnants of the Solvay waste and associated calcite deposits in the shelf along the right (facing downstream) bank (see Chapter 5, Figure 5-2). It is likely that a portion of the mercury-contaminated material in the sediments was removed during the channelization and dredging project at the mouth of Ninemile Creek. This reach appears to be highly depositional.



Source: from the Image Archives of the Historical Map & Chart Collection
Office of Coast Survey/National Ocean Service/NOAA

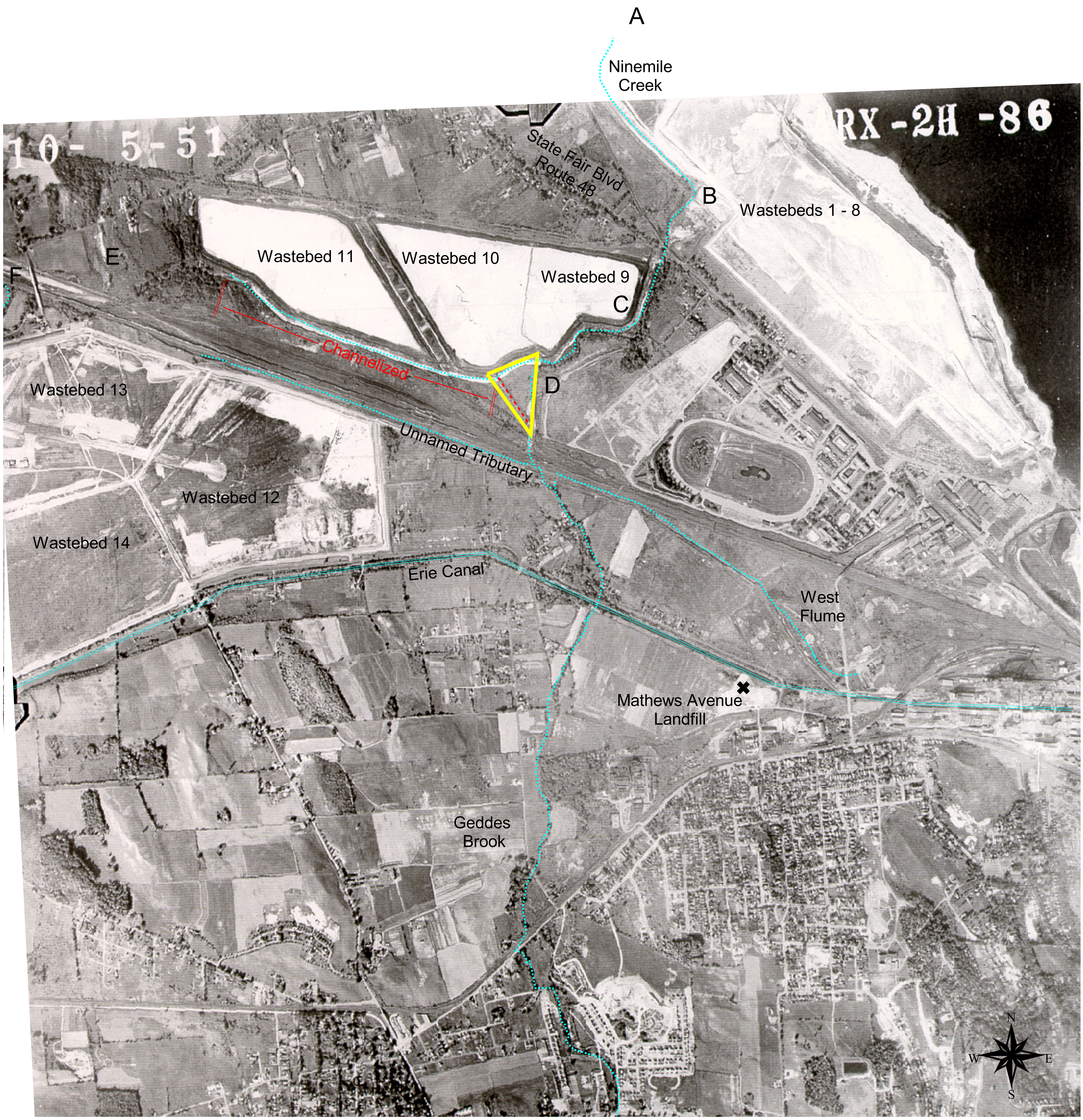
Geddes Brook/ Ninemile Creek RI	Figure 3-1 Map of Portion of Erie Canal, 1923	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 3-2 Aerial Photograph, 1938, with Historical Markings	TAMS

Note: Date of photo not known; assumed to have been taken between 1939 and 1944 (see Chapter 3 text)

Geddes Brook/ Ninemile Creek RI	Figure 3-3 Aerial Photograph - Between 1939 and 1944	TAMS



elevated structure

triangle of land between Geddes Brook and Ninemile Creek

Geddes Brook/ Ninemile Creek RI	Figure 3-4 Aerial Photograph, 1951	TAMS

elevated structure

triangle of land between Geddes Brook and Ninemile Creek

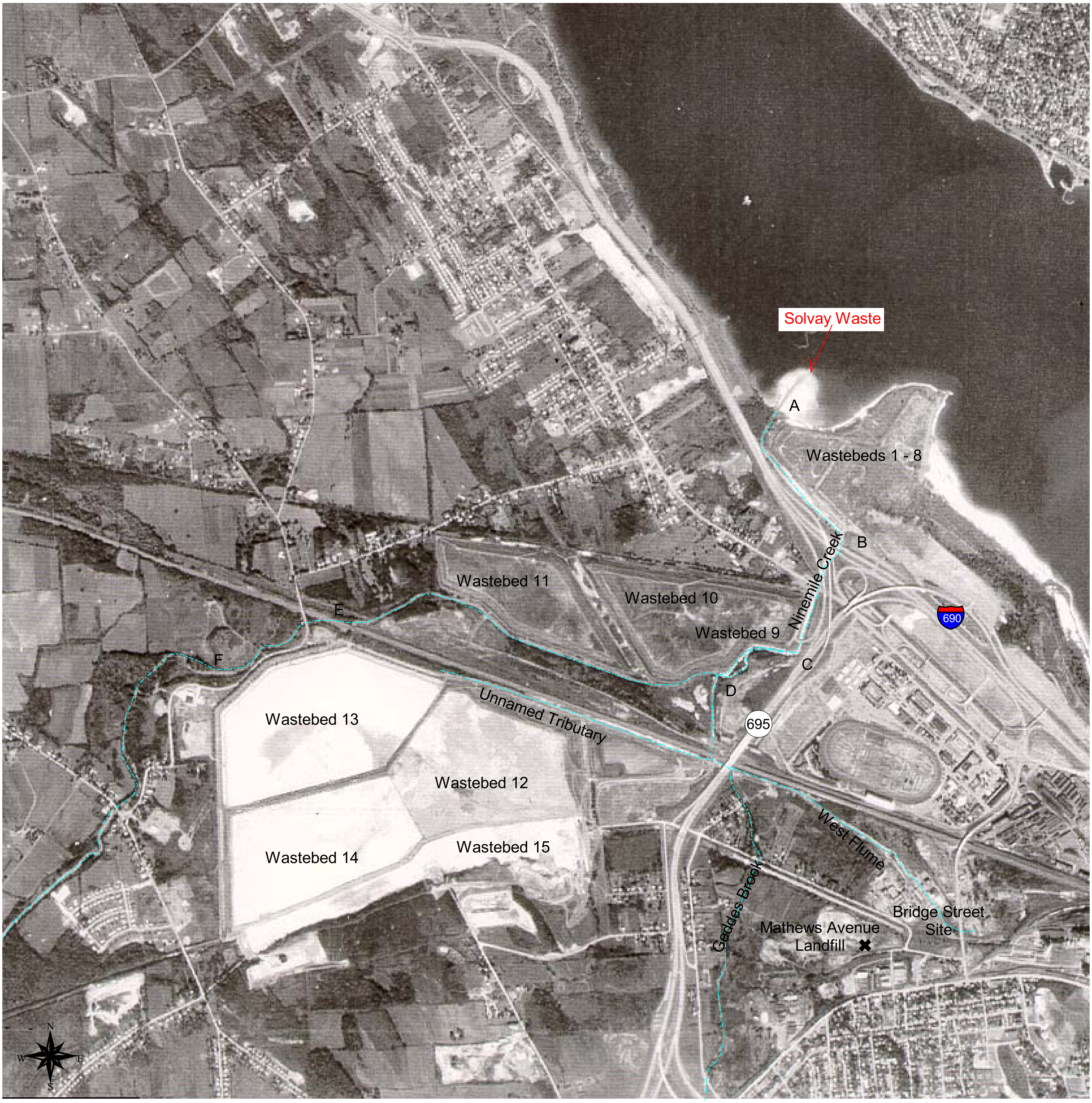
N
W E
S

Geddes Brook/ Ninemile Creek RI	Figure 3-5 Aerial Photograph, 1959	TAMS

triangle of land between Geddes Brook and Ninemile Creek

Geddes Brook/ Ninemile Creek RI	Figure 3-6 Aerial Photograph, 1966	TAMS

Geddes Brook/ Ninemile Creek RI	Figure 3-7 Aerial Photograph, 1967	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 3-8 Aerial Photograph, 1978	TAMS

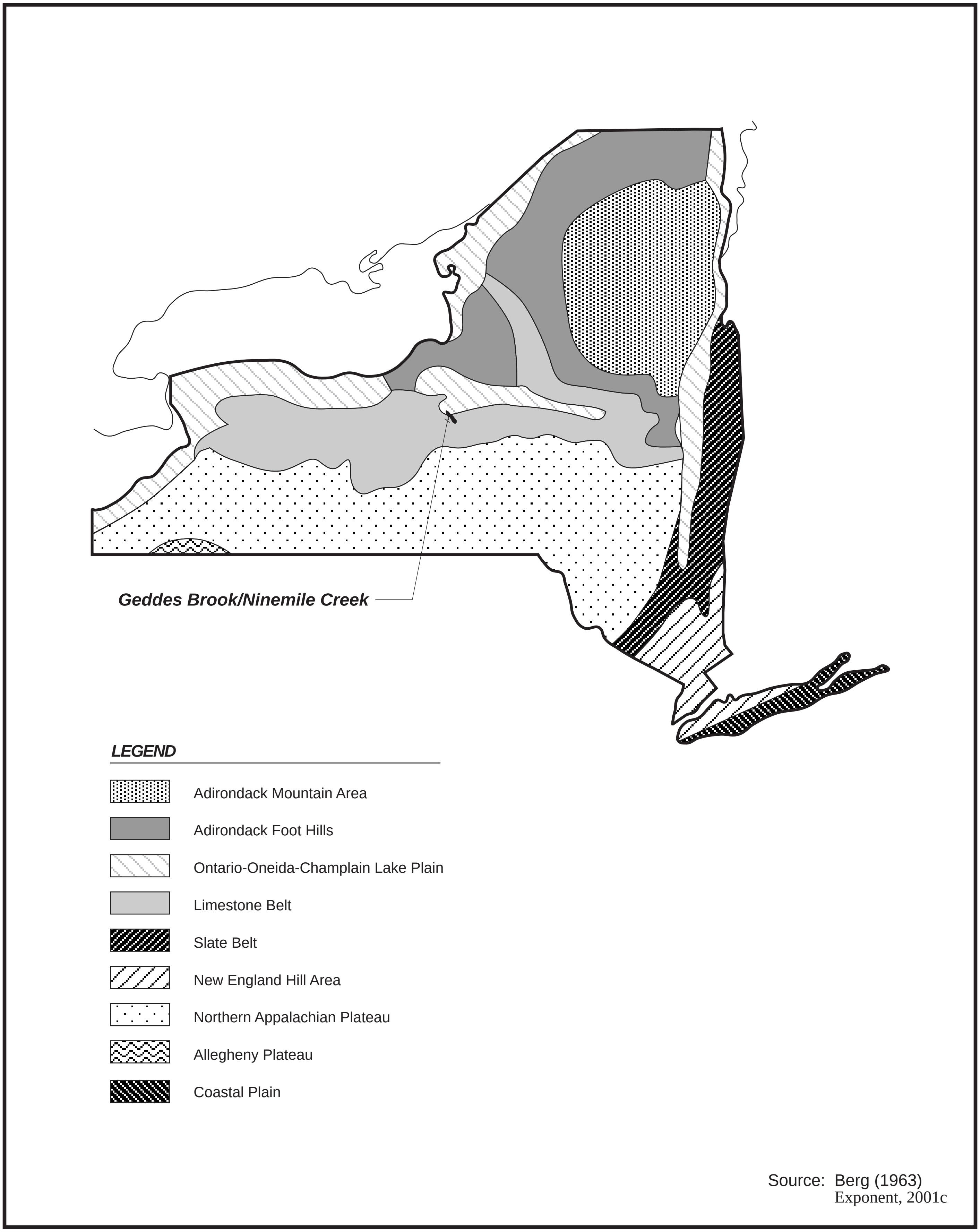
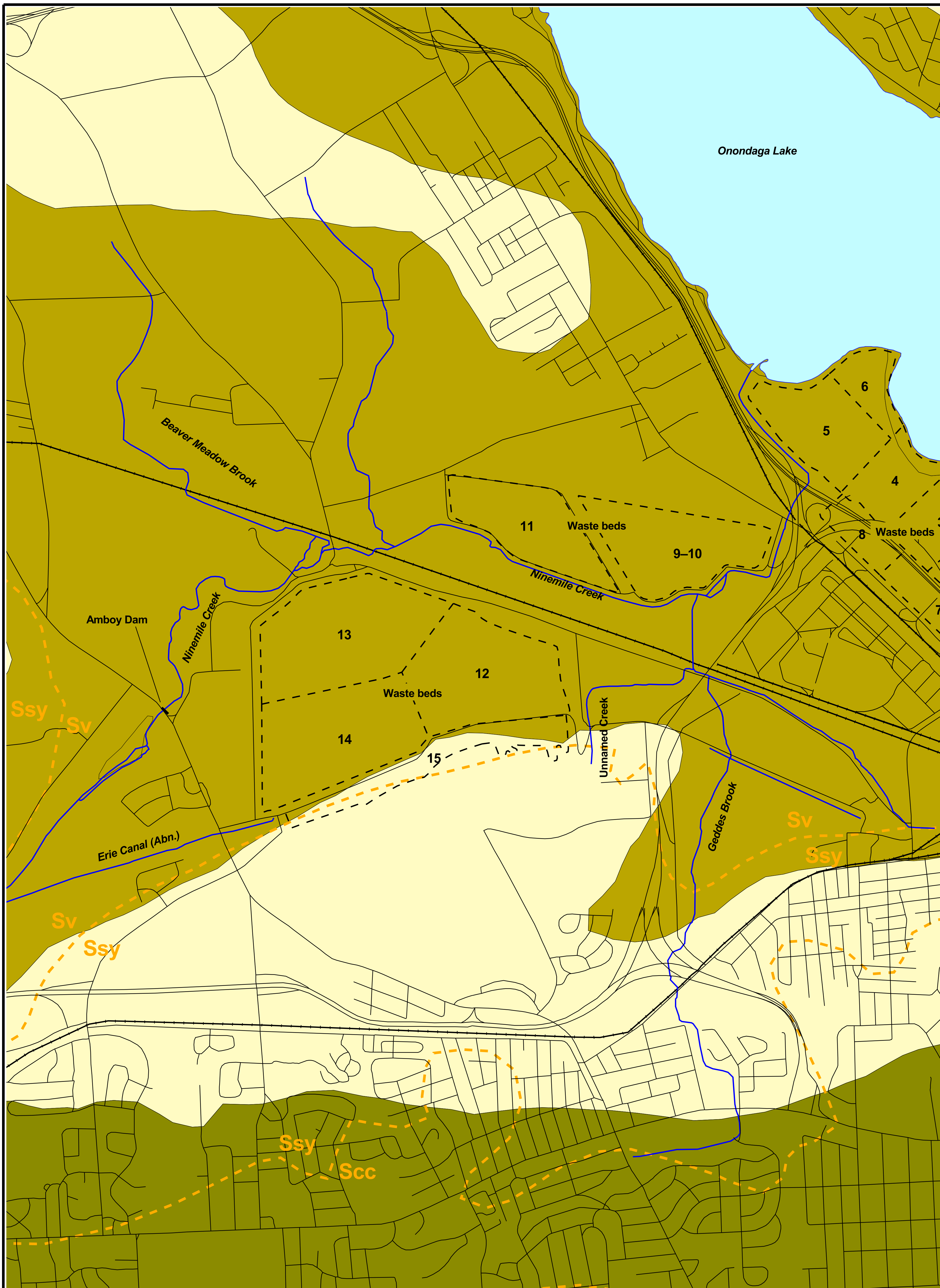


Figure 3-9. Physiographic Regions of New York State



LEGEND

Waste beds
Streams
Roads
Water

Surficial Geology
Lacustrine silt and clay
Bedrock
Till

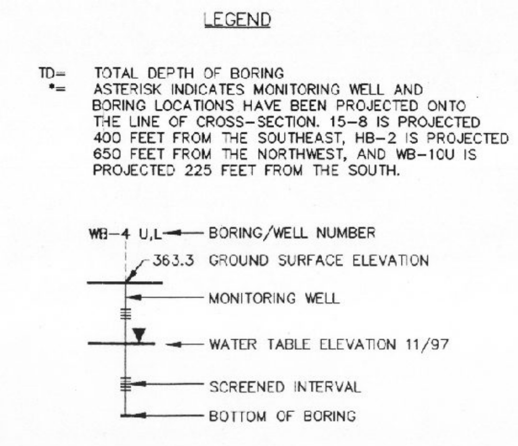
Bedrock Geology
- - - - - Bedrock contacts
Scc - Camillus Formation, dolomite and gypsiferous shales
Sv - Vernon Formation, thick-bedded red and green mudstones that grade westwardly to gray argillaceous dolostones and green dolomite shale with some gypsum
Ssy - Syracuse Formation, gray argillaceous dolostones, clay, green dolomite shale gypsum and evaporites (salt and anhydrite)

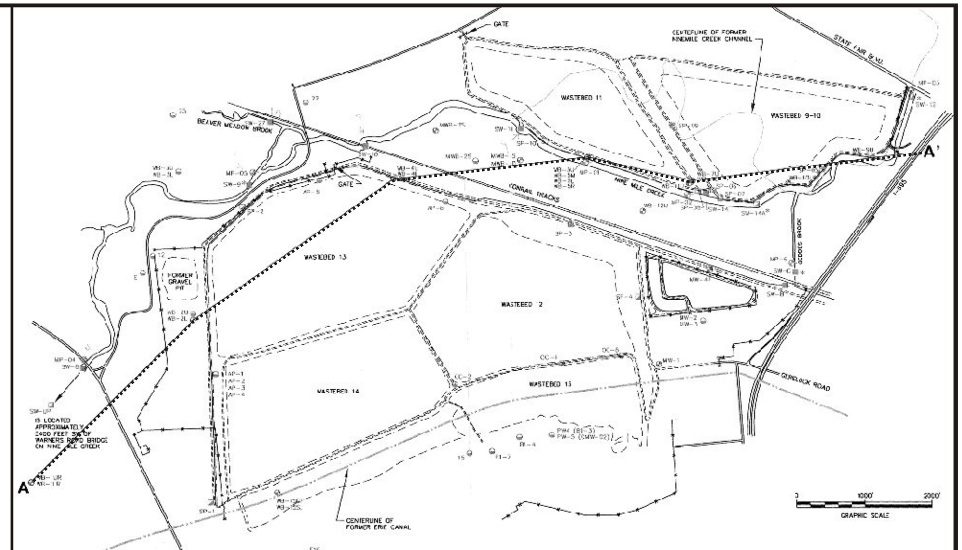
0 2000 4000 Feet
0 500 1000 Meters

Sources:
USGS, Syracuse West, NY quadrangle, 1978.
USGS, Camillus, NY quadrangle, 1978.
New York State Museum, surficial and bedrock geology, last revised 2/15/94.
Exponent, 2001c

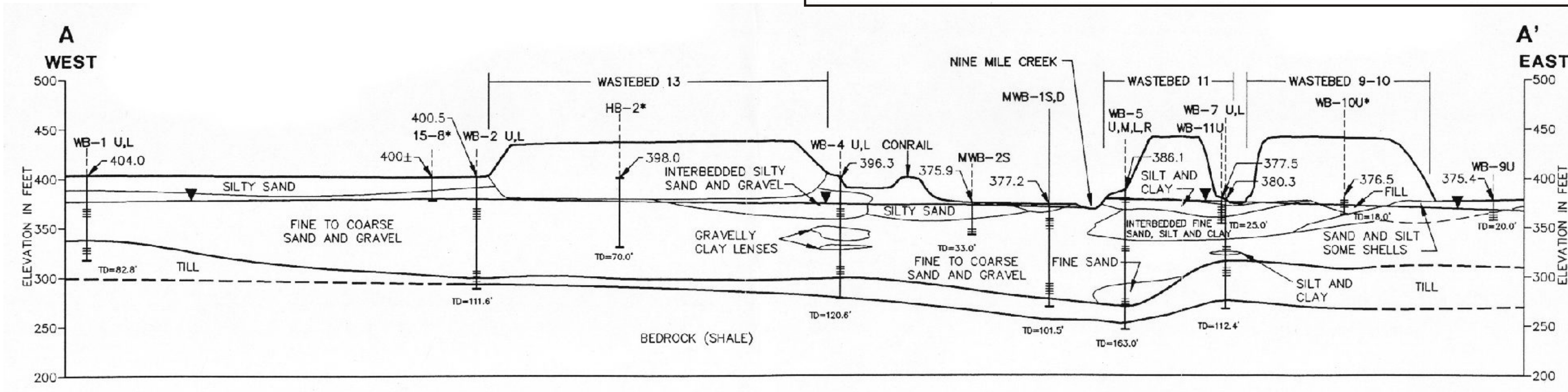
Note: Bedrock contacts surficial geology, and some hydrologic features have been inferred or interpreted.

Figure 3-10. Surficial and Bedrock Geology of Ninemile Creek and Geddes Brook Study Area



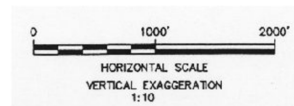


Location of cross section A - A'



NOTES:

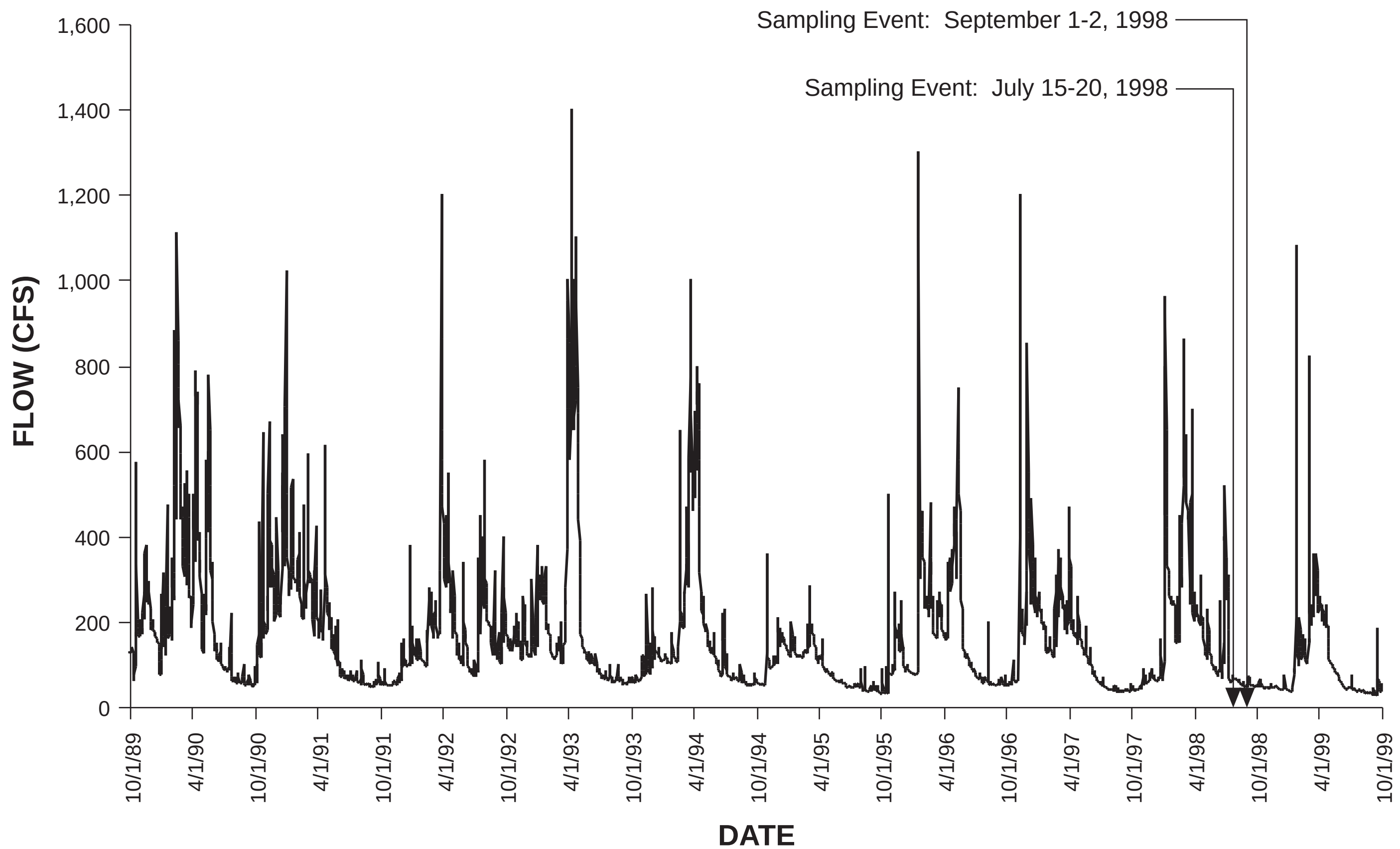
1. ELEVATIONS ARE IN FEET AND REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.
2. GROUND SURFACE ELEVATIONS FOR MW-1 THRU MW-4, WB-15CF, AND WB-15S FROM THE "WASTE BED/LAGOON INVESTIGATION", PREPARED BY C&S ENGINEERS, INC., JANUARY 1993.
3. WB-1U AND WB-1L WERE ABANDONED AND REPLACED BY WB-1UR AND WB-1LR, RESPECTIVELY, DURING OCTOBER 30 TO NOVEMBER 5, 1997.
4. GROUND SURFACE ELEVATIONS MP-01 THROUGH MP-06 AND TOP OF INNER CASING ELEVATIONS FOR NEW MONITORING WELLS WB-1UR, WB-1LR, WB-9U, WB-10U, WB-11U, AND WB-12U WERE SURVEYED DECEMBER 22 AND 23, 1997 BY BLASLAND, BOUCK & LEE, INC.
5. BORING 15-8 WAS COMPLETED BY ONONDAGA SOIL TESTING INC. 1967, 1971; HB BORINGS WERE COMPLETED BY HOUGH, 1950.



Source: BBL, 1999

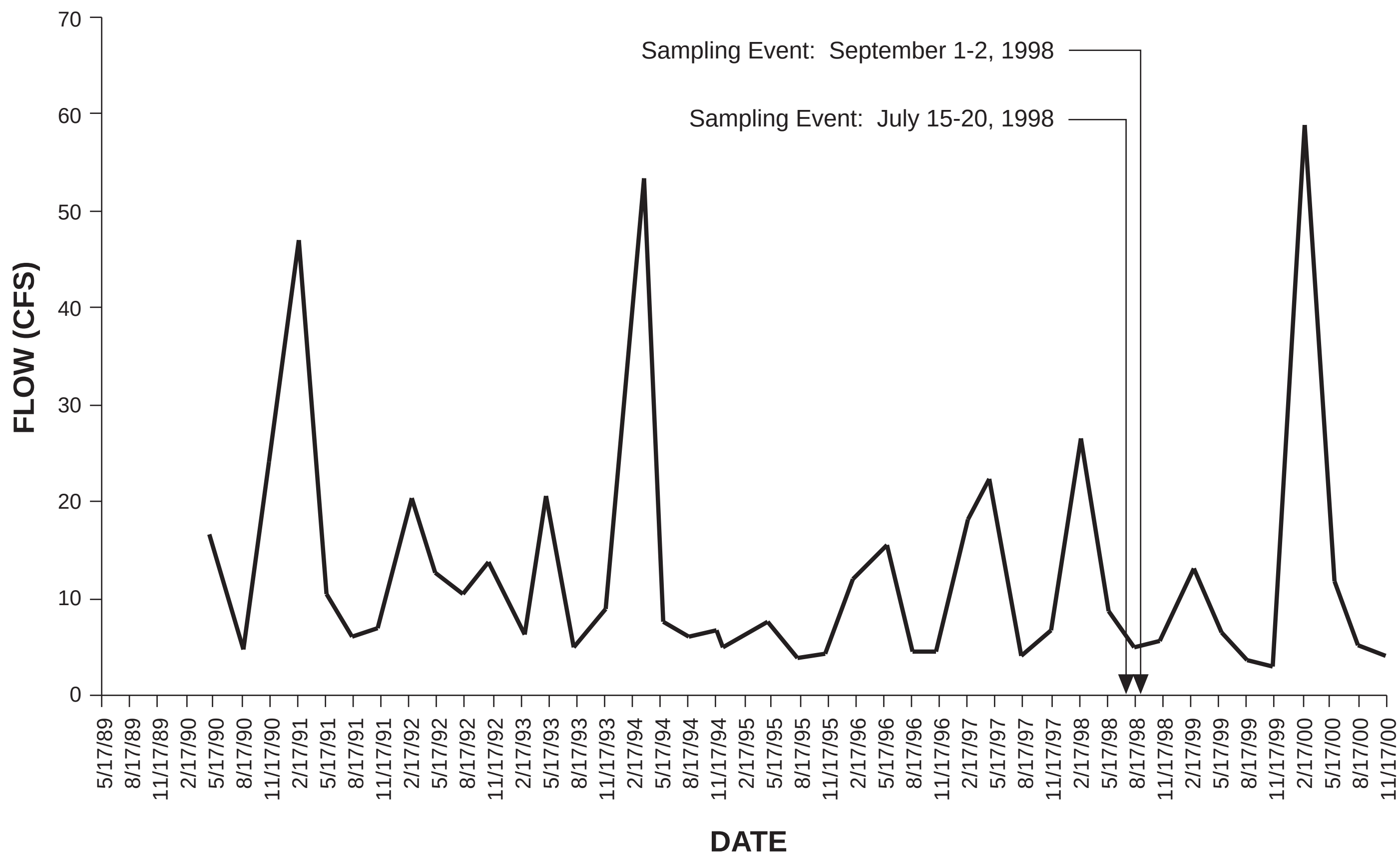
Figure 3-11

Geologic Cross Section of the Geddes Brook/Ninemile Creek Study Area



Source: Exponent, 2001c

Figure 3-12. Ninemile Creek Streamflow at Lakeland, NY USGS Station Number 04240300, 1989-1999



Source: Exponent, 2001c

Figure 3-13. Downstream Geddes Brook Streamflow, Quarterly 1989–2000

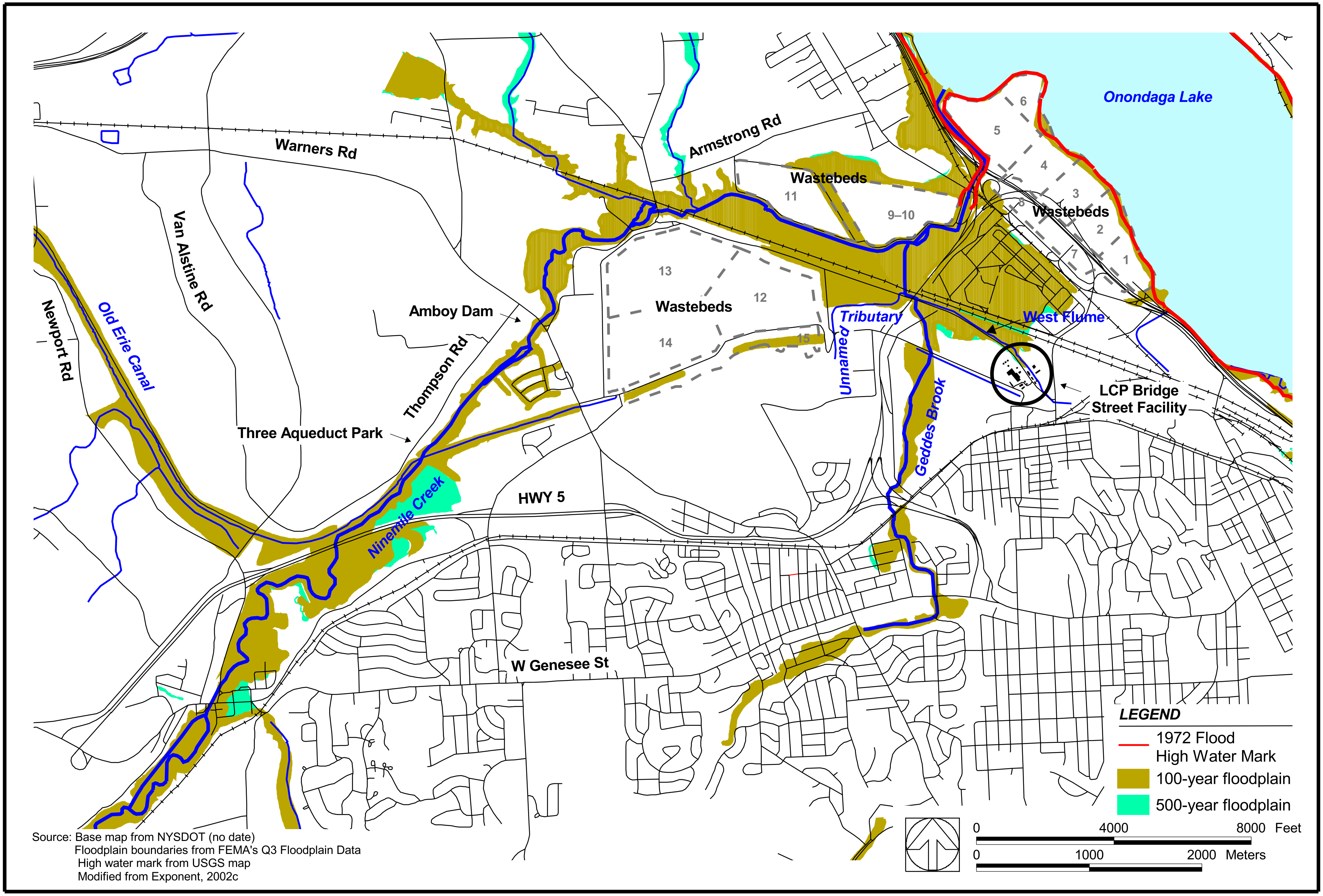
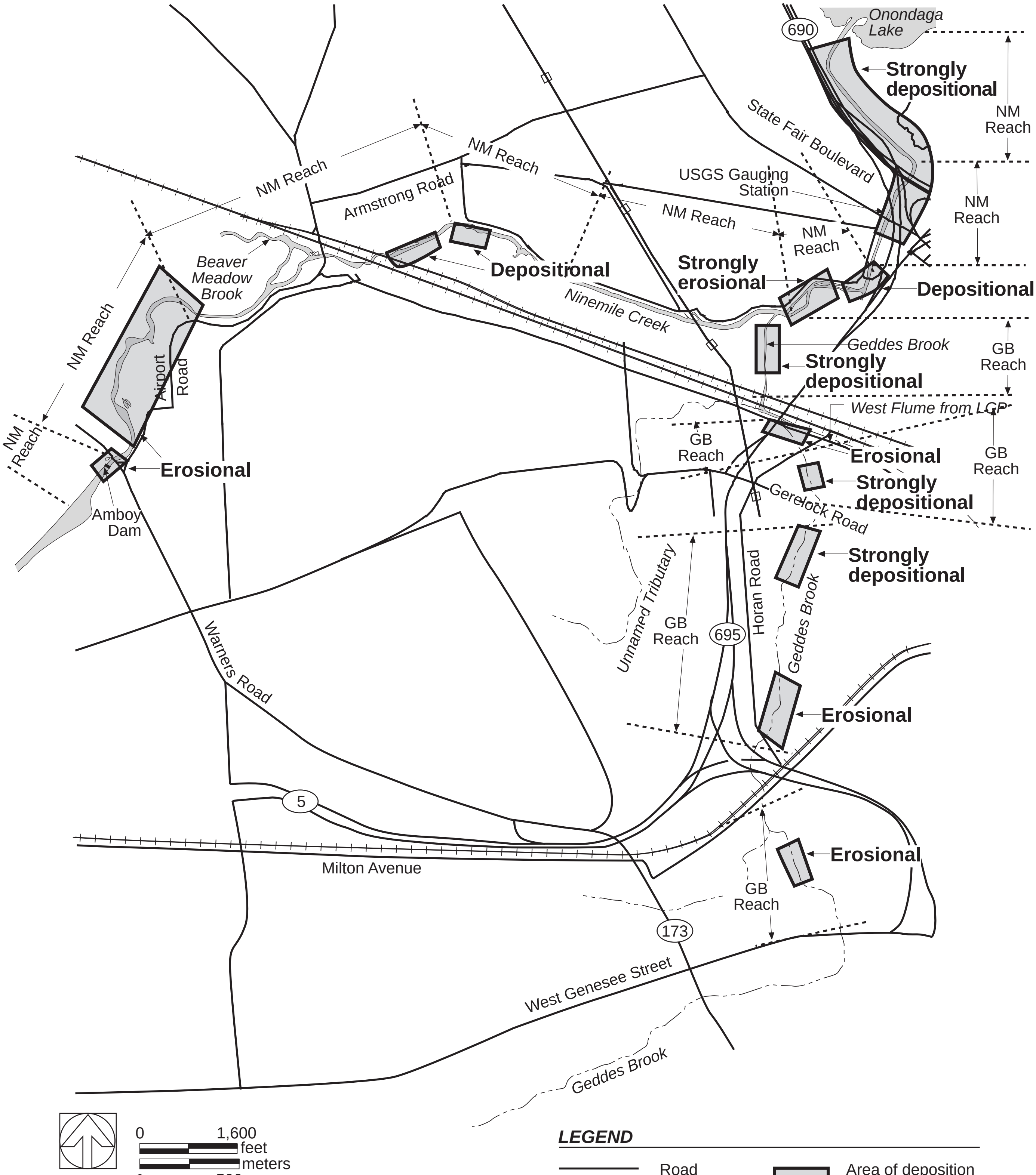


Figure 3-14. FEMA 100-year Floodplain, 500-year Floodplain and Historic High Water Mark



Note: Ninemile Creek reach boundaries modified from CDR (1991).

Source: Modified from Exponent, 2001c

Figure 3-15. Sediment Transport Regimes, Geddes Brook/Ninemile Creek (1998)

Table 3-1. Annual Streamflow Measured in Ninemile Creek

Year	Annual Mean Flow (ft^3/s)
1971	241
1972	336
1976	269
1977	273
1978	229
1979	237
1980	148
1981	160
1982	148
1983	154
1984	182
1985	135
1986	173
1987	123
1988	94.5
1989	160
1990	254
1991	152
1992	184
1993	183
1994	166
1995	91.2
1998	160
1999	98.1
2000	167

Notes: USGS Gauge No. 04240300 is located at Ninemile Creek, Lakeland, NY.
Annual streamflow data not available for years 1973-1975 and 1996-1997.

Source: USGS, 2003.

4. SOURCES AND POTENTIAL SOURCES OF CHEMICAL PARAMETERS OF INTEREST

Based on data acquired during the Geddes Brook/Ninemile Creek remedial investigation (RI), as well as investigations from other Honeywell sites and non-Honeywell sites, this chapter describes external sources and potential sources of mercury and other chemical parameters of interest (CPOIs) to the Geddes Brook/Ninemile Creek site. This chapter addresses some of the more prevalent CPOIs, or classes of CPOIs, associated with these sources and potential source areas, and are:

- Mercury and other metals.
- Benzene, toluene, ethylbenzene, and xylenes (BTEX).
- Chlorinated benzenes.
- Polycyclic aromatic hydrocarbons (PAHs).
- Polychlorinated biphenyls (PCBs).
- Polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs).
- Ionic waste constituents, including calcium, chloride, and sodium.

The nature and extent of all CPOIs within the Geddes Brook/Ninemile Creek site and the fate and transport of numerous CPOIs are discussed in Chapters 5 (Nature and Extent of Contamination) and 6 (Transport and Fate of Chemical Parameters of Interest), respectively.

Past and present sources and potential sources factor into the analysis of contaminant fate and transport, as well as the analysis of remedial alternatives in a feasibility study (FS). Available information on sources and potential sources of CPOIs from upland sites and areas of concern are summarized.

Potential external sources of CPOIs include urban runoff, groundwater discharges, and/or active discharges from facilities (disposal sites or plant sites) located in the Geddes Brook/Ninemile Creek watershed. CPOIs also originated from sources outside the watershed, but were disposed of within the watershed (i.e., the Solvay Wastebeds). Information on the various sites and areas of concern that may act as sources of CPOIs, including Honeywell and non-Honeywell sites, is presented in this chapter as follows:

- Honeywell's LCP Bridge Street site and the West Flume (Section 4.1).
- Honeywell's Wastebeds 1 to 15 (Section 4.2).
- Honeywell's Mathews Avenue Landfill site (Section 4.3).
- Non-Honeywell sites (Section 4.4).
- Honeywell's Main Plant and Willis Avenue sites (Section 4.5). These are sites of importance to the Geddes Brook/Ninemile Creek site, but are located outside of the Geddes Brook/Ninemile Creek watershed.

The Honeywell sites and referenced non-Honeywell sites are shown in Figure 4-1. Of the Honeywell sites shown in Figure 4-1 that are within the Geddes Brook/Ninemile Creek watershed (i.e., LCP Bridge Street, Mathews Avenue Landfill, and Wastebeds 1 to 15), the LCP Bridge Street site is currently the only "subsite" of the Onondaga Lake National Priorities List (NPL) site. Four of the other Honeywell sites shown in Figure 4-1 that are outside of the Geddes Brook/Ninemile Creek watershed are also subsites (i.e., Semet Residue Ponds, Willis Avenue, Wastebed B/Harbor Brook, and Onondaga Lake).

Based on recent information available through May 2003, this chapter also takes into consideration ongoing or planned remedial activities. For example, some of Honeywell's sites are being actively remediated or may be in the near future; thus, continuing loads from these sources may change significantly relative to historical conditions.

Honeywell has agreed to implement an interim remedial measure (IRM) for Geddes Brook (NYSDEC, 2002). The scope of the IRM includes full bank-to-bank sediment removal (estimated to be 4,200 cubic yards) from Geddes Brook, beginning at the confluence with the West Flume and ending at the confluence with Ninemile Creek. Contaminated floodplain soils along Geddes Brook will also be addressed as part of this IRM. A Geddes Brook IRM Work Plan (Parsons, 2002a) prepared by Honeywell was approved by NYSDEC in April 2003 (T. Smith, pers. comm., 2002 and 2003). The data collected as part of the Geddes Brook IRM, which include supplemental floodplain soil and soils underlying sediments in Geddes Brook, are discussed in Chapter 5 and presented in Appendix M, Geddes Brook IRM Analytical Data and Validation Report (2002). The impact of this IRM on the Geddes Brook/Ninemile Creek site will be further evaluated in the Geddes Brook/Ninemile Creek FS. While external sources of mercury and other CPOIs are summarized here, a more complete description of contaminant loads and transport in the site can be found in Chapter 6.

As discussed previously in this report (Section 1.3 of Chapter 1, Introduction), Honeywell's manufacturing/disposal operations generally represent the most prevalent sources of CPOIs to the Geddes Brook/Ninemile Creek site. For example, USEPA (1973) cites an AlliedChemical letter of July 21, 1970 to the New York Department of Health stating that, "prior to May 9, 1970, the mercury discharged to Geddes Brook (tributary to Ninemile Creek) averaged 22 pounds per day." Additional large amounts of mercury were discharged or lost to the environment, such as the separate-phase elemental mercury disposed of and/or spilled at, and in the vicinity of, the mercury-cell buildings at both the LCP Bridge Street and Willis Avenue plant sites, as well as that discharged directly to Onondaga Lake. It is not possible to fully account for the mass of mercury historically discharged, as Honeywell asserts that no records of spills or discharges were kept for most of the plants' operational histories (PTI, 1992).

4.1 LCP Bridge Street and the West Flume

Geddes Brook receives mercury and other CPOIs from Honeywell's LCP Bridge Street site via the West Flume (formerly referred to as the "West Sewer" by AlliedChemical [New York State Department of Health {NYSDOH}, 1951]), which passes through the LCP Bridge Street site before discharging to the brook (see Chapter 1, Figure 1-2). Since Geddes Brook discharges to Ninemile Creek, the LCP Bridge Street site and the West Flume are also ultimately sources of mercury to the creek as well.

The LCP Bridge Street site consists of approximately 20 acres (8 hectares) of land that was used for various industrial activities from 1953 to 1988, among others, by Honeywell and Linden Chemical. A detailed history of ownership, manufacturing processes, and waste management at the LCP Bridge Street site is described in the LCP Bridge Street RI report (NYSDEC/TAMS, 1998) and is summarized here.

Between 1919 and the late 1940s, the Atmospheric Nitrogen Company constructed and operated a plant to manufacture ammonia at the site. With the exception of water used in the electrolytic cells, all products and raw materials related to this process were gaseous. Residual contamination resulting from ammonia manufacturing is, therefore, unlikely to have existed. Debris from demolition of this facility in the early 1950s was used to fill the LCP Bridge Street site.

The Allied Chemical Corporation, Solvay Process Division (predecessor to AlliedSignal) constructed a chlor-alkali facility at the site in 1953. From 1953 to 1988, mercury-cell technology was used to produce liquid chlorine and caustic soda. After 1968, both mercury-cell and diaphragm-cell techniques were used in chlorine and caustic soda production. Waste substances generated by the mercury-cell process included:

- Spent sulfuric acid.
- Sodium hydrochlorite solution.
- Spent purged brine, muds contaminated with mercury, cell wash-down wastes, endbox purges, cell washings, and brine leaks.
- Hydrogen.

Wastes generated by the diaphragm-cell process included:

- Sodium sulfate and salt.
- Sodium chloride and sodium hydroxide.
- Asbestos and lead.
- Hydrogen.

Some of the above materials may have been disposed of in the wastebeds or discharged to the West Flume.

Hydrogen gas generated as a byproduct of the chlor-alkali process was used to manufacture hydrogen peroxide between 1955 and 1969. Xylene used in hydrogen-peroxide production was recycled, and spent or contaminated catalyst (palladium) was sent to the supplier for reactivation. While no waste stream was reportedly generated by this process, xylene contamination was found in on-site groundwater, which is the subject of a second operable unit (OU) of the LCP Bridge Street site.

Linden Chemicals and Plastics (LCP) purchased the Bridge Street site in 1979, and installed a hydrochloric acid production facility in 1980 and a sodium hypochlorite bleach plant in 1981. In 1981, LCP also obtained interim status as a hazardous waste storage facility under the Resource Conservation and Recovery Act (RCRA). Two lined surface impoundments southwest of the mercury-cell and diaphragm-cell buildings were taken out of service in 1984, and received NYSDEC and USEPA closure certification in 1989 (USEPA ID No. NYD095586376). Manufacturing operations at the site continued until LCP shut down the facility in 1988.

The FS for the LCP Bridge Street site (Gradient and Parsons, 1999) was reviewed by NYSDEC, which issued a record of decision (ROD) in September 2000 (NYSDEC, 2000b). Most of the buildings at the LCP Bridge Street site were demolished as part of two IRMs. Remediation (described below) will commence pending completion and NYSDEC approval of the remedial design, which is being carried out under the terms of the NYSDEC-approved remedial design work plan (Parsons, 2002b).

Current sources of mercury to the West Flume from the LCP Bridge Street site include:

- Direct discharge of contaminated groundwater.
- Discharge from a ponded area at the site.
- Particulate mercury from surface runoff (NYSDEC/TAMS, 1998).

A major source of mercury to the shallow groundwater at the LCP Bridge Street site is a zone of residual elemental liquid mercury (i.e., dense non-aqueous phase liquid [DNAPL]) which is entrained in the upper aquifer below and north of the former mercury-cell building (NYSDEC/TAMS, 1998). The lower aquifer also contains elemental mercury, however, this mercury does not appear to be mobile as a DNAPL or in the groundwater. PCBs are found in LCP Bridge Street site soils at concentrations as high as 76 mg/kg, and the site may have been a historical source of PCBs to the Geddes Brook/Ninemile Creek site (NYSDEC/TAMS, 1998). The ROD (NYSDEC, 2000b) requires that the LCP Bridge Street site remediation include the following:

- The excavation of sediments from the West Flume that exceed the background mercury concentration of 0.2 mg/kg (approximately 19,000 cubic yards) and placement of these sediments on site under a low-permeability cap.

- The excavation of sediments from Wetlands A and B that exceed the background mercury concentration of 0.2 mg/kg (approximately 31,000 cubic yards) and placement of these sediments on site under a low-permeability cap.

- The sewer system located downgradient of the mercury cell and diaphragm cell buildings will be cleaned and filled.

- The excavation of approximately 3,200 cubic yards of brine mud from the brine mud disposal area and placement of this brine mud on site under a low-permeability cap.

- Approximately 4,500 cubic yards of shallow soil mercury-contaminated principal threat waste from the vicinity of the mercury cell building, retort, and still areas, and the MW-14 area will be excavated, treated, and placed back on site under a low-permeability cap.

- A 6 NYCRR Part 360 equivalent low-permeability cap covering approximately 18.5 acres will be placed over the LCP Bridge Street facility to cover and contain shallow facility soils, excavated brine muds, building demolition debris, and excavated sediments from the West Flume and wetlands that exceed the soil cleanup goals, sediment background levels, and/or which present unacceptable risks.

- A subsurface barrier wall will be installed around the facility to contain site-impacted shallow and deep groundwater.

- Long-term monitoring will be conducted of groundwater, surface water, sediment, and biota to ensure the effectiveness of the selected remedy.

- A deed restriction will be placed on the facility to restrict unacceptable future use at the facility, and to protect the cap and slurry wall.

- The ROD also states that if monitoring results from deep borings in the vicinity of the mercury-cell building area and groundwater monitoring wells indicate that elemental mercury is mobile and that it would not be effectively contained by the cap and barrier wall system, mercury DNAPL recovery wells or other treatment methods will be considered.

4.1.1 Sources and Migration Pathways of Mercury

The primary current source of both dissolved and particulate mercury to the Geddes Brook/Ninemile Creek site is the LCP Bridge Street site via the West Flume (NYSDEC/TAMS, 1998). Historically, mercury-contaminated waste was also disposed of in the Solvay Wastebeds (USEPA, 1973). Chapter 6 provides loading estimates based on an analysis of the available data.

4.1.2 Sources and Migration Pathways of Additional Chemical Parameters of Interest

Based on the production processes at the LCP Bridge Street site, PCBs, lead, hexachlorobenzene, and PCDD/PCDFs might be expected to have been released to the West Flume and then into the Geddes Brook/Ninemile Creek site. In addition to surface water transport, groundwater from the LCP Bridge Street site is a potential source of CPOIs to the Geddes Brook/Ninemile Creek site. However, the LCP Bridge Street RI concluded that contamination other than mercury in groundwater in the area south of the West Flume (Operable Unit 1 [OU-1]) is benign in terms of migration to the lake system. A groundwater plume of chlorinated solvents (vinyl chloride, chloroethane, methylene chloride, 1,1-dichloroethane, 1,2-dichloroethene, and 1,1,1-trichloroethane) and benzene that exists east of the LCP Bridge Street site and south of the West Flume originates from an upgradient, off-site source and dissipates over a short distance on site and before the groundwater reaches the ponded area of OU-1 (NYSDEC/TAMS, 1998). Honeywell is currently performing an RI/FS at OU-2 of the LCP Bridge Street site to assess media contaminated with xylenes and other CPOIs in the area of the former hydrogen peroxide plant north of the West Flume (Parsons Engineering Science, 2001).

In addition to the LCP Bridge Street site, it should be noted that although the Honeywell Main Plant is outside the Geddes Brook watershed, the plant also discharged to the West Flume and Wastebeds 12 to 15. Thus, the West Flume and the wastebeds served as sources of Solvay wastes and possibly other wastes to the Geddes Brook/Ninemile Creek site from operations outside of the current Geddes Brook/Ninemile Creek watershed.

4.2 Solvay Wastebeds

The disposal areas that have the most obvious impact (chemically, physically, and visually) on Geddes Brook and Ninemile Creek are the Solvay Wastebeds. The wastebeds associated with Geddes Brook and Ninemile Creek are located in the towns of Camillus and Geddes, in Onondaga County, New York (see Chapter 1, Figure 1-2, and Figure 4-1). The wastebeds are surrounded by commercial and industrial areas, as well as some residential neighborhoods and agricultural areas.

These uncontained, unlined wastebeds represent the primary means of disposal (i.e., landfilling) for the wastes produced by the Solvay operations and, in part by the Syracuse works. Initial Solvay waste disposal practices consisted of filling low-lying land adjacent to Onondaga Lake. Later, unlined wastebeds designed specifically for Solvay waste disposal were built using containment dikes constructed of materials including native soils, Solvay waste, and cinders, or by using bulkheads made with timber along the lakeshore (Blasland & Bouck, 1989). As discussed in Chapter 1, the Solvay Process created sodium carbonate from brine (sodium chloride in water), limestone, and ammonia (PTI, 1992). The ammonia and part of the carbon dioxide used in the process were to have been recovered during the chemical reactions and reused (PTI, 1992). However, the fact that the ammonia concentration in lower Ninemile Creek (below the Solvay Wastebeds) was significantly elevated (a factor of 7.6) above the concentration in upper Ninemile Creek (at Amboy Dam) (Effler and Whitehead, 1996) indicates that significant amounts of ammonia were disposed of in the wastebeds, which have been a source of ammonia to Geddes Brook and Ninemile Creek. This is consistent with the statement in PTI (1992) that ammonia waste was sent to the Solvay Wastebeds.

4.2.1 Description of the Solvay Process and Waste

The Solvay Process was a synthetic means for producing sodium carbonate (soda ash) from brine (sodium chloride in water), carbon dioxide, and ammonia. Brine was obtained locally (in Tully about 20 miles away) by the solution recovery of rock salt, and carbon dioxide was produced on site by burning limestone with coal. Waste was produced in the brine purification and ammonia reclamation processes and sent to the wastebeds from the Calcium Chloride Plant's waste pumping station at the Main Plant site. Wastes were generated by the following plants: Soda Ash, Soda Ash Process Brine Purification, Ammonia Chloride, Sodium Bicarbonate, Power, Bridge Street Chlorine, Calcium Chloride, Sodium Nitrite, Lime Kiln, Potassium Carbonate, and Willis Avenue (BBL, 1999; PTI, 1992).

Typical Solvay Process wastes sent to the wastebeds were 60 to 70 percent water and contained, on a dry-weight basis (BBL, 1999):

- Calcium carbonate – 50 percent.
- Calcium chloride – 11 percent.
- Calcium hydroxide – 11 percent.
- Sodium chloride – 9 percent.
- Silica – 5.5 percent.
- Magnesium oxide – 4 percent.
- Calcium sulfate – 2.5 percent.
- Aluminum and iron oxides – 2.5 percent.

The wastes piped to the wastebeds may also have contained ammonia, aluminum, arsenic, barium, cadmium, chromium, chlorobenzene, copper, lead, mercury, nickel, and zinc. In addition, chlor-alkali wastes containing mercury, lead, and asbestos were occasionally discharged to Wastebeds 12 to 15 (BBL, 1999a; PTI, 1992).

So as to best classify the contaminant type and means of transport, the Solvay Wastebeds are grouped into four different areas: Wastebeds A to M, 1 to 8, 9 to 11, and 12 to 15. In total, these wastebeds cover an area of approximately 3.1 sq mi (8.1 sq km) (2,000 acres) (Effler and Harnett, 1996). However, Wastebeds A to M are not located in the Geddes Brook/Ninemile Creek watershed, and do not appear to be potential sources of CPOIs to the Geddes Brook/Ninemile Creek site. Accordingly, they are not discussed further in this report.

4.2.2 History of the Solvay Wastebeds

The history of the Solvay Wastebeds is described in Blasland & Bouck (1989), BBL (1999), and PTI (1991, 1992) and is summarized here, with the exception of Wastebeds A to M, which are located near the south end of Onondaga Lake and were used prior to Wastebeds 1 to 15. Honeywell began operations at the Syracuse Works (Main Plant) in 1881 and continued using the Solvay Process and generated Solvay waste and other wastes until the Main Plant closed in 1986 (Blasland & Bouck, 1989). Figure 4-1 shows the location of Wastebeds 1 to 15.

4.2.2.1 Wastebeds 1 to 8

Wastebeds 1 to 8, occupying approximately 315 acres of the former Geddes Marsh on the southwest side of Onondaga Lake, were used for Solvay Process waste disposal from 1926 until 1944. Wastebeds 1 to 4 were in use by 1926, prior to the use of Wastebeds 5 and 6. Honeywell constructed Wastebeds 5 and 6 following diversion of Ninemile Creek to the north of Wastebed 6. Disposal in

Wastebeds 7 and 8, southwest of Wastebeds 1 to 6, did not begin until after 1939 and continued until 1944.

Disposal of Solvay Process waste into Wastebeds 1 to 8 was discontinued after a containment dike failed in 1944. Wastebeds 1 to 8 contain an estimated 19.4 million cubic meters (m^3) of material (Blasland & Bouck, 1989). Sampling of the groundwater and seeps at Wastebeds 1 to 8 indicated high concentrations of BTEX (up to 15,700 µg/L), PAHs (up to 3,600 µg/L total PAHs), and phenols (up to 3,200 µg/L) (TAMS, 1995). Elevated concentrations of mercury were also detected in groundwater (up to 2,400 ng/L). However, these samples also contained high turbidity values, making the significance of these mercury results unclear. Wastebeds 1 through 5 show evidence of active erosion directly into Onondaga Lake. Wastebeds 1 to 8 are to be further investigated.

4.2.2.2 Wastebeds 9 to 11

Honeywell again diverted Ninemile Creek in 1944 for the construction of Wastebeds 9 to 11, and the remaining abandoned creek bed was filled with natural materials. Waste disposal in Wastebeds 9 to 11 began in 1944 and continued until 1968, and included the disposal of brine purification sediments and boiler water purification wastes, as well as Solvay Process waste. Wastebeds 9 to 11 occupy approximately 126 acres, and contain an estimated 6.3 million m^3 of waste material (Blasland & Bouck, 1989). Sampling of surface water at seeps adjacent to these wastebeds detected phenol and 1,4-dichlorobenzene (BBL, 1999).

4.2.2.3 Wastebeds 12 to 15

Waste disposal in Wastebeds 12 to 15 began in the 1950s and continued until 1986. The location of Wastebed 13 was originally the Syracuse Municipal Airport. In addition to Solvay Process waste, Wastebeds 12 to 15 received brine purification sediments, treated mercury cell wastes, boiler water purification wastes, and boiler bottom and fly ash. During 1986, the Onondaga County Department of Drainage and Sanitation (OCDDS) disposed of liquid sludge (3 to 5 percent solids) and dewatered sludge from the Syracuse Metropolitan Sewage Treatment Plant (Metro) in Wastebeds 15 and 12, respectively. Between 1981 and 1986, Metro used wastebed overflow as a chemical reagent for phosphorus precipitation. Honeywell's Wastebeds 12 to 15 occupy approximately 536 acres and contain an estimated 37 million m^3 of waste material (Blasland & Bouck, 1989). Chlorinated benzenes were found in the area of Wastebed 15 (BBL, 1999). Surface water runoff and groundwater seepage from Wastebeds 12 to 15 have historically been collected in part by a drainage ditch (referred to as the "unnamed tributary"), which runs along the base of Wastebeds 12, 13, and 14, and then discharges into Geddes Brook downstream of the West Flume. Sampling conducted by USEPA in 1972 showed that the wastebed overflow contained 14,500 to 54,500 ng/L of total mercury, indicating a load of 0.97 lbs/day (439 g/day) (USEPA, 1973).

4.2.3 Summary of Chemical Parameter of Interest Migration from the Solvay Wastebeds

The three wastebed groups discussed in the previous sections are addressed in terms of known contaminant types and means of transport to Geddes Brook and Ninemile Creek, as follows:

- **Wastebeds 1 to 8** contain groundwater contaminated with BTEX, PAHs, phenols, and mercury and other metals, as well as ionic waste constituents. Because of the proximity of these wastebeds to Onondaga Lake, these contaminants enter the lake directly from groundwater and surface water. Some contaminated groundwater and surface water also discharges to lower Ninemile Creek.

- **Wastebeds 9 to 11** are sources of various contaminants, including ionic waste constituents (e.g., calcium, sodium, and chloride ions), metals, phenol, and dichlorobenzene. Contaminants in groundwater from these wastebeds discharge to Ninemile Creek.

- **Wastebeds 12 to 15** are sources of various contaminants, including ionic waste constituents (e.g., calcium, sodium, and chloride ions), metals, and chlorobenzene. Contaminants in groundwater from these wastebeds discharge to Ninemile Creek. Surface water concentrations of the ionic waste constituents and total dissolved solids (TDS) in the unnamed tributary from Wastebeds 12 to 15 are the highest observed in the Geddes Brook/Ninemile Creek system. Surface water concentrations of these contaminants in Geddes Brook downstream of the unnamed tributary are higher than at upstream stations. Chlorobenzene was also detected in the unnamed tributary (at concentrations between 4.8 and 5.5 μg/L), although downstream concentrations in Geddes Brook remained below the detection limit (10 μg/L).

Overall, the wastebed areas are readily identified as an ongoing source of ionic waste constituents to Geddes Brook and Ninemile Creek. In addition, some of the wastebeds are potential ongoing sources of organic constituents, as well as mercury, to Geddes Brook and Ninemile Creek. Some of these contaminants were placed in the wastebed areas as part of the original Solvay waste disposal operations, while others may be the result of waste disposal subsequent to the placement of Solvay waste. Due to the extensive volume of waste material (over 90 million m^3) in Wastebeds 1 to 15 (Blasland & Bouck, 1989), it is anticipated that the load or discharge of contaminants to Ninemile Creek will continue into the foreseeable future. The sheer volume of the wastebeds is sufficient for them to be a substantial source of ionic waste constituents to Geddes Brook and Ninemile Creek.

4.3 Mathews Avenue Landfill Site

Honeywell's Mathews Avenue Landfill site is bordered by Geddes Brook to the west and the Old Erie Canal to the north (see Figure 4-1 and Chapter 1, Figure 1-2). The currently inactive Mathews Avenue Landfill was operated by Honeywell as a 6 NYCRR Part 360 construction and demolition

(C&D) debris disposal site and may have received debris from the LCP Bridge Street site (Montgomery Watson Harza [MWH], 2002). Honeywell applied for closure of the landfill in 1988 under Part 360, and environmental sampling was performed by Honeywell at the landfill (MWH, 2002). Honeywell entered into an Order on Consent with NYSDEC (NYS index # D07-0007-01-01) in September 2002 for implementation of a PSA and, if warranted, an RI/FS.

The objective of the Mathews Avenue Landfill PSA is to investigate the site for the presence of industrial contaminants through the review of historical documents and the analysis of environmental samples (MWH, 2002). The results will be used to determine if an RI/FS is warranted. Samples were collected from soil borings, groundwater monitoring wells, and test pits on and adjacent to the landfill. Groundwater monitoring wells were installed and sampled both upgradient and downgradient of the landfill. Surface water and sediment samples were collected from drainage/wetland areas near the landfill, the Old Erie Canal, and Geddes Brook both upstream and downstream of the landfill. The data collected from this investigation and the results of Honeywell's PSA were not available in time for inclusion in this RI report.

4.4 Non-Honeywell Sites

While Honeywell sites have been the primary contributors of contaminants to Geddes Brook and Ninemile Creek, there are other potential sources in the watershed that may have impacted Geddes Brook and Ninemile Creek and the areas of the site covered by this RI. In addition to runoff from developed areas in the Geddes Brook/Ninemile Creek watershed, industrial wastes have been disposed of in numerous areas near these tributaries.

While this RI emphasizes Honeywell sites and contaminants to Geddes Brook and Ninemile Creek, there are other sites in the Geddes Brook/Ninemile Creek watershed whose location and activities help to interpret the contaminant distributions described in Chapter 5, based on data collected by Honeywell. As shown in Figure 4-1, areas near the lower reaches of Geddes Brook and Ninemile Creek have been used for the disposal of industrial and solid wastes, including an area downstream of the West Flume (State Fair Landfill), and an area upstream of the West Flume near Honeywell's inactive Mathews Avenue Landfill (Village of Solvay Landfill, Pass & Seymour landfill, Frazer & Jones landfill, and Stanton Foundry landfill).

4.4.1 State Fair Landfill

The State Fair Landfill (NYSDEC Site No. 734033) is located near State Fair Boulevard, in the Town of Geddes, just east of Geddes Brook and Ninemile Creek (Figure 4-1). The site is situated in an area where surface water and groundwater discharges from the site could adversely affect the downgradient Wetland SYW-18 and Geddes Brook.

During operation, the landfill reportedly had a history of violations, according to NYSDEC Refuse Disposal Area Inspection Reports from 1973 to 1978. Violations include dumping waste into water, leaching into a water course, burning of waste, and unsatisfactory cover (URS Consultants, Inc., 1991). Based on this information, the State Fair Landfill was placed on the New York State Inactive Hazardous Waste Disposal Site Registry. After further investigation, NYSDEC recommended in

October 1994 that this site be delisted from the registry on the basis that on-site sampling conducted in 1992 did not reveal the presence of hazardous constituents and that hazardous waste disposal could not be confirmed at the State Fair Landfill site (R. Marino, pers. comm., 1994). The New York State Department of Health (NYSDOH) concurred with the NYSDEC decision in a letter dated July 26, 1994 (A. Wakeman, pers. comm., 1994).

4.4.2 Village of Solvay Landfill

The Village of Solvay Landfill is located approximately 1,000 ft (300 m) east of Geddes Brook and south of the West Flume (Figure 4-1). Information on this site was obtained from the Village of Solvay's Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) 104(e) responses and supplemental information. The Village of Solvay Landfill operated as a solid waste disposal facility from the early 1950s up until late 1991. Wastes disposed of at the landfill include household waste, C&D debris, and yard waste. These wastes were not segregated by type during disposal.

A small stream flowing in a northwesterly direction toward Geddes Brook is directly adjacent to the landfill, along its eastern border. Portions of the landfill's waste are exposed along this boundary. In addition, the landfill is situated in an area that was formerly a freshwater wetland. The high water table and saturated soil conditions typically associated with wetlands indicate that groundwater transport of potential landfill contamination is a possible path of release to Geddes Brook. A Closure Investigation Report (CIR) (C&S Engineers, 1995) indicated that low levels of inorganic parameters (sodium, ammonia, sulfate, cadmium, iron, bromide, magnesium, and manganese) and one volatile organic compound (VOC), 1,1-dichloroethene, were detected in samples of groundwater, surface water, or leachate collected during the closure investigation. Sampling being conducted by Honeywell at the adjacent Mathews Avenue Landfill site may provide additional information on the potential impact of the Village of Solvay Landfill on the surrounding area and Geddes Brook.

4.4.3 Pass & Seymour

Pass & Seymour is located approximately 2,500 ft (760 m) east of Geddes Brook (Figure 4-1) in an area where surface water and groundwater discharges from the site could impact Geddes Brook. Information on this site was obtained from Pass & Seymour's CERCLA 104(e) responses and supplemental information.

Pass & Seymour operated an on-site landfill between 1980 and 1994. It is estimated that 2,000 lbs/week of scrap porcelain from molds used for the manufacture of porcelain fixtures were disposed of in the on-site landfill.

A sediment sample collected by NYSDEC in a ditch near the Pass & Seymour site indicates that select metals in surface sediment exceed NYSDEC screening criteria (cadmium, copper, lead, mercury, silver, and zinc). Sampling being conducted by Honeywell at the adjacent Mathews Avenue Landfill site may provide additional information on the potential impact of the Pass & Seymour landfill on the surrounding area and Geddes Brook.

4.4.4 Frazer & Jones

The Frazer & Jones facility is located approximately 1,000 ft (300 m) east of Geddes Brook (Figure 4-1). Information on this site was obtained from Frazer & Jones' CERCLA 104(e) responses and supplemental information. The Frazer & Jones on-site landfill operated as a disposal facility from 1915 to 1988. Wastes disposed at the landfill include spent core sands, iron shot blast, and scrubber dust.

Similar to the Village of Solvay Landfill, the Frazer & Jones landfill is situated in the area that was formerly a freshwater wetland. The high water table and saturated soil conditions typically associated with wetlands indicate that groundwater transport of landfill contamination is a potential path of release to Geddes Brook.

As noted in the 1986 NYSDEC Phase I Report, "the main concern regarding this site is the potential environmental hazard of surface water, groundwater and soil contamination due to migration of phenolic compounds from the landfilled spent foundry sand ... and no methods of containment or diversion" were used during disposal (NYSDEC, 1986). High levels of chromium were detected in the foundry slag waste and the pickling liquor waste (sulfuric sludge). Frazer & Jones confirmed that the slag waste, which they considered non-hazardous based on extraction procedure toxicity testing in 1989, was disposed of in the on-site landfill prior to 1988. Spent pickling liquor or sulfuric sludge (considered hazardous due to chromium toxicity and pH) was legally disposed of at off-site hazardous waste facilities from 1983 to 1989, after which time this waste was no longer generated. It was indicated in the NYSDEC Phase I Report that, since no records were found for the period prior to 1983, the hazardous spent pickling liquor was likely disposed of in the on-site landfill prior to 1983. Based on environmental sampling performed at the site, NYSDEC delisted the site in 1991 from the New York State Registry of Inactive Hazardous Waste Disposal Sites.

4.4.5 Stanton Foundry

The Stanton Foundry facility and landfill is located between Geddes Brook and the Frazer & Jones site (Figure 4-1). Information on this site was obtained from Stanton Foundry's CERCLA 104(e) responses and supplemental information.

Waste sand was the primary waste generated by foundry operations that included the manufacture of gray iron castings, along with a relatively small amount of iron and limestone slag wastes. Stanton Foundry indicated that this waste sand was a non-hazardous, industrial waste. Approximately 50 tons of waste sand were generated weekly and disposed of in the on-site landfill on the Stanton Foundry property adjacent to Geddes Brook. A total of approximately 120,000 tons of waste sand was disposed of in the on-site landfill by the Stanton Foundry and its predecessor between 1941 and 1988. Surface water and groundwater discharges from the site could impact the downgradient wetlands and Geddes Brook.

4.5 Honeywell's Potential Sources of Chemical Parameters of Interest Outside of the Geddes Brook/Ninemile Creek Watershed

Honeywell's Main Plant and Willis Avenue sites (two of the three facilities that comprised the Syracuse Works) are not located in the Geddes Brook/Ninemile Creek watershed. Thus, these sites are not likely to be current sources of CPOIs to the Geddes Brook/Ninemile Creek site. However, wastes from these facilities (PTI, 1992) were transported to disposal areas (i.e., the Solvay Wastebeds) within the Geddes Brook/Ninemile Creek watershed, including Solvay waste from the Main Plant that was placed in Wastebeds 1 to 15. The presence of other compounds such as benzene, chlorobenzene, phenols, etc. in the wastebeds suggests that other wastes mixed with Solvay wastes were also placed in the wastebeds.

Furthermore, wastewater and cooling water were discharged from the Main Plant to the West Flume, which discharges to Geddes Brook. The West Flume was designated as Discharge 002 under the New York State Pollutant Discharge Elimination System (SPDES) permit. Prior to the closure of the Honeywell Syracuse Works, discharges from the Main Plant to the West Flume averaged 36 cubic feet per second (cfs) (1.04 cubic meters per second [m^3/s]) (USEPA, 1973). Because the Main and Willis Avenue Plants were, or could have been, sources of CPOIs to the Geddes Brook/Ninemile Creek site via waste disposal to Wastebeds 1 to 15 and/or wastewater discharges to the West Flume, the plants and their associated CPOIs are discussed below. Additional information on these sites and adjacent Honeywell disposal sites (Semet Residue Ponds, Willis Avenue Ballfield, and Wastebed B/Harbor Brook) can be found in the Onondaga Lake RI (TAMS, 2002c). Figure 4-1 provides the locations of these sites.

4.5.1 Willis Avenue Site

The Willis Avenue site is a former chlor-alkali and chlorinated benzenes plant with a long history of operation, and is one of two major sources of mercury, as well as a major source of chlorinated compounds, to Onondaga Lake. (The other major source of mercury to the lake is the LCP Bridge Street site.)

The chlor-alkali plant operated from 1918 until 1977, producing chlorine and other chemicals. The plant utilized both diaphragm and mercury cells for chlorine production. The 102 mercury cells originally part of this operation were designed in the 1930s and started with sodium chloride brine. In 1947 and 1948, the plant was redeveloped and a new process was installed. The number of mercury cells was reduced to 59, and the plant converted to potassium chloride brine (O'Brien & Gere, 1990). Chlorinated benzenes were produced at the facility from 1918 to 1977. The area is the subject of an RI being carried out by O'Brien and Gere for Honeywell that began in 1991 and is still ongoing.

The following discussion of CPOI transport from the Willis Avenue site has been derived primarily from the draft Willis Avenue site RI report (O'Brien & Gere, 2002c), which is under review by NYSDEC. More detailed information on the history and potential CPOI loads associated with the Willis Avenue facilities is included in the Onondaga Lake Site History Report (PTI, 1992), the

History of the Willis Avenue Plant Report (O'Brien & Gere, 1990), and the Onondaga Lake RI report (TAMS, 2002c).

The following discussion addresses the Willis Avenue Plant site – Lakeshore Area and areas associated with the former Willis Avenue Plant that are located near the site on Main Plant property (i.e.., the Petroleum Storage and Chlorobenzene Hot Spots areas).

Willis Avenue Plant Site – Lakeshore Area

The location of the Willis Avenue Plant site proper is at the corner of Willis Avenue and State Fair Boulevard, although former plant operations, such as the loading and unloading of material, also took place on the lakeshore. Other operations associated with the Willis Avenue Plant site, such as distillation of coal and oil to produce benzene, took place at the Main Plant site. Wastes were disposed of in Wastebeds 12 to 15 (PTI, 1992) and possibly were released to the West Flume.

The CPOIs in soil and groundwater at the Willis Avenue site include chlorinated benzenes, BTEX, mercury, PAHs, PCBs, and PCDD/PCDF. Most of the observed contamination is consistent with previous industrial activities, which included production of chlorinated benzene products in the plant area; storage and fractionation of petroleum to produce benzene, toluene, ethylbenzene, and naphthalene in the Petroleum Storage Area; and production of chlorine in mercury and diaphragm cells (O'Brien & Gere, 2002c).

Mercury is found in groundwater wells (WA-1, WA-2, WA-3) along the lakeshore at concentrations as high as 8,900 ng/L. However, the I-690 storm drains that inadvertently collected groundwater near the lakeshore downgradient of the Willis Avenue site contained mercury at concentrations that averaged approximately 15,000 ng/L and ran as high as 20,000 ng/L.

DNAPL containing chlorinated benzenes is found at the shore of Onondaga Lake in the intermediate groundwater aquifer immediately adjacent to the concrete causeway previously used by Honeywell for loading and unloading materials. DNAPL is being pumped from recovery wells for disposal (O'Brien & Gere, 2002d). Chlorobenzene (mono) was evident in groundwater samples collected from in-lake piezometers and monitoring wells in October 1992, with the highest concentrations of chlorobenzene in the fill zone at 25,000 μg/L. In groundwater sampling events during the Willis Avenue RI (O'Brien & Gere, 2002c), higher concentrations of chlorobenzene at 87,000 μg/L, 1,4-dichlorobenzene at 72,000 μg/L, benzene at 55,000 μg/L, and toluene at 80,000 μg/L were detected in the lakeshore area in wells screened in the marl, where the DNAPL is typically found.

4.5.2 Main Plant

The Honeywell Main Plant was located south of the Willis Avenue Plant and Tributary 5A. The major products of this facility included soda ash produced by the Solvay Process and related products, although numerous other processes also took place here (PTI, 1992). The Honeywell Main Plant was the source of the Solvay waste found in numerous locations in the area, including the wastebeds within the Geddes Brook/Ninemile Creek system. Also, some of the wastes from the Main Plant were discharged to the West Flume, a tributary to Geddes Brook.

The Petroleum Storage Area and Chlorobenzene Hot Spot Area are locations on the Main Plant site (see Figure 4-1) that are being addressed as part of the Willis Avenue Plant RI/FS. The Petroleum Storage Area, located southwest of the former Willis Avenue Plant on the northern edge of the former Main Plant near Tributary 5A, operated from 1915 to 1970, fractionally distilling coke light oil to produce benzene, toluene, xylenes, and naphthalene. Benzene produced at this site was pumped to the Willis Avenue Plant area for use in the manufacture of chlorinated benzene products. The facility was demolished in 1973. Most recently, No. 2 fuel oil was stored in the Petroleum Storage Area. The storage tanks were dismantled during closure of the Honeywell facility, and subsequent investigations found no evidence of No. 2 fuel oil in groundwater in the area. However, BTEX and naphthalene were detected in the groundwater at elevated levels.

The Chlorobenzene Hot Spot Area is a location on the former Main Plant site where a pipeline that had carried chlorobenzene residual wastes to the Main Plant grounds had leaked. Benzene and chlorobenzene have been detected in monitoring wells in this area (O'Brien & Gere, 2002c).

NYSDEC is evaluating the data available for the former Main Plant to determine what, if any, future activities are appropriate.

4.6 Summary

The Geddes Brook/Ninemile Creek site has been affected by direct and indirect releases from industrial plant and documented disposal sites. Discharges from the Honeywell LCP Bridge Street site to the West Flume and Wastebeds 12 to 15 (and potentially Wastebeds 9 to 11), and subsequently into Geddes Brook and Ninemile Creek, have contributed the greatest amount of mercury and other hazardous substances. The wastes from the Main Plant site, and possibly the Willis Avenue site, also entered the Geddes Brook/Ninemile Creek site through discharges into the West Flume and through discharges, seeps, and groundwater from Wastebeds 1 to 15. Wastes originating from the Honeywell plants may have also entered the Geddes Brook/Ninemile Creek site from the Mathews Avenue Landfill site.

CPOIs potentially being transported to the Geddes Brook/Ninemile Creek site from the Honeywell sites include, among others, mercury and other metals, BTEX compounds, chlorinated benzenes, naphthalene and other PAHs, PCBs, and ionic waste constituents.

Honeywell sites have contributed contaminants to Geddes Brook and Ninemile Creek. There are other potential sources in the watershed from which contaminants may have also reached Geddes Brook and Ninemile Creek. In addition to runoff from developed areas in the Geddes Brook and Ninemile Creek basins, industrial and solid wastes have been disposed of near Geddes Brook, including the following:

- An area near Geddes Brook, downstream of the West Flume (State Fair Landfill).

- An area near Geddes Brook, upstream of the West Flume near Honeywell's inactive Mathews Avenue Landfill (Village of Solvay Landfill, Pass & Seymour landfill, Frazer & Jones landfill, and Stanton Foundry landfill).

More quantitative discussion of fluxes to the Geddes Brook/Ninemile Creek site can be found in Chapter 6 of this RI report.

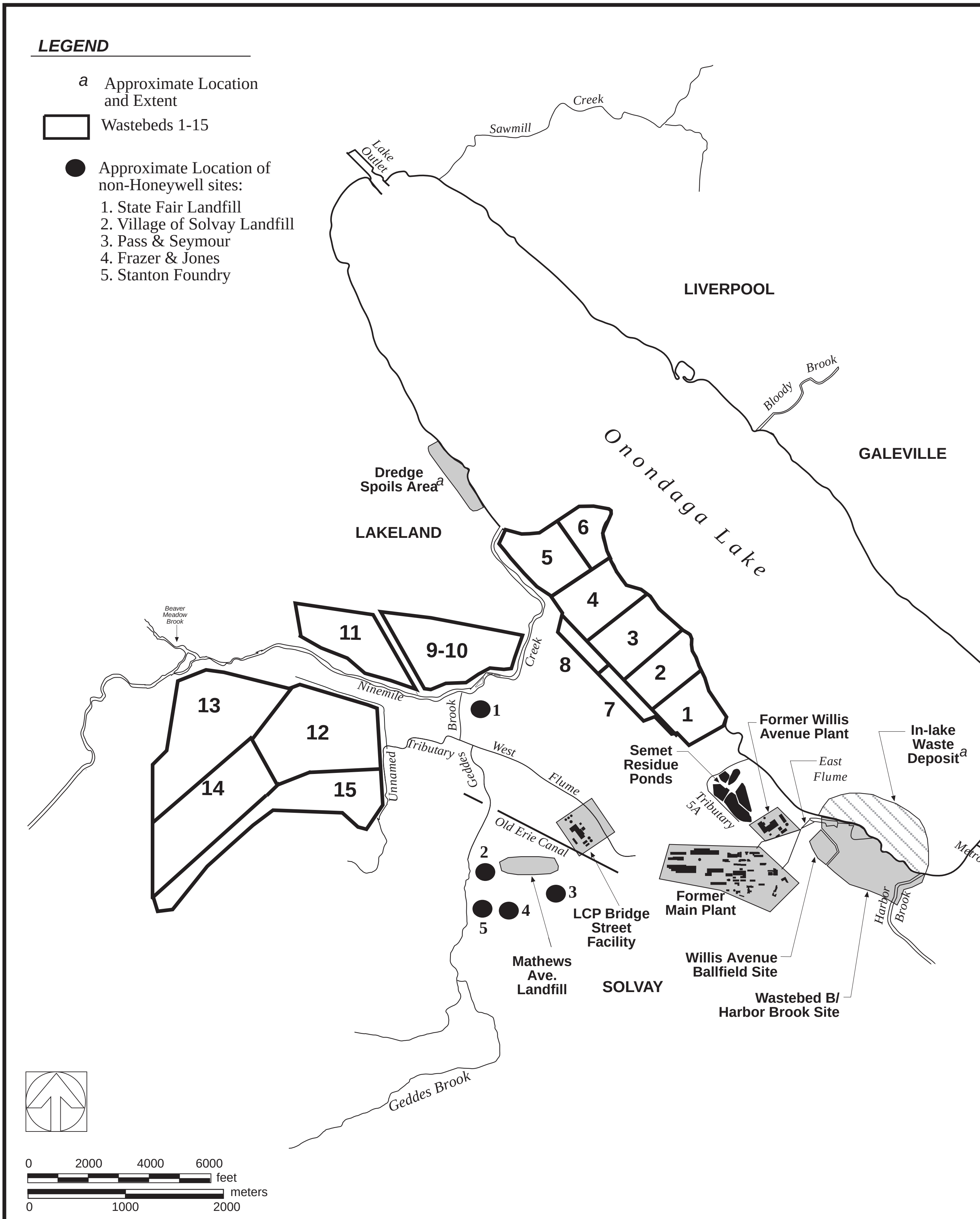


Figure 4-1. Location of Honeywell and Other Referenced Sites Near Geddes Brook/Ninemile Creek

5. NATURE AND EXTENT OF CONTAMINATION

This chapter presents and interprets the results of investigations designed to identify the nature and extent of contamination within the Geddes Brook/Ninemile Creek site. Those investigations include the assessment of contaminant distribution in sediment; floodplain areas, which include island soil, wetland sediment, and non-wetland soil; surface water; and fish tissue.

The distribution of the classes of chemical parameters of interest (CPOIs) at the site is also addressed in this chapter. The CPOIs were identified in Section 1.4 of Chapter 1, Introduction, as those elements or compounds selected as:

- Contaminants of potential concern (COPCs; see Chapter 1, Table 1-1) in the Geddes Brook/Ninemile Creek Human Health Risk Assessment (HHRA) (TAMS, 2003b).

- Contaminants of concern and stressors of concern (COC/SOCs) (see Chapter 1, Table 1-1) in the Geddes Brook/Ninemile Creek Baseline Ecological Risk Assessment (BERA) (TAMS, 2003a).

CPOIs identified at the Geddes Brook/Ninemile Creek site include the following:

- Mercury and other metals.
- Volatile organic compounds (VOCs).
- Semivolatile organic compounds (SVOCs).
- Pesticides.
- Polychlorinated biphenyls (PCBs).
- Polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs).
- Ionic waste constituents.

The data discussed in this chapter are primarily derived from the results of the four major RI/FS field and laboratory investigations conducted by Honeywell and NYSDEC, including:

- Geddes Brook/Ninemile Creek RI/FS Phase 1 sampling conducted by Exponent for Honeywell in 1998.

- Geddes Brook/Ninemile Creek supplemental RI/interim remedial measure (IRM) sampling conducted by Blasland, Bouck & Lee (BBL) for Honeywell in 2001.

- Ninemile Creek supplemental RI floodplain sampling conducted by O'Brien & Gere for Honeywell in 2002.

- Ninemile Creek supplemental young-of-year (YOY) fish sampling conducted by NYSDEC and TAMS in 2002.

Additional wetland sample data collected by Honeywell from Wetland SYW-10 at the mouth of Ninemile Creek during the 2000 Onondaga Lake Phase 2 RI are also presented. Details of these RI/FS investigations are discussed in Chapter 2, Field and Laboratory Investigations, and the data are presented in Appendices A (Analytical Data Collected by Honeywell/Exponent [1998]), E (Analytical Data Collected by Honeywell/Exponent/BBL [2000/2001]), and G (Ninemile Creek Supplemental RI Floodplain Soil and Fish Sampling [2002] – Analytical Data and Validation Reports). The locations of the 1998, 2000, 2001, and 2002 RI/FS sampling stations are presented in Figures 2-1 and 2-2 of Chapter 2.

Where appropriate, data from other relevant investigations are also presented in this chapter, with more detailed discussion provided in Sections 2.13 and 2.14 of Chapter 2. The sampling locations of these other relevant investigations are presented in Figure 2-3 of Chapter 2.

In addition to describing the nature and extent of contamination, an objective of this chapter is to present patterns of contaminant distribution relevant to the discussion of contaminant transport and fate in Chapter 6, Transport and Fate of Chemical Parameters of Interest. To this end, statistical summaries of the RI data and screening of these data against appropriate standards, criteria, and guidance values are presented in Appendices I (Summary Statistics Tables of Chemical Parameters of Interest) and J (Sediment, Soil, and Surface Water Screening Tables), respectively. Statistical summaries of the data are grouped by medium, analyte, depth interval (for sediment and soil samples), and by area in the site (i.e., upper and lower Geddes Brook and upper and lower Ninemile Creek). Upper and lower Geddes Brook refer to stations above and below the West Flume confluence, respectively, while upper and lower Ninemile Creek refer to stations above and below the Geddes Brook confluence (with the exception of 2001 sediment Transect TN-16, which is considered part of lower Ninemile Creek [T. Larson, pers. comm., 2001a]).

Sediment data from Geddes Brook, Ninemile Creek, and the wetlands were screened against NYSDEC risk-based sediment screening criteria, which include lowest effect level (LEL) and severe effect level (SEL) screening criteria for metal CPOIs, and the human health bioaccumulation (HHB), wildlife bioaccumulation (WB), acute toxicities for benthic aquatic life (ATBAL), and chronic toxicities for benthic aquatic life (CTBAL) screening criteria for organic CPOIs (NYSDEC, 1999). Non-wetland floodplain soil data were screened against NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4046 (NYSDEC, 2003) recommended soil cleanup objectives. In addition to what is presented in this RI, the BERA (TAMS, 2003a) addresses chemical interactions, such as acid volatile sulfides, as well as potential synergistic or antagonistic effects that multiple CPOIs may have on each other.

5.1 Data Quality Assessment

Over 75,000 data points were collected during the four major RI sampling programs from 1998 to 2002. The chemical analysis data were reported as acceptable by the laboratories, with the exception of a limited number of results that were rejected during the quality assurance (QA) review process. The overall data set was considered adequate to support the analyses performed in and the objectives of this RI. Quality assurance reports are provided for the following:

- Exponent data collected for Honeywell in 1998 (Appendices B [Quality Assurance Review Summaries for Analytical Data {1998}], C [Sediment Toxicity Test Data and Quality Assurance Review Summary {1998}], and D [Benthic Macroinvertebrate Survey Data and Quality Assurance Review Summary {1998}] of this RI).

- BBL data collected for Honeywell in 2001 (Appendix F [Quality Assurance Review Summaries for Analytical Data {2001}] of this RI).

- O'Brien & Gere data collected for Honeywell in 2002 (Appendix G1 [Ninemile Creek Floodplain Soils Data and Validation Report {2002}] of this RI).

- NYSDEC/TAMS data collected in 2002 (Appendix G2 [Young-of-Year Fish Sampling Data and Validation Report {2002}] of this RI).

The QA report for the 2000 Wetland SYW-10 data presented in Appendix E of this RI is included in the Onondaga Lake RI as Appendix B2 (TAMS, 2002c). Data used in this RI from other sources (see Chapter 2, Table 2-1 and Appendix L [Summary of Data Collected Independently of the Geddes Brook/Ninemile Creek RI]) were not all subjected to additional data quality review by Honeywell and/or NYSDEC.

5.2 Sediment Characterization

This section summarizes the measured occurrence of CPOIs in Geddes Brook and Ninemile Creek sediment, including inorganic and organic compounds and conventional parameters of interest (e.g., calcium carbonate, grain size, and total organic carbon [TOC]). Sediment samples were collected in 1998 by Exponent and in 2001 by BBL, as discussed below.

For the 1998 Geddes Brook/Ninemile Creek RI, Exponent collected sediment samples in July at six Geddes Brook locations (Stations GB1, GB2, GB3, GB6, GB7, and GB8) and ten Ninemile Creek locations (Stations NM1 through NM10) (Chapter 2, Figure 2-1). A surface interval (approximately 0 to 0.15 meters [m]) was sampled at each station. Deeper intervals (0.15 to 0.45, 0.45 to 0.75, and 0.75 to 1.05 m) were also sampled at many of the locations. Samples were analyzed for Target Analyte List (TAL) metals plus methylmercury, VOCs, SVOCs, pesticides, PCBs, PCDD/PCDFs, chloride, TOC, percent solids, and grain-size distribution.

For the supplemental RI in 2001, BBL collected sediment samples from February through April from 18 transects in Ninemile Creek (Transects TN-1 through TN-18), five transects in Geddes Brook (Transects TG-1 through TG-5), two discrete locations in Geddes Brook (Stations GBCulvt and MN-3), and four discrete locations in Ninemile Creek (Stations CN-1, CN-2, MN-1, and MN-2) (see Chapter 2, Figure 2-2). In most cores, the following depth intervals were analyzed: 0 to 0.15, 0.15 to 0.45, 0.45 to 0.75, and 0.75 to 1.05 m. Deeper intervals (below 1 m) were analyzed in select cores, according to the sampling plan (BBL, 2001), while some cores were only analyzed in the top 1 m because of difficulty penetrating the sediment.

Each transect generally consisted of three sediment cores. In three of the sediment transects that cross islands in Ninemile Creek (i.e., Transects TN-11, TN-13, and TN-14), the middle cores of the transects were collected on the islands and are considered island soil samples (i.e., Stations TN-11-2, TN-13-2, and TN-14-2). The island soil samples are discussed in Section 5.3, along with the floodplain soil samples and wetland sediment samples. All sediment samples were analyzed for mercury and TOC. A subset of samples was analyzed for methylmercury, while a separate subset was analyzed for TAL metals plus cyanide, VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), and PCDD/PCDFs.

Sediment contaminant maps (Figures 5-1 through 5-14) and plots of concentration profiles (Appendix K [Sediment and Soil Contaminant Profiles]) depict the distribution and extent of sediment contamination within the Geddes Brook/Ninemile Creek site for significant CPOIs. Table 5-1 presents the means and ranges of concentrations of various metals in the sediments of the major reaches of Geddes Brook and Ninemile Creek. Further discussion comparing upstream and downstream concentrations is provided in Chapter 6. Summary statistics, which combine 1998 and 2001 sediment data, of contaminant concentrations in Geddes Brook and Ninemile Creek sediment are presented in Appendix I. In addition, Geddes Brook and Ninemile Creek sediment data (from both 1998 and 2001) were screened against NYSDEC's Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999). These screening criteria included two criteria for metals (i.e., LEL and SEL) and four TOC-normalized criteria for organic compounds (i.e., human health bioaccumulation, acute toxicity for benthic aquatic life, chronic toxicity for benthic aquatic life, and wildlife bioaccumulation). The screening results are presented in Appendix J.

Development of Sediment Contaminant Distribution Maps

Sediment contaminant distribution maps (Figures 5-1 through 5-14), which include both the 1998 and 2001 sediment data, are presented for CPOIs that were frequently detected in the Geddes Brook/Ninemile Creek site and for which there were several exceedances of sediment screening criteria. The contaminant maps present sediment concentration patterns from the surface sediments down to the 1.05 m depth for the following depth intervals: 0 to 0.15, 0.15 to 0.45, 0.45 to 0.75, and 0.75 to 1.05 m. In cases where a particular CPOI was detected at a deeper depth than the deepest interval mapped for that CPOI, the concentration value of the CPOI at the deeper interval is noted on the maps at the appropriate sampling stations. The maps for mercury, methylmercury, arsenic, and total polycyclic aromatic hydrocarbons (PAHs), for which there are sufficient data from deeper intervals, present sediment data from the surface to a depth of approximately 5 m. The approximate additional depth intervals for mercury, methylmercury, arsenic, and total PAHs are:

- **Mercury** – 1.05 to 1.65, 1.65 to 2.65, 2.65 to 3.65, and 3.65 to 4.65 m.
- **Methylmercury –** 1.05 to 1.5, 1.5 to 2, 2 to 3, and 3 to 4 m.
- **Arsenic** – 1.05 to 1.5, 1.5 to 2.5, 2.5 to 3.5, and 3.5 to 4.5 m.
- **Total PAHs** – 1.05 to 2, 2 to 3, 3 to 4, and 4 to 5 m.

The contaminant distribution maps were generated as point maps using ArcView™ software. Data points were presented at the sampling locations, and the points were colored depending on their CPOI concentration. Concentrations were binned (i.e., each range of concentrations is represented by a specific color) to reflect the NYSDEC risk-based sediment screening criteria to identify areas affected by various contaminants. For those NYSDEC sediment screening criteria expressed in terms of organic content, the criterion was converted to a dry-weight basis based on the average TOC (2.1 percent) measured in Geddes Brook and Ninemile Creek sediment samples. Because the TOC varies with location (0.05 to 13 percent), the organic CPOI maps must be interpreted with caution from a risk-based perspective. Specifically, the organic carbon-based criteria shown on the maps represent a general guide to those areas exceeding NYSDEC screening criteria. Chapter 8 of the BERA (TAMS, 2003a) presents maps showing the results of screening against the NYSDEC sediment criteria based on sample-specific TOC values.

5.2.1 Mercury

Mercury in surface sediment (0 to 0.15 m) exceeds the LEL screening criterion of 0.15 mg/kg and the SEL of 1.3 mg/kg throughout most of the Geddes Brook/Ninemile Creek site (Figures 5-1a and 5-2). Concentrations exceed 10 mg/kg (presented as a general frame of reference to aid in the interpretation of the figures and is approximately an order-of-magnitude greater than the SEL), at the following locations:

- Six locations in Reach CD in Ninemile Creek along Transects TN-10, TN-12, NM6, MN-2, TN-14, and TN-15 in the right channel section (facing downstream).

- One station in Reach AB of Ninemile Creek along Transect TN-1.

- One station in Geddes Brook along Transect TG-3, located downstream of the West Flume before Geddes Brook enters the culvert under the railroad tracks.

The average concentrations of mercury in surface sediments in upper and lower Geddes Brook were 0.18 and 2.62 mg/kg, respectively, and the average concentrations in upper and lower Ninemile Creek were 0.43 and 3.08 mg/kg, respectively (Appendix I). In Reach CD of lower Ninemile Creek, the average mercury concentration was 4.95 mg/kg. In Ninemile Creek just upstream of the Geddes Brook confluence (Transect TN-16), which is a depositional area and has likely been affected by discharges from Geddes Brook, the highest surface sediment concentration was 2 mg/kg at Station TN-16-3. Thus, this transect has been included within the lower Ninemile Creek data set in the risk assessments. Mercury in three surface sediment samples from just above Amboy Dam exceed 0.5 mg/kg, including Stations NM2 (0.83 mg/kg), TN-17-1 (0.86 mg/kg), and TN-18-1 (1.4 mg/kg).

Concentrations of mercury exceeding the LEL extend to a depth of at least 4 m (Figures 5-1b and 5-2). From 0.15 to 1 m, concentrations in Reach CD of Ninemile Creek near the large island and in lower Geddes Brook continue to exceed 10 mg/kg. Station TN-14-3 in Ninemile Creek contained the highest concentrations of mercury, ranging from 28.3 to 118 mg/kg, in this depth interval. From 1 to 1.65 m, three samples between Transects TN-9 and TN-15 (i.e, Stations TN-9-3, TN-13-3, TN-15-3) on the right side (facing downstream) of Ninemile Creek in the area of the islands and two samples in lower Geddes Brook exceed the SEL. Below 1.65 m there are fewer stations that were analyzed, but mercury concentrations in lower Ninemile Creek exceed the LEL and SEL in ten and three samples, respectively. The highest concentration (8.8 mg/kg) below 1.65 m in lower Ninemile Creek occurred in the depth interval from 3.4 to 4 m at Transect TN-8; however, the concentration (0.04 mg/kg) below this interval at this station was lower than the LEL. In Reaches AB and BC of lower Ninemile Creek, the mercury concentrations tend to be lower than in Reach CD, but still exceed the LEL and SEL occasionally down to 2.65 m.

Mercury concentrations in Ninemile Creek showed a distinct distribution pattern. For Transects TN-15 to TN-10 (within Reach CD), concentrations were elevated in cores located on the right side (facing downstream) of the island (average concentration of 12.72 mg/kg) versus the left side (average concentration of 0.26 mg/kg). The right hand channel is a relatively quiescent (i.e., depositional) region where water entering Ninemile Creek from Geddes Brook hugs the shoreline and does not readily mix across the entire Ninemile Creek cross section. The presence of islands in this reach also impedes complete mixing of the suspended solids discharged from Geddes Brook into Ninemile Creek, thus leading to higher deposition and concentrations of mercury, as well as other CPOIs, in this area. Downstream transects (within Reaches AB and BC, where islands are absent) do not show the same pattern.

Mercury was also analyzed in sediment near four manmade structures or debris areas (Stations MN-1 and MN-2 in Ninemile Creek and Stations GBCulvt and MN-3 in Geddes Brook) and at two discrete locations between the islands in Ninemile Creek (Stations CN-1 and CN-2), as follows:

- Station MN-1 was located along the west bank of Ninemile Creek in sediment built up by the bridge abutment for State Fair Boulevard and the US Geological Survey (USGS) gauge platform. Mercury concentrations at this station exceed the LEL in the top 1 m, with values of 1.0 mg/kg at the 0 to 0.15 m depth and 1.3 mg/kg at the 0.15 to 0.45 m depth.

- Station MN-2 was located on the east (right) side of the large island in Ninemile Creek, next to a downed tree. Mercury concentrations at this station were 18.1 mg/kg at 0 to 0.15 m, 54.9 mg/kg at 0.15 to 0.45 m, 1.7 mg/kg at 0.45 to 0.75 m, and 0.09 mg/kg at 0.75 to 1.03 m. These concentrations are similar to those found at Stations TN-13-3 and TN-14-3, which are situated to either side of Station MN-2.

- Station GBCulvt was located downstream of the Geddes Brook culvert, which runs under the railroad tracks behind the New York State Fairgrounds. The mercury concentration at this station was 0.86 mg/kg at the 0 to 0.18 m depth interval.

- Station MN-3 was located in Geddes Brook, just downstream of Station GBCulvt, in a backwater area created by water from the culvert. Mercury concentrations at this station were 1.0 mg/kg at 0 to 0.15 m and 1.3 mg/kg at 0.15 to 0.45 m.

- The two discrete sample stations associated with the three islands in Ninemile Creek were located near the downstream end of the largest island (Station CN-1) and near the downstream end of the second island (Station CN-2).

  - Mercury concentrations at Station CN-1 were 0.02 to 0.05 mg/kg for all three intervals, down to 0.75 m.

  - The surface interval (0 to 0.15 m) at Station CN-2 contained 0.8 mg/kg of mercury, while the 0.15 to 0.45 m interval contained 6.6 mg/kg (duplicate average of 6.3 and 6.8 mg/kg). Concentrations were 1.2 mg/kg at the depth interval of 0.45 to 0.75 m and less than 0.05 mg/kg in the next two deeper intervals, down to 0.75 m.

The mercury concentration data for surface sediment from 1998 and 2001 compare reasonably well to historical data. For the Phase II Investigation for Onondaga Lake (and its tributaries) in 1987 (NYSDEC, 1989), NYSDEC reported a mercury concentration of 13 mg/kg from sediment at the USGS gauging station in Ninemile Creek. Sediment collected from this same area as part of the NYSDEC Rotating Intensive Basin Study (RIBS) (NYSDEC, 1992) in 1989 and 1990 contained mercury at concentrations in sediment of 2 and 1 mg/kg, respectively. The closest 1998 and 2001 sampling stations to these historical locations are Station NM8, which had a mercury concentration in sediment of 1.15 mg/kg at 0 to 0.15 m in 1998, and Station TN-6-3, which had a mercury concentration in sediment of 2.9 mg/kg at 0 to 0.15 m in 2001. While the NYSDEC mercury concentration (13 mg/kg) is higher than other samples in this immediate area, comparable concentrations in surface sediment were found upstream and downstream at other 2001 sample locations within this same reach (e.g., in Transects TN-7 and TN-4).

For the lower end of Geddes Brook, subsequent to 1987, the surface sediment concentrations reported for mercury were much lower than the concentration of 21 mg/kg that was reported in lower Geddes Brook in the Phase II Investigation for Onondaga Lake in 1987 (NYSDEC, 1989). These data include 2.5 mg/kg (collected in lower Geddes Brook by CDR in 1990), 3.4 and 0.44 mg/kg (Stations GB7 and GB8, collected by Exponent in 1998), and 2.3 and 2.5 mg/kg (Stations TG-1-1 and TG-1-2, collected by BBL in 2001). Mercury concentrations in Ninemile Creek surface sediment upstream of Geddes Brook ranged from 0.46 to 1.6 mg/kg in 1990, less than 1.0 mg/kg in 1998, 0.05 to 0.23 mg/kg in 1999, and 0.04 to 2.0 mg/kg in 2001.

Patterns of methylmercury (Figures 5-3a and 5-3b) were similar to those of mercury, with concentrations higher in lower Geddes Brook than in upper Geddes Brook and higher in lower Ninemile Creek than in upper Ninemile Creek. Concentrations exceeding 2 µg/kg occurred in surface sediments (0 to 0.15 m) throughout the Geddes Brook/Ninemile Creek site. Concentrations of methylmercury in surface sediment ranged from 0.03 to 6.26 µg/kg, with the highest values occurring at Stations TN-7-3 (6.26 µg/kg), TN-12-3 (5.82 µg/kg), and NM8 (5.03 µg/kg). From 0.15 to 1.05 m, elevated methylmercury concentrations (greater than 3 µg/kg) occurred mostly in lower Ninemile Creek, especially on the right side of the islands facing downstream in Reach CD. The highest methylmercury concentrations between 0.15 and 1.05 m depth were detected at Station TN-10-3 at concentrations of 20.1 µg/kg at a depth of 0.45 to 0.75 m, 14.9 µg/kg at a depth of 0.75 to

1.05 m, and 9.01 µg/kg at a depth of 0.15 to 0.45 m. Concentrations of methylmercury deceased below 1.05 m, with only three stations exceeding 3 µg/kg. Methylmercury exceeded 2 µg/kg at a depth of 3 to 4 m at Station TN-8-3, but decreased to 0.04 µg/kg below this depth interval. Profiles (concentration versus depth) of mercury and methylmercury sediment data for each of the sediment cores are provided in Appendix K (Figures K-1 and K-2).

5.2.2 Other Metals and Cyanide

The results of the sediment screening (Appendix J, Sediment, Soil, and Surface Water Screening Tables) indicate that the metals other than mercury with at least one sample exceeding the respective NYSDEC LEL criteria include arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc. The BERA (TAMS, 2003a) identified six metals other than mercury as chemicals of concern based on comparing sediment data with ecological screening criteria (summarized in Chapter 1, Table 1-1 of this RI). These metals are arsenic, copper, lead, manganese, nickel, and zinc. The HHRA (TAMS, 2003b) identified aluminum, antimony, arsenic, chromium, iron, lead, manganese, selenium, thallium, and cyanide as COPCs based on the human health screening (summarized in Chapter 1, Table 1-1 of this RI).

Contaminant distribution maps are presented for arsenic (Figures 5-4a and 5-4b), chromium (Figure 5-5), copper (Figure 5-6), lead (Figure 5-7), nickel (Figure 5-8), and zinc (Figure 5-9). Figures are not presented for some of these inorganics (e.g., cadmium, cyanide, and thallium) because there were too few detected values, or because they are common in sediments and the distribution of values did not indicate a pattern (e.g., aluminum, iron, and manganese). Profiles of sediment data for all metals other than mercury, with the exception of thallium and cyanide, are presented in Appendix K (Figures K-3 to K-12). For these two CPOIs, there were too few detected values to warrant an illustration in profile view. All other metals and cyanide are discussed in more detail below:

- **Aluminum** – Aluminum was detected in all sediment samples from all reaches and all depth intervals in both Geddes Brook and Ninemile Creek (see Appendix K, Figure K-3). Aluminum concentrations in Ninemile Creek ranged from 969 to 15,400 mg/kg, with the highest concentration in Ninemile Creek occurring above the confluence with Geddes Brook (see Appendix I). Concentrations in Geddes Brook ranged from 1,420 to 18,800 mg/kg. Within the Geddes Brook/Ninemile Creek site, there were no significant differences in mean concentrations at different depth intervals.

- **Antimony** – Antimony was detected in 10 surface and 33 subsurface sediment samples from lower Geddes Brook and lower Ninemile Creek. Antimony concentrations in lower Ninemile Creek and lower Geddes Brook ranged from 0.24 to 0.42 mg/kg and 0.21 to 0.84 mg/kg, respectively (Appendix I). Antimony was not detected in any upper Ninemile Creek or upper Geddes Brook samples. There were no exceedances of the NYSDEC LEL (2.0 mg/kg) or SEL (25 mg/kg) criteria.

- **Arsenic –** Arsenic (Figures 5-4a and 5-4b) was detected in sediment samples from all reaches in both Geddes Brook and Ninemile Creek. In surface sediments (0 to 0.15 m), concentrations of arsenic exceeding the LEL criterion of 6 mg/kg occurred in all reaches of Ninemile Creek and in lower Geddes Brook (Figures 5-4a and K-4). Concentrations in surface sediments above 20 mg/kg occurred at Transects TN-1 and TN-5 and Station NM9, which are downstream of the I-690 overpass. Below 0.15 m, higher concentrations (i.e., those exceeding 20 mg/kg) occurred more frequently than in the surface sediments, with Transects TN-5 and TN-14 in Ninemile Creek exhibiting elevated concentrations to a depth of at least 2 m. Concentrations exceeding the SEL criterion of 33 mg/kg occurred to a depth of at least 1.5 m, with the maximum concentration of 101 mg/kg occurring at both Stations TN-7-2 and TN-15-3 (0.75 to 1.05 m).

- **Chromium** – Chromium (Figure 5-5) was detected in all sediment samples from all reaches in both Geddes Brook and Ninemile Creek. Concentrations in Ninemile Creek ranged from 2.4 to 138 mg/kg, and averaged about 15 mg/kg. Concentrations in Geddes Brook ranged from 6.8 to 56.1 mg/kg, and averaged about 18 mg/kg. In surface sediments (0 to 0.15 m), concentrations at all stations were below the SEL criterion of 110 mg/kg and only three samples exceeded the LEL of 26 mg/kg (Figures 5-5 and K-6). Concentrations exceeding the LEL occurred at Transect TN-8 to a depth of at least 3 m.

- **Copper –** Copper (Figure 5-6) was detected in all sediment samples from all reaches in both Geddes Brook and Ninemile Creek. Concentrations in Ninemile Creek ranged from 2.9 to 107 mg/kg, and averaged about 24 mg/kg. Concentrations in Geddes Brook ranged from 10.9 to 189 mg/kg, and averaged about 48 mg/kg. In surface sediments (0 to 0.15 m), concentrations of copper exceeded the LEL criterion of 16 mg/kg in 38 samples located in all reaches of Ninemile Creek and lower Geddes Brook (Figures 5-6 and K-7). Below 0.15 m, concentrations exceeding the LEL were more prevalent in Reaches CD and BC than in upper Ninemile Creek or in Reach AB. Concentrations exceeded the SEL criterion of 110 mg/kg only in Transect TG-4, located in Geddes Brook just downstream of the West Flume discharge point, from 0.45 to 1.25 m depth.

- **Cyanide –** Cyanide was not detected in sediment in 1998. In 2001, cyanide was detected in a few samples in Geddes Brook (ranging from 0.82 to 1.7 mg/kg in one sample each from Transects TG-2, TG-3, and TG-4) and Ninemile Creek (ranging from 0.74 to 8.4 mg/kg in three samples from Transect TN-1, two samples from Transect TN-2, one sample from Transect TN-8, four samples from Transect TN-11, and one sample from Transect TN-15). The highest detected values were 3.8 and 8.4 mg/kg for Station TN-1-2 in Ninemile Creek at depth intervals of 0.35 to 0.41 m and 0.24 to

0.30 m, 4.1 mg/kg for Station TN-2-2 in Ninemile Creek at the 0.33 to 0.39 m depth interval, and 3.1 mg/kg for Station TN-11-1 in Ninemile Creek at the 0.15 to 0.45 m depth interval. All other detected values were less than 2.0 mg/kg.

- **Iron** – Iron was detected in sediment samples from all reaches at all depth intervals in both Geddes Brook and Ninemile Creek. Iron concentrations in Ninemile Creek ranged from 1,690 to 43,500 mg/kg and concentrations in Geddes Brook ranged from 2,850 to 29,700 mg/kg (see Appendix I). Iron exceeded the NYSDEC LEL criterion of 20,000 mg/kg in subsurface sediment only at two locations in 1998 (0.15 to 0.45 m depth interval) and seven locations in 2001 (0.15 to 0.45, 0.45 to 0.75, and 0.75 to 1 m depth intervals). Iron exceeded the NYSDEC SEL of 40,000 mg/kg at one location, Station TN-12-3 in Ninemile Creek, with the highest concentration, 43,500 mg/kg, found at the 0.75 to 1 m depth interval.

- **Lead** – Lead (Figure 5-7) was detected in all sediment samples from all reaches of Geddes Brook and Ninemile Creek. Concentrations in Ninemile Creek ranged from 1.4 to 532 mg/kg, and averaged about 45 mg/kg. Concentrations in Geddes Brook ranged from 14.8 to 356 (average of duplicate samples) mg/kg, and averaged about 58 mg/kg. Twenty-one samples exceeded the LEL criterion of 31 mg/kg in surface sediments (0 to 0.15 m), and four samples exceeded of the SEL criterion of 110 mg/kg, with one exceedance occurring in each of the three lower Ninemile Creek reaches and one occurring in lower Geddes Brook (Figures 5-7 and K-9). The average concentrations of lead in surface sediments (0 to 0.15 m) from upper Geddes Brook, lower Geddes Brook, upper Ninemile Creek, and lower Ninemile Creek were 40.9, 36.4, 22.7, and 39.7 mg/kg, respectively. The highest lead concentration of 532 mg/kg occurred in the 0.15 to 0.45 m depth interval in Transect TN-5, which is just downstream of the I-690 overpass. Below 0.15 m the frequency of LEL exceedances decrease, but the concentrations in certain transects remain above the SEL down to a 3 m depth. The transects with continued elevated concentrations relative to the SEL include Transect TG-4 to a depth of at least 1.75 m, Transect TN-8 to a depth of at least 3 m, and Transect TN-6 to a depth of at least 1.75 m.

- **Nickel** – Nickel (Figure 5-8) was detected in all sediment samples in upper and lower Ninemile Creek and upper and lower Geddes Brook. Concentrations in Ninemile Creek ranged from 3 to 88.6 mg/kg, and averaged about 18 mg/kg. Concentrations in Geddes Brook ranged from 7.9 to 137 mg/kg, and averaged about 33 mg/kg. In surface sediments (0 to 0.15 m), 18 samples exceeded the LEL criterion of 16 mg/kg (Figures 5-8 and K-11). The average concentrations of nickel in surface sediments from upper Geddes Brook, lower Geddes Brook, upper Ninemile Creek, and lower Ninemile Creek were 12.1, 16.9, 14.0, and 15.1 mg/kg, respectively. Below 0.15 m, concentrations exceeding the SEL criterion of 50 mg/kg occurred in lower Geddes Brook and in the right channel section in Reach CD in Ninemile Creek. The highest concentration, 137 mg/kg, occurred in Geddes Brook at a depth of 1 to 1.3 m in Transect TG-4, just downstream of the West Flume. Below a depth of 0.45 m, there were no samples exceeding the LEL downstream of Transect TN-5.

- **Selenium** – Selenium was detected in 6 surface and 84 subsurface sediment samples from lower Geddes Brook and lower Ninemile Creek. Selenium concentrations in lower Ninemile Creek and lower Geddes Brook ranged from 0.29 to 2.8 mg/kg and 0.31 to 1.3 mg/kg, respectively (Appendix I). Selenium was not detected in any upper Geddes Brook or upper Ninemile Creek sediment samples. There are no NYSDEC LEL or SEL screening criteria for selenium.

- **Thallium** – Thallium was detected in a limited number of sediment samples from Geddes Brook and Ninemile Creek, with average concentrations of 2.0 mg/kg in 1998 and 0.84 mg/kg in 2001. In 1998, thallium was detected only in Ninemile Creek at Stations NM2 (2.0 mg/kg), NM5 (2.1 mg/kg), NM8 (2.0 mg/kg), and NM9 (1.9 mg/kg). In 2001, the range of detected concentrations was 0.55 to 1.2 mg/kg in Geddes Brook and 0.56 to 1.6 mg/kg in Ninemile Creek. There was no discernable pattern in thallium concentration in sediment.

- **Zinc** – Zinc (Figure 5-9) was detected in all sediment samples from all reaches in both Geddes Brook and Ninemile Creek. Concentrations in Ninemile Creek ranged from 11.6 to 195 mg/kg, and averaged 49 mg/kg. Concentrations in Geddes Brook ranged from 44.2 to 232 mg/kg, and averaged 109 mg/kg. In surface sediments (0 to 0.15 m), concentrations exceeding the LEL criterion of 120 mg/kg occurred mostly in Geddes Brook, while concentrations downstream of Transect TN-7 in Ninemile Creek were below the LEL (Figures 5-9 and K-12). The average concentrations of zinc in surface sediments from upper Geddes Brook, lower Geddes Brook, upper Ninemile Creek, and lower Ninemile Creek were 170, 122, 52, and 62 mg/kg, respectively. Below the 0.15 m depth, concentrations exceeding the LEL only occurred in Geddes Brook, with the highest concentration of 232 mg/kg occurring at the 0.45 to 0.75 m depth interval in Transect TG-4, just downstream of the West Flume. There were no transects with concentrations greater than the LEL at depths below 0.75 m.

5.2.3 Organic Contaminants

Geddes Brook/Ninemile Creek site sediment data were screened against four TOC-normalized criteria for organic compounds: human health bioaccumulation, acute toxicity for benthic aquatic life, chronic toxicity for benthic aquatic life, and wildlife bioaccumulation. Summary tables of the number of exceedances for organic compounds at each sampling interval for Geddes Brook and Ninemile Creek sediment are presented in Appendix J. In addition, the BERA (TAMS, 2003a) and HHRA (TAMS, 2003b) identified numerous organic COCs based on screening sediment data against risk-based criteria (see Chapter 1, Table 1-1 of this RI).

The subsections below present a summary of the contamination levels of the organic CPOIs. Figures depicting the contaminant distribution for the primary organic CPOIs are presented in this chapter, including: hexachlorobenzene (Figure 5-10), total PAHs (Figures 5-11a and 5-11b), Aroclors 1254 and 1268 (Figures 5-12 and 5-13, respectively), and calculated PCDD/PCDF toxicity equivalents (TEQ) values for humans/mammals, birds, and fish (Figures 5-14, 5-15, and 5-16, respectively). In addition, figures illustrating the contaminant profiles with depth for these and other organic CPOIs are presented in Appendix K, Figures K-13 to K-35.

5.2.3.1 Volatile Organic Compounds

Two individual VOCs, benzene and methylene chloride, were identified as CPOIs in sediment.

Benzene was detected in 1998 at a single station (Station NM5), near the large island in lower Ninemile Creek, with concentrations ranging from 5.3 to 12 µg/kg, with one value exceeding the human health bioaccumulation criterion (Appendix K, Figure K-13).

Methylene chloride was detected at concentrations up to 60 µg/kg in 1998, with this maximum reported in the surface sediments (0 to 0.15 m) of Station NM10 in lower Ninemile Creek. In 2001, four samples contained methylene chloride concentrations greater than 1,000 µg/kg in lower Ninemile Creek, as follows:

- Station TN-1-1 – 58,000 µg/kg at the surface interval (0 to 0.15 m).
- Station TN-1-2 – 3,600 µg/kg at the surface interval (0 to 0.15 m).
- Station TN-2-2 – 10,000 µg/kg at the surface interval (0 to 0.15 m).
- Station TN-2-2 – 12,000 µg/kg at the 0.15 to 0.45 m depth interval.

In addition, Station TN-2-2 contained methylene chloride concentrations ranging from 188 to 500 µg/kg in deeper intervals (0.45 to 2 m).

Methylene chloride was occasionally detected in the sediment data collected independently of this RI (NYSDEC, 1989; BBL, 1999) at concentrations generally lower than observed in 1998 and 2001. Volatile organic CPOIs were not analyzed during the NYSDEC RIBS investigation (NYSDEC, 1992). Given the sporadic occurrence of elevated concentrations, the higher concentrations in the 1998 and 2001 RI data are likely the result of more extensive sampling.

5.2.3.2 Semivolatile Organic Compounds

Several SVOCs were identified as CPOIs for sediment in the risk assessments as shown in Table 1-1, including 1,4-dichlorobenzene, hexachlorobenzene, various individual PAHs, and phenol.

1,4-Dichlorobenzene

1,4-Dichlorobenzene concentrations exceeding 500 µg/kg were found at no locations in 1998 and at only four locations in 2001 (Figure K-14). Detection limits varied from sample to sample, but generally ranged from 500 to 600 µg/kg. The highest detected concentration, 1,700 µg/kg, was found at both Geddes Brook Transect TG-1 (near the mouth of Geddes Brook) at 1.05 to 1.36 m depth and in the surface sediment (0 to 0.15 m) of Transect TN-7 (upstream of the USGS gauging station in Ninemile Creek). The second highest detected concentration, 1,300 µg/kg, was found at Station TG-4-1 (just downstream of the West Flume discharge into Geddes Brook), at the 0.75 to 1.05 m depth interval. The concentration in the next depth interval (1.05 to 1.28 m) at this station was 920 µg/kg. Station TN-5-2, located at the bend as Ninemile Creek flows past Wastebeds 1 to 8, had concentrations of 830 µg/kg at the 1.05 to 1.55 m depth interval and 640 µg/kg at the 1.55 to 2.16 m depth interval.

Hexachlorobenzene

Hexachlorobenzene was detected at numerous locations in Geddes Brook and Ninemile Creek using two analytical techniques: mass spectrometry (MS) and electron capture detection (ECD) (Figures K-15 and K-16). Although the ECD provides a much lower detection limit (10 µg/kg versus 500 to 600 µg/kg for MS), the results from these two analytical techniques are generally consistent, and values are averaged in the contaminant distribution map (Figure 5-10[1]). The NYSDEC (1999) human health and wildlife bioaccumulation screening values, which were converted to dry weight based on an average TOC of 2.1 percent, are exceeded in several samples from 1998 and 2001 in both lower Geddes Brook and lower Ninemile Creek. In surface sediments (0 to 0.15 m), concentrations in lower Geddes Brook and lower Ninemile Creek (Reaches BC and CD) generally exceeded the human health bioaccumulation criterion. The highest surface sediment concentrations occurred at Stations NM7 (2,450 µg/kg), GB7 (795 µg/kg), TG-3-1 (755 µg/kg), TG-2-1 (700 µg/kg), and TN-6-3 (650 µg/kg).

Concentrations of hexachlorobenzene were higher at depth relative to the surface interval, with lower Geddes Brook having values greater than 10,000 µg/kg to a depth of 1.28 m. From 0.15 to 0.45 m, concentrations at Ninemile Creek Stations TN-14-3 and TN-15-3, on the right side of the island in Reach CD, and at Station TG-3-2 in lower Geddes Brook were over an order-of-magnitude greater than the NYSDEC wildlife bioaccumulation criterion. From 0.45 to 0.75 m, elevated concentrations (greater than 5,000 µg/kg) occurred at Station TN-14-3 (26,000 µg/kg) in Ninemile Creek and at Stations TG-4-1 (17,500 µg/kg), TG-3-2 (11,500 µg/kg), and TG-2-1 (5,150 µg/kg) in lower Geddes Brook. Below 0.75 m, concentrations exceeding the NYSDEC wildlife criterion occurred at four stations in Ninemile Creek (TN-5-1, TN-6-1, TN-8-2, and TN-14-3) and four stations in lower Geddes Brook (TG-1-1, TG-1-2, TG-4-1, and GB7). The highest concentrations of hexachlorobenzene in the site occurred at Station TG-4-1 in lower Geddes Brook just downstream

[1] Because of the large difference in concentration between the screening values used in the figure, the actual concentrations for individual samples above 3.15 µg/kg are presented to aid in the interpretation of Figure 5-10.

of the West Flume, with values of 107,500 µg/kg at a depth of 0.75 to 1.05 m and 140,000 µg/kg at a depth of 1.05 to 1.28 m, indicating that the West Flume has been a major source of this CPOI.

Polycyclic Aromatic Hydrocarbons

Several individual PAHs exceeded NYSDEC screening criteria in both lower Geddes Brook and lower Ninemile Creek (see Appendix J); however, to simplify illustration and discussion, the individual PAHs, including acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, 2-methylnaphthalene, phenanthrene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, fluoranthene, and pyrene were summed for a total PAH concentration. Figures 5-11a and 5-11b herein and Figure K-17 in Appendix K present the contaminant distribution for total PAHs at the various depth intervals. In surface sediments, total PAHs exceeding the National Oceanic and Atmospheric Administration (NOAA) effects range-low (ER-L) value of 4,000 µg/kg for total PAHs occurred throughout Geddes Brook and at several stations along lower Ninemile Creek. The highest surface sediment concentrations occurred at Stations GB1 (119,500 µg/kg), GB2 (24,500 µg/kg), and TG-1-2 (42,130 µg/kg). Both Stations GB1 and GB2 were located in upper Geddes Brook, upstream of the reach shown in Figure 5-11a.

For the 0.15 to 0.45 m depth interval, ten stations had total PAH concentrations greater than 4,000 µg/kg, with the highest values at Stations TN-5-3 (29,500 µg/kg) and TN-8-3 (33,900 µg/kg) in lower Ninemile Creek. For the 0.45 to 1.05 m depth interval, values exceeding 10,000 µg/kg occurred in Ninemile Creek Stations TN-15-3 (23,700 µg/kg), TN-8-3 (18,800 µg/kg), and TN-12-1 (17,100 µg/kg) and in Geddes Brook Stations TG-2-1 (10,700 µg/kg), TG-4-1 (55,200 µg/kg), and TG-3-2 (12,600 µg/kg). Below a 1 m depth (Figure 5-11b), three stations exceeded 10,000 µg/kg (Stations TN-12-3, TN-8-3, and TG-4-1), and concentrations exceeding 1,000 µg/kg continued to a depth of 4 m at Station TN-8-3.

Phenol

Phenol was detected in Ninemile Creek at Stations NM7 and NM9 in 1998 and at Transects TN-5, TN-8, TN-11, TN-12, TN-14, and TN-15 in 2001 (Figure K-20). The highest phenol concentrations were at Station TN-11-1 in Ninemile Creek (ranging from 210 to 1,700 µg/kg from the surface down to 2.25 m). The second highest set of phenol concentrations was at Station TN-5-3 (830 µg/kg at 0.15 to 0.45 m) and Station TN-5-2 (700 µg/kg at 0.75 to 1.05 m). This transect (TN-5) is located at the bend as Ninemile Creek flows past Wastebeds 1 to 8. In Geddes Brook, phenol was detected at Stations TG-1-1, TG-2-1, and TG-2-2 at concentrations ranging from 65 to 250 µg/kg. Samples within ten transects and stations (NM7 and NM9) in lower Geddes Brook and lower Ninemile Creek exceed the NYSDEC chronic toxicity criterion (10.5 µg/kg, assuming 2.1 percent TOC).

SVOC Summary

These SVOC CPOIs were occasionally detected in the sediment data collected independently of this RI (NYSDEC, 1989; BBL, 1999) at concentrations generally lower than observed in 1998 and 2001. Semivolatile organic CPOIs were not analyzed as part of the NYSDEC RIBS (NYSDEC, 1992). The higher concentrations observed in the 1998 and 2001 RI data are likely due to the more extensive sampling in those years.

5.2.3.3 Pesticides

The BERA and HHRA (TAMS, 2003a,b) identified dieldrin, DDT and metabolites, heptachlor epoxide, and the sum of heptachlor and heptachlor epoxide as COPCs (Chapter 1, Table 1-1 of this RI). Concentrations of these pesticides exceed the NYSDEC (1999) human health and wildlife bioaccumulation screening values and the benthic aquatic life chronic toxicity value (Appendix J). Contaminant profiles for these CPOIs are presented in Appendix K, Figures K-21 to K-30.

- **Dieldrin** – Patterns of detection for dieldrin were similar to those for heptachlor epoxide and DDT and its metabolites, which are addressed below. Dieldrin was detected at Station TN-8-3 in lower Ninemile Creek, with concentrations ranging from 8.5 to 49 µg/kg. Station GB6 in lower Geddes Brook contained dieldrin at concentrations ranging from 12 to 25 µg/kg.

- **DDT and metabolites** – In Geddes Brook, the maximum concentration for 4,4′-DDT, 94 µg/kg, occurred at a depth interval of 0.75 to 1.05 m at Station TG-4-1, located just downstream of the West Flume. The highest concentration of 4,4′-DDD (110 µg/kg) was also detected at Station TG-4-1, but at the 1.05 to 1.28 m depth interval. The next highest concentration of 4,4′-DDT, 61 µg/kg, occurred in Geddes Brook at Station TG-3-2, at the 0.45 to 0.73 m depth interval.

  In Ninemile Creek, all detected values for DDT and its metabolites, with the exception of those at Transects TN-5, TN-8, and NM6 were less than 5 µg/kg. Station TN-8-3 contained 4,4′-DDD, 4,4′-DDE, and 4,4′-DDT at concentrations of 5.3, 9.3, and 8.3 µg/kg (averages of duplicate samples), respectively, at the 0.15 to 0.45 m depth interval. At three intervals (from 0.45 to 1.98 m) at this station, 4,4′-DDE was found at 6 to 7 µg/kg. Station TN-5-3 (0.15 to 0.45 m) contained 4,4′-DDD at 11 µg/kg. The highest 4,4′-DDT concentration, 12 µg/kg, was at Station TN-5-1 (0.15 to 0.45 m). Station NM6 contained 4,4′-DDE at a concentration of 7.4 µg/kg at 0 to 0.15 m.

- **Heptachlor epoxide** – In Geddes Brook, the maximum concentration for heptachlor epoxide, 180 µg/kg, occurred at depths of 1.05 to 1.28 m at Station TG-4-1 located just downstream of the West Flume. At Station TG-4-2, heptachlor epoxide was detected in surface sediments (0 to 0.15 m) at 65 µg/kg. The next highest concentration of heptachlor epoxide, 33 µg/kg, occurred in Geddes Brook at Station TG-3-2 at the 0.45 to 0.73 m depth interval.

In Ninemile Creek, all detected values for heptachlor epoxide, with the exception of Transects TN-8 and TN-15, were less than 5 µg/kg. The highest heptachlor epoxide concentration, 13 µg/kg, was at Station TN-15-3 (0.45 to 0.75 m). Station TN-8-3 contained heptachlor epoxide at a concentration of 6.8 µg/kg at 0.15 to 0.45 m.

These pesticides were not detected in the sediment data collected independently of this RI (NYSDEC, 1989; BBL, 1999) and were not analyzed as part of the NYSDEC RIBS sampling conducted in 1989 and 1990 (NYSDEC, 1992).

5.2.3.4 Polychlorinated Biphenyls

Of the PCBs identified as sediment CPOIs in the risk assessments, Aroclor 1260 was detected only three times and Aroclors 1254 and 1268 were detected more frequently in sediment. Detection limits were generally 17 to 19 µg/kg in 1998 and 20 to 30 µg/kg in 2001. For Aroclors 1254 and 1268, detection limits in some of the deep samples from Geddes Brook were elevated (e.g., up to 130,000 µg/kg at Station TG-4-1, at a depth interval of 1.05 to 1.28 m). As Aroclors 1254 and 1268 are the dominant Aroclors found in the Geddes Brook/Ninemile Creek site and are associated with Honeywell operations, their distribution has been mapped and is presented in Figures 5-12 and 5-13. Note that while the figures and text discuss the concentrations of individual PCB Aroclors, the NYSDEC sediment screening criteria are based on total PCBs. When TOC-normalized, the calculated sum of PCBs for several stations exceeded the NYSDEC human health and wildlife bioaccumulation screening criteria for total PCBs (Appendix J).

- **Aroclor 1254** – In surface sediments (0 to 0.15 m), 11 Aroclor 1254 values exceeded the NYSDEC wildlife bioaccumulation criterion for total PCBs of 29.4 µg/kg based on an average TOC of 2.1 percent (Figures 5-12 and K-31), with the highest concentration of 300 µg/kg occurring at Station NM6. Below 0.15 m, concentrations of Aroclor 1254 exceeding the NYSDEC chronic toxicity criterion for total PCBs of 405 µg/kg occurred at Stations TN-8-3 (520 µg/kg at 0.15 to 0.45 m) and TN-15-3 (2,000 µg/kg at 0.45 to 0.75 m) in lower Ninemile Creek, and at Station TG-2-1 (2,000 µg/kg at 0.45 to 0.75 m) in lower Geddes Brook. Aroclor 1254 concentrations of about 100 µg/kg continued to a depth of about 4 m at Station TN-8-3.

- **Aroclor 1268** – In surface sediments (0 to 0.15 m), concentrations of Aroclor 1268 (Figures 5-13 and K-32) exceeding the NYSDEC wildlife criterion for total PCBs (based on 2.1 percent TOC) occurred in lower Geddes Brook and Reach CD of Ninemile Creek, as well as at Station TN-1-3 (1,000 µg/kg) in Reach AB of Ninemile Creek. Below 0.15 m, concentrations of Aroclor 1268 exceeding the NYSDEC chronic toxicity criterion for total PCBs occurred in lower Ninemile Creek at Stations TN-8-2 (600 µg/kg at 0.15 to 0.45 m), TN-12-3 (1,000 µg/kg at 0.15 to 0.45 m), TN-15-3 (500 µg/kg at 0.15 to 0.45 m), and TN-14-3 (2,000 µg/kg at 0.75 to 1.05 m). Concentrations exceeding the

NYSDEC wildlife criterion for total PCBs continued to a depth of 3 m at Station TN-6-1 and to a depth of 4 m at Station TN-8-3.

- **Aroclor 1260** – Of the three detections of Aroclor 1260, the maximum concentration was 300 µg/kg at Station TG-2-1 (0.15 to 0.45 m) in lower Geddes Brook. Aroclor 1260 was detected at concentrations of 10 and 7 µg/kg at Stations TN-1-1 and TN-1-2 in lower Ninemile Creek.

The PCBs identified as CPOIs were occasionally detected in the sediment data collected independently of this RI (NYSDEC, 1989, 1992; BBL, 1999) at concentrations generally lower than those observed in 1998 and 2001. No detections of PCBs were reported in NYSDEC (1989); however, this investigation had relatively high detection limits for PCBs (310 to 5,900 µg/kg). In NYSDEC (1992), detections of Aroclors 1254 and 1260 and an unresolved mixture of Aroclors 1016 and 1242 were reported in Ninemile Creek at the USGS gauging station in Lakeland at concentrations ranging from 4 to 6 µg/kg. In BBL (1999), detections of Aroclor 1248 and 1260 were reported in Ninemile Creek upstream of the Geddes Brook confluence at concentrations ranging from 6 to 65 µg/kg. Given the sporadic occurrence of elevated concentrations, the higher concentrations observed in the RI data set (1998 and 2001) are likely due to the more extensive sampling.

5.2.3.5 Dioxins and Furans

PCDD/PCDFs were converted to TEQs for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) using the World Health Organization (WHO) toxic equivalency factors (TEFs) for humans and mammals, birds, and fish (Van den Berg et al., 1998). All discussions are based on TEQs calculated using one-half the detection limits for non-detect results.

In Geddes Brook, human/mammalian TEQ values ranged from 2.7 to 13.4 ng/kg in surface sediments (0 to 0.15 m), with the highest value found at Station GB1 (Figure K-33). Below 0.15 m, the highest human/mammalian TEQ value was found at Station TG-4-1 (218 ng/kg at 1.05 to 1.28 m), although samples were not analyzed for PCDD/PCDFs at all sampling stations (Figure 5-14a). Human/mammalian TEQ values exceeding the NYSDEC wildlife criterion of 4.2 ng/kg (based on 2.1 percent TOC) occurred to a depth of at least 1.28 m at Stations TG-4-1 and TG-1-2. Avian and fish TEQ values also exceeded the wildlife screening value (Appendix J). Avian TEQ values in Geddes Brook (Figures 5-14b and K-34) ranged from 3.3 to 58 ng/kg in surface sediment, with the highest value found at Station GB7. The highest avian TEQ value within sediment cores was found at Station TG-4-1 (1,243.9 ng/kg) at 0.125 to 0.128 m. Fish TEQ values in Geddes Brook ranged from 2.3 to 11.5 ng/kg in surface sediment, with the highest concentration found at Station GB1 (Figures 5-14c and K-35). The highest fish TEQ value within sediment cores was found at Station TG-4-1 (162 ng/kg at 1.05 to 1.28 m).

In Ninemile Creek, human/mammalian TEQ values in surface sediment (0 to 0.15 m) ranged from 0.37 to 34.6 ng/kg, with the highest value found at Station NM8 (Figure 5-14a). Below 0.15 m, the highest human/mammalian TEQ value within the Ninemile Creek sediment cores was found at Station TN-14-3 (70.6 ng/kg at 0.45 to 0.75 m). The next highest values in Ninemile Creek were found in cores of Transect TN-6 and at Stations TN-8-2, NM7, and NM8. Human/mammalian TEQ values exceeding the NYSDEC wildlife criterion of 4.2 ng/kg occurred to a depth of 4 m at Station TN-8-3 and to a depth of 2.4 m at Station TN-6-1. Fish TEQ values exceeded the wildlife screening value at all depth intervals at locations in Ninemile Creek (Figure 5-14b). Avian TEQ values (Figures 5-14b and K-34) ranged from 0.44 to 213 ng/kg in surface sediment, with the highest value found at Station NM8. The highest avian TEQ value within Ninemile Creek sediment cores was found at Station TN-6-1 (187 ng/kg at 0.45 to 0.75 m). Fish TEQ values (Figures 5-14c and K-35) ranged from 0.41 to 24.6 ng/kg in surface sediment, with the highest concentration found at Station NM8. The highest fish TEQ value within sediment cores was found at Station TN-14-3 (65.6 ng/kg at 0.45 to 0.75 m).

PCDD/PCDFs were not analyzed in the sediment investigations conducted independently of this RI (NYSDEC, 1989, 1992; BBL, 1999).

5.2.3.6 Non-Aqueous-Phase Liquid

During the 2001 sampling program, evidence of non-aqueous-phase liquid (NAPL), such as droplets, sheen, or odors, was noted in sediment samples in Geddes Brook (Station TG-1-2) and Ninemile Creek (Stations MN-1, MN-2, and TN-15-3).

5.2.4 Conventional Properties

Conventional sediment properties that were analyzed include TOC and calcium. Calcium data are typically reported by analytical laboratories with the metals data but are discussed here, since calcium is considered a marker for Solvay waste materials. Sediment concentrations are presented on a dry-weight basis in this section. Grain-size distribution was also determined during the sediment sampling and is discussed below.

5.2.4.1 Total Organic Carbon

In Geddes Brook, TOC levels in surface sediment (0 to 0.15 m) varied considerably throughout the study area, with concentrations ranging from 4,770 to 44,200 mg/kg. The maximum TOC concentration was measured at Station TG-3-1. Below 0.15 m, TOC concentrations were generally lower, with concentrations ranging from 1,160 to 33,100 mg/kg.

In Ninemile Creek, TOC concentrations varied greatly among sampling stations. Surface sediment (0 to 0.15 m) TOC concentrations ranged from 1,820 mg/kg at Station TN-14-3 to 74,500 mg/kg at Station TN-3-2. Contrary to what was observed in Geddes Brook, there was often no decrease in TOC concentration in deeper sediments. The maximum TOC concentration in sediment below 0.15 m, 129,000 mg/kg, was measured at Stations TN-3-3 (0.15 to 0.45 m) and TN-15-3 (0.75 to 1.05 m).

5.2.4.2 Calcium

In Geddes Brook, average calcium concentrations in surface sediment (0 to 0.15 m) were higher in lower reaches than in upper reaches (Appendix I). In both 1998 and 2001, the average calcium concentrations were 217,000 mg/kg in lower Geddes Brook and 115,000 mg/kg in upper Geddes

Brook. Average calcium concentrations increased with depth in lower Geddes Brook sediment and decreased with depth in upper Geddes Brook sediment.

As with Geddes Brook, average calcium concentrations in Ninemile Creek surface sediment (0 to 0.15 m) are higher in lower reaches (within the Solvay Wastebed area) than in upper reaches (above the Solvay Wastebed area) (Appendix I). In both 1998 and 2001, the average calcium concentrations were 201,000 mg/kg in lower Ninemile Creek and 78,000 mg/kg in upper Ninemile Creek. In lower Ninemile Creek samples from 1998 and 2001, average calcium concentrations were similar in the top 1 m of sediment, and decreased slightly at depths greater than 1 m. In upper Ninemile Creek, calcium was only analyzed in the top two depth intervals, and average calcium concentrations decreased with depth.

An discernable pattern is apparent in the surface sediment (0 to 0.15 m) calcium concentrations within Ninemile Creek Transects TN-12, TN-14, and TN-15 from 2001. Calcium concentrations were highest in cores collected from the right side of the creek facing downstream (i.e., core 3 in each transect). For example, in Transect TN-12, the surface calcium concentrations were 71,000 mg/kg at Station TN-12-1 and 203,000 mg/kg at Station TN-12-3. In Transect TN-14, the surface calcium concentrations were 23,600 mg/kg at Station TN-14-1 and 331,000 mg/kg at Station TN-14-3. In Transect TN-15, the surface calcium concentrations were 23,800 mg/kg at Station TN-15-1 and 387,000 mg/kg at Station TN-15-3. A similar pattern was found for mercury (see Section 5.2.1), with concentrations highest in cores collected from the right side of the creek facing downstream for these transects.

5.2.4.3 Grain-Size Distribution

The physical characteristics of sediment (based on qualitative observations) and their relationship to erosional and depositional regions are discussed in Chapter 3, Site History and Physical Characteristics, and Appendix H, Hydrological Evaluation (1998). The following quantitative summary is based on 1998 data only. Lower Geddes Brook stations (GB6, GB7, and GB8) contained approximately 20 to 30 percent sandy sediment. Upstream Geddes Brook stations (GB1, GB2, and GB3) contained a higher percentage of sandy sediment (69, 70, and 53 percent, respectively). Most Geddes Brook sampling stations contained less than 2 percent gravel within the sediments, although surface sediment at Station GB6 contained 47 percent gravel and Station GB8 contained 15 percent. Sampling locations in which the sediment was not mainly sand or gravel had high percentages of silt. The particle size of sediments in Geddes Brook is primarily smaller than 2.00 mm (90 percent).

Surface sediment in Ninemile Creek averaged approximately 55 percent silt (range of 33 to 78 percent). Some sections of Ninemile Creek contained a significant amount of gravel, such as Stations NM1 (45 percent gravel) and NM5 (19 percent gravel), and a few stations contained less than 5 percent gravel within their surface sediments. Sampling sites contained approximately 25 percent sandy sediments, with downstream stations generally less sandy. Sediments in Ninemile Creek are mainly composed of particles smaller than 2.00 mm (90 percent). Some sites contained even finer particles, such as Station NM9 (90 percent of its particles are smaller than 0.074 mm).

5.3 Floodplain and Island Soil/Wetland Sediment Characterization

This section discusses the nature and extent of contamination of CPOIs (see Chapter 1, Table 1-1), including inorganic, organic, and conventional parameters in the floodplain areas, which include the islands in Ninemile Creek, as well as Wetlands SYW-18 and SYW-10 sediments within the limits of the Geddes Brook/Ninemile Creek site. Samples for floodplain (non-wetland) soil, island soil, and wetland sediment include those collected during the Geddes Brook/Ninemile Creek RI/FS sampling in 1998, the Wetland SYW-10 sampling during the Onondaga Lake RI in 2000, the Geddes Brook and Ninemile Creek supplemental RI sampling in 2001, and the Ninemile Creek supplemental RI floodplain sampling in 2002. In addition, Section 5.3.5 discusses the Geddes Brook IRM data collected in 2002. While the results of this sampling were not available in time for inclusion in the distribution maps or screening for this RI, summary statistics for the floodplain soils are presented in Appendix I (Tables I-52 to I-55) and the validation report, analytical data results, and concentration maps, as provided by Honeywell, are presented in Appendix M, Geddes Brook IRM Analytical Data and Validation Report (2002). Mercury patterns in sediment in relation to floodplain soils are discussed further in Section 5.4.

The 1998, 2000, 2001, and 2002 floodplain soil samples were characterized as either "wetland sediment" or "floodplain soils," based on their locations within the delineated wetlands (SYW-10 or SYW-18) or as visually verified by oversight personnel (e.g., 2002 samples collected in a wetland area on the east side of the mouth of Ninemile Creek). As discussed in the Wetland Delineation Report (Appendix E of the BERA [TAMS, 2003a]), the islands in Reach CD of Ninemile Creek are within Wetland SYW-18. A listing of Geddes Brook and Ninemile Creek floodplain sample locations that were screened as wetland sediment is presented in Appendix J (Table J-5).

Wetland (SYW-18 and SYW-10) sediment data were screened against criteria in NYSDEC's Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999). Screening criteria included two criteria for metals (i.e., LEL and SEL) and four TOC-normalized criteria for organic compounds (i.e., human health bioaccumulation, acute toxicity for benthic aquatic life, chronic toxicity for benthic aquatic life, and wildlife bioaccumulation). Summary tables of the number of exceedances for wetland sediment are shown in Appendix J (Tables J-14 through J-17).

Soil data (non-wetland) were screened against guidance values in NYSDEC's TAGM #4046: *Determination of Soil Cleanup Objectives and Cleanup Levels*. Screening criteria in TAGM #4046 for metals include a range of concentrations for eastern US background soils and recommended soil cleanup objectives (RSCOs). Screening criteria in TAGM #4046 for organic compounds include a soil cleanup objective to protect groundwater quality, US Environmental Protection Agency (USEPA) health-based levels for carcinogens and systemic toxicants, and an RSCO. Summary tables of the number of exceedances for metals and organic compounds at each sampling interval for floodplain (non-wetland) soil are shown in Appendix J (Tables J-6 through J-13).

In 1998, for the Geddes Brook/Ninemile Creek RI, Exponent collected floodplain soil and wetland sediment samples at the 0 to 0.15 m depth interval from three Geddes Brook locations (Stations GB1, GB2, and GB6), and five Ninemile Creek locations (Stations NM1, NM2, NM4, NM5, and NM9). At each location, three samples were collected along each transect perpendicular to the streambed, evenly spaced from the water's edge outward into the floodplain. Transects at all stations were located on either the right or left sides of the brook or creek (see Chapter 2, Figures 2-1 and 2-2 for approximate locations). Samples were analyzed for TAL metals plus methylmercury, VOCs, SVOCs, pesticides, PCBs, PCDD/PCDFs, chloride, TOC, and percent solids.

In 2000, as part of the Onondaga Lake RI, Exponent collected eight wetland sediment samples from four locations within Wetland SYW-10, east of I-690 (Stations S379, S380, S381, and S382; see Chapter 2, Figure 2-2 for approximate locations). At each station, samples were collected from the 0 to 0.15 and 0.15 to 0.30 m depth intervals and analyzed for TAL metals, VOCs, SVOCs, pesticides, PCBs, PCDD/PCDFs, TOC, grain size, and total solids.

In 2001, for the Geddes Brook/Ninemile Creek supplemental RI sampling, BBL collected floodplain soil and wetland sediment samples from two transects along Geddes Brook and 13 transects along Ninemile Creek (see Chapter 2, Figure 2-2) at two separate depth intervals (0 to 0.15 and 0.15 to 0.30 m). No transects were sampled in upper Geddes Brook or upper Ninemile Creek. With the exception of four transects (Transects FG-2, FN-8, FN-11, and FN-12), three cores were collected on each side of the brook or creek at distances of approximately 1, 3, and 5 m from the shoreline. At Transect FN-12, the transect crossed an island in Ninemile Creek, and three soil cores were collected on each side of the island, in addition to each side of the creek (for a total of 12 cores). At Transect FN-11, the transect crossed an island in Ninemile Creek and three cores were collected on each side of the island, in addition to three on the left side and two on the right side of the creek (for a total of 11 cores). At Transects FG-2 and FN-8, only two cores were collected from the right side (for a total of five cores per transect).

In addition to the floodplain soil, BBL collected soil samples on three islands during the sediment sampling in 2001. Cores at Stations TN-11-2, TN-13-2, and TN-14-2 in the sediment transects are actually island soil samples and are discussed here with the floodplain soil samples. Because they were collected during the sediment sampling, island soil cores were sectioned into the following depth intervals: 0 to 0.15, 0.15 to 0.45, 0.45 to 0.75, and 0.75 to 1.05 m. All samples were analyzed for mercury and TOC. A subset of samples was analyzed for methylmercury, while a separate subset was analyzed for TAL metals plus cyanide, VOCs, SVOCs, pesticides, PCBs including Aroclor 1268, and PCDD/PCDFs.

In 2002, for the Ninemile Creek supplemental RI floodplain investigation, floodplain soil and wetland sediment samples were collected at 64 locations within 12 transects along Ninemile Creek between Geddes Brook and Onondaga Lake, at depth intervals of 0 to 0.15, 0.15 to 0.30, 0.30 to 0.60, and 0.60 to 0.90 m. Samples were analyzed for TOC, mercury, TCL SVOCs (PAHs and hexachlorobenzene only), and PCDD/PCDFs.

Figures 5-15 through 5-26 show contaminant distribution maps for CPOIs with significant detections in soil and wetland sediment. The CPOIs that warranted illustration due to the frequency of detections include mercury (Figure 5-15), arsenic (Figure 5-16), chromium (Figure 5-17), copper (Figure 5-18), lead (Figure 5-19), nickel (Figure 5-20), zinc (Figure 5-21), hexachlorobenzene (Figure 5-22), total PAHs (Figure 5-23), Aroclor 1254 (Figure 5-24), Aroclor 1268 (Figure 5-25), and PCDD/PCDFs (Figure 5-26). Table 5-2 presents the means and ranges of concentrations of various metals in the floodplain soils of the major reaches of Geddes Brook and Ninemile Creek. Further discussion comparing upstream to downstream concentrations is provided in Chapter 6. Summary statistics and screening against appropriate NYSDEC guidance values are presented in Appendices I and J, respectively. Profiles for CPOIs in floodplain soil and wetland sediment are presented in Appendix K (Figures K-36 to K-68).

Soil data collected independently of this RI are limited to a single station along Ninemile Creek upstream of the Geddes Brook confluence (BBL, 1999), so an analysis of trends in concentration over time is not warranted, due to the lack of data.

5.3.1 Mercury

Mercury was detected in all 33 samples collected from the upper and lower Geddes Brook floodplain and in 437 of the 448 samples collected from the upper and lower Ninemile Creek floodplain during the RI sampling from 1998 to 2002. The general pattern of mercury distribution in the floodplain of Ninemile Creek is that elevated concentrations were found in the area of the islands (Reach CD), especially on the right (facing downstream) side. The lowest concentrations were seen in the next reach (Reach BC), with increased concentrations again seen at the mouth of Ninemile Creek (Reach AB). The mercury contamination is more spatially extensive in Reach CD, and less consistent and pervasive downstream.

In surface soil and wetland sediment (0 to 0.15 m), mercury concentrations exceed the NYSDEC SEL (1.3 mg/kg) at many locations along the entire reach of lower Ninemile Creek and lower Geddes Brook (Figures 5-2 and 5-15), as follows:

- Surface concentrations exceeding 10 mg/kg (presented as a general frame of reference to aid in the interpretation of the figures and is approximately an order-of-magnitude greater than the SEL) occurred in five stations along Ninemile Creek, including:
  - Station NMFP-T-12-250 – 11.1 mg/kg.
  - Station NMFP-T-12-350 – 12.5 mg/kg.
  - Station NMFP-T-13-50L – 12.7 mg/kg.
  - Station NMFP-T-13-25L – 20.1 mg/kg.
  - Station NM5 – 58.7 mg/kg.
- Surface concentrations exceeding 10 mg/kg occurred in four stations along Geddes Brook, including:
  - Station FG-1-4 – 13.8 mg/kg.
  - Station FG-1-5 – 13.6 mg/kg.
  - Station FG-1-6 – 14.1 mg/kg.
  - Station FG-2-4 – 10.7 mg/kg.

The highest surface soil concentration (58.7 mg/kg) was detected in 1998 at Station NM5, located along the right bank of Ninemile Creek, approximately 1.1 m from the water's edge and next to the large island. The average mercury concentrations in surface samples along upper and lower Geddes Brook were 0.12 and 4.33 mg/kg, respectively. The average mercury concentrations in surface soils along upper and lower Ninemile Creek were 0.27 and 2.16 mg/kg, respectively.

At the 0.15 to 0.30 m depth interval, the number of stations exceeding 10 mg/kg increased relative to the surface interval, with the highest values occurring in Transects FN-1, FN-2, FN-9, FG-1, FG-2, NMFP-T-12, and NMFP-T-13 (59.5 mg/kg).

Below 0.30 m, concentrations in several transects (NMFP-T-3, NMFP-T-5, NMFP-T-12, and NMFP-T-13) continued to exceed the LEL, and samples in Reach CD of Ninemile Creek (Transects NMFP-T-3 and NMFP-T-5) and those closer to Onondaga Lake, near the mouth of the creek (Transects NMFP-T-12 and NMFP-T-13) exceeded the SEL.

Deeper floodplain soils were collected during the 2002 supplemental floodplain sampling program, at depth intervals ranging from 0.3 to 0.6 and 0.6 to 0.9 m. From 0.3 to 0.6 m, mercury was detected in 46 of the 51 samples that were analyzed. The maximum mercury concentration was observed at Transect NMFP-T-13 (76.9 mg/kg), approximately 7.5 m from the water's edge on the right side of Ninemile Creek facing downstream. Mercury concentrations in this depth interval (0.3 to 0.6 m) also exceeded 10 mg/kg at the following locations:

- **NMFP-T-3-05** – 5 ft (1.5 m) from the water's edge on the right side of Ninemile Creek at a concentration of 21.7 mg/kg.

- **NMFP-T-5-05** – 5 ft (1.5 m) from the water's edge on the right side of Ninemile Creek at a concentration of 12 mg/kg.

- **NMFP-T-13-50** – 50 ft (15 m) from the water's edge on the right bank of the Ninemile Creek, facing downstream, at a concentration of 21 mg/kg.

- **NMFP-T-13-260** – 260 ft (80 m) from the water's edge on the right side of Ninemile Creek at a concentration of 13.1 mg/kg.

Mercury was detected in 46 of the 50 2002 floodplain samples collected from the 0.6 to 0.9 m depth interval. The maximum mercury concentration (43.1 mg/kg) in this depth interval was observed at Station NMFP-T-3-05 (5 ft [1.5 m) from the right side of Ninemile Creek, facing downstream). Three additional 2002 floodplain soil locations at this deepest interval exceeded 10 mg/kg, including two along Transect NMFP-T-13 at locations 5 ft (1.5 m) and 25 ft (8 m) from the water's edge on the right bank of Ninemile Creek, facing downstream, at concentrations of 10.3 and 11.9 mg/kg, respectively, and one at NMFP-T-12-25, 25 ft (7.5 m) from the water's edge on the left bank of Ninemile Creek, facing downstream, at a concentration of 13.8 mg/kg. Thirteen 2002 floodplain samples from this depth interval (0.6 to 0.9 m) contained mercury concentrations between 1 and 10 mg/kg.

Some of the sediment transects in Ninemile Creek traversed islands. In these three sediment transects, mercury concentrations in island soil were variable. Concentrations were highest at Station TN-11-2 (1.9 mg/kg at 0 to 0.15 m, 4.7 mg/kg at 0.15 to 0.45 m, and less than 1 mg/kg in deeper intervals). At Station TN-13-2, mercury concentrations were highest at the surface (1.6 mg/kg) and less than 0.5 mg/kg in deeper intervals. Concentrations were less than 0.5 mg/kg in all intervals at Station TN-14-2.

Mercury concentrations in lower Geddes Brook floodplain samples downstream of the culvert (which passes under railroad tracks) were higher in the three cores (numbered 4, 5, and 6) located on the right side facing downstream (i.e., the side closest to the New York State Fairgrounds). This pattern is particularly evident in Transect FG-1, located near the confluence with Ninemile Creek. In this transect, total mercury concentrations averaged 13.8 and 32.3 mg/kg in the 0 to 0.15 and 0.15 to 0.3 m intervals, respectively, on the right side facing downstream, and 1.9 and 0.31 mg/kg in the 0 to 0.15 and 0.15 to 0.30 m intervals, respectively, on the left side facing downstream. This pattern was not found in the Geddes Brook sediment samples.

Methylmercury was analyzed for a small subset of the surface (0 to 0.15 m) soil samples collected in 1998. Where analyzed, methylmercury was detected in all samples from upper and lower Ninemile Creek and upper and lower Geddes Brook, as follows:

- **Upper Ninemile Creek** – nine samples had methylmercury concentrations ranging from 0.11 to 3.31 µg/kg, with an average of 1.56 µg/kg.

- **Lower Ninemile Creek** – seven samples had concentrations ranging from 0.66 to 27.5 µg/kg, with an average of 5.83 µg/kg.

- **Upper Geddes Brook** – six samples had methylmercury concentrations ranging from 0.35 to 1.83 µg/kg, with an average of 0.89 µg/kg.

- **Lower Geddes Brook** – four samples had methylmercury concentrations ranging from 2.86 to 5.31 µg/kg, with an average of 4.03 µg/kg.

Note that methylmercury concentrations in floodplain soils were not screened in the RI because NYSDEC sediment and soil criteria are not available for this form of mercury.

5.3.2 Other Metals

Numerous metals (i.e., aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, thallium, vanadium, and zinc) were identified as CPOIs for floodplain and island soils and wetland sediment in the risk assessments (Chapter 1, Table 1-1). The nature and extent of metals distribution in the floodplain and island soils and wetland sediment is discussed with the objective of identifying areas of relatively high and low concentrations. Soil concentrations were screened against NYSDEC TAGM #4046 soil cleanup objectives, including the eastern US background maximum concentrations, eastern US background minimum concentrations, and

RSCOs. Wetland sediment concentrations were screened against NYSDEC sediment criteria (see Appendix J).

- **Aluminum** – Aluminum was detected in all soil and wetland sediment samples from all reaches of both Geddes Brook and Ninemile Creek. Concentrations along Ninemile Creek ranged from 1,810 mg/kg at Station FN-13-1 to 24,200 mg/kg at Station NM4c, and averaged 8,149 mg/kg (see Appendix I and Figure K-38). Concentrations along Geddes Brook ranged from 4,820 mg/kg at Station GB6b to 20,700 mg/kg at Station FG-2-5, and averaged 8,120 mg/kg. There are no significant differences between the average concentrations along upper Ninemile Creek (11,900 mg/kg) and lower Ninemile Creek (7,700 mg/kg), and between upper Geddes Brook (7,750 mg/kg) and lower Geddes Brook (8,200 mg/kg). At stations in both Geddes Brook and Ninemile Creek where samples were collected from surface and deeper intervals, there were no significant differences in average concentration between the surface and subsurface.

- **Antimony** – Where analyzed, antimony was detected in about 30 percent of the samples from lower Ninemile Creek and lower Geddes Brook. Antimony was not detected in the upper reaches of the site. With the exception of a concentration of 10 mg/kg at Station S380 at the 0.15 to 0.30 m depth interval in Wetland SYW-10, antimony concentrations did not exceed the NYSDEC LEL criterion of 2 mg/kg, and there were no exceedances of the SEL criterion of 25 mg/kg. There is no NYSDEC RSCO for antimony. Antimony concentrations along lower Ninemile Creek ranged from 0.19 to 0.51 mg/kg, except for the single sample from Station S380 near the mouth of Ninemile Creek (10 mg/kg). The average concentration in samples along lower Ninemile Creek was 0.59 mg/kg (0.33 mg/kg if the sample from Station S380 is excluded). Concentrations along lower Geddes Brook ranged from 0.21 to 0.35 mg/kg, with an average of 0.28 mg/kg.

- **Arsenic** – Where analyzed, arsenic was detected in all samples from all reaches along both Geddes Brook and Ninemile Creek. With the exception of a surface concentration of 18.4 mg/kg at Station S379 in Wetland SYW-10, arsenic concentrations exceeding the NYSDEC TAGM #4046 RSCO of 7.5 mg/kg in both the 0 to 0.15 and 0.15 to 0.3 m depth intervals only occurred along lower Geddes Brook and along Reach CD of Ninemile Creek just downstream of Geddes Brook (Figures 5-16 and K-40). There were no exceedances of the NYSDEC SEL criterion of 33 mg/kg. Concentrations along Ninemile Creek within the study area ranged from 1.7 mg/kg at Station FN-4-4 to 31 mg/kg at Station FN-13-3B, and averaged 5.8 mg/kg. Concentrations along Geddes Brook within the study area ranged from 3.4 mg/kg at Station GB2c to 8.9 mg/kg at Station FG-1-4, and averaged 5.6 mg/kg.

- **Barium** – Barium was found in all soil and wetland sediment samples from all reaches of both Geddes Brook and Ninemile Creek, and all samples exceeded the NYSDEC TAGM #4046 eastern US background minimum concentration (Appendix J). Concentrations along Ninemile Creek ranged from 25.4 mg/kg at Station FN-10-2 to 157 mg/kg at Station S380, and averaged 72.1 mg/kg. Concentrations along Geddes Brook ranged from 26.8 mg/kg at Station FG-2-2 to 109 mg/kg at Station FG-2-5, and averaged 53.2 mg/kg (Appendix I). The average concentrations in the surface interval along upper and lower Ninemile Creek were 95 and 68 mg/kg, and corresponding values along upper and lower Geddes Brook were 50 and 52.6 mg/kg, respectively (Appendix I). There were no significant differences between average concentrations in the surface and subsurface depth intervals in both Geddes Brook and Ninemile Creek.

- **Cadmium** – Cadmium was detected in about 25 percent of the floodplain, island, and wetland samples collected along both Geddes Brook and Ninemile Creek. Detected concentrations in Ninemile Creek ranged from 0.036 mg/kg at Station FN-12-7 (0.15 to 0.30 m) to 1 mg/kg at Station S380, and averaged 0.21 mg/kg. Detected concentrations along Geddes Brook ranged from 0.21 mg/kg at Station FG-1-6A to 1.7 mg/kg at Station GB1b (0 to 0.15 m) and averaged 0.57 mg/kg (Appendix I and Figure K-42). Only the surface sample at Station GB1b exceeded the NYSDEC TAGM #4046 RSCO of 1.0 mg/kg.

- **Chromium** – Chromium was detected in all samples from all reaches along both Geddes Brook and Ninemile Creek. At both the 0 to 0.15 and 0.15 to 0.3 m depth intervals, concentrations of chromium exceeded the NYSDEC TAGM #4046 RSCO of 10 mg/kg at all reaches along Ninemile Creek and lower Geddes Brook (Figure 5-17). Concentrations exceeding the NYSDEC LEL of 26 mg/kg occurred mostly along Reach CD of Ninemile Creek. Concentrations along Ninemile Creek ranged from 6.8 mg/kg at Station FN-13-1 to 72 mg/kg at Station FN-4-2, and averaged 22.9 mg/kg. Concentrations along Geddes Brook ranged from 11.6 mg/kg at Station GB2c to 29.9 mg/kg at Station FG-2-5, and averaged 18.7 mg/kg (Figure K-43).

- **Copper** – Copper was detected in all samples from all reaches of both Geddes Brook and Ninemile Creek. In surface samples (0 to 0.15 m), concentrations of copper greater than the NYSDEC TAGM #4046 RSCO of 25 mg/kg occurred throughout the site (Figures 5-18 and K-44). From 0.15 to 0.3 m, higher concentrations above the RSCO occurred mostly along Reaches BC and CD of Ninemile Creek. Concentrations along Ninemile Creek ranged from 8.7 mg/kg at Station FN-13-3 to 87.4 mg/kg at Station FN-6-5, and averaged 32.1 mg/kg. Concentrations along Geddes Brook ranged from 16.7 mg/kg at Station GB1c to 70.2 mg/kg at Station FG-1-3, and averaged 34.6 mg/kg.

- **Iron** – Iron was detected in all samples along all reaches of both Geddes Brook and Ninemile Creek (Figure K-45). Concentrations along Ninemile Creek ranged from 4,120 mg/kg at Station S380 to 41,700 mg/kg at Station NM4c, and averaged 16,100 mg/kg. Concentrations along Geddes Brook ranged from 8,780 mg/kg at Station FG-2-4 to 31,000 mg/kg at Station FG-2-5, and averaged 15,000 mg/kg. At stations where surface and deeper intervals were sampled along Geddes Brook, the average concentration in the surface interval (14,800 mg/kg) was comparable to that in the deeper interval (15,400 mg/kg).

  Similarly, at stations where surface and deeper intervals were sampled along Ninemile Creek, the average concentration in the deeper interval (15,700 mg/kg) was comparable to that in the surface interval (16,500 mg/kg). All floodplain soil samples exceeded the NYSDEC TAGM #4046 RSCO of 2,000 mg/kg while about 11 percent of the wetland and island samples exceeded the NYSDEC LEL of 20,000 mg/kg (Appendix J).

- **Lead** – Lead was detected in all samples along all reaches of both Geddes Brook and Ninemile Creek (Figures 5-19 and K-46). In surface samples (0 to 0.15 m), concentrations exceeding the NYSDEC LEL of 31 mg/kg occurred more frequently along Reach CD of Ninemile Creek. Surface concentrations exceeding the NYSDEC SEL of 110 mg/kg occurred at Stations FN-6-5 (466 mg/kg), FN-6-6 (345 mg/kg), and S379 (115 mg/kg) along Ninemile Creek and Station FG-2-4 (192 mg/kg) along Geddes Brook. Below 0.15 m, concentrations remained greater than the NYSDEC SEL at Station FN-6-5 (317 mg/kg) along Ninemile Creek and Stations FG-1-4 (173 mg/kg) and FG-2-4 (139 mg/kg) along Geddes Brook. The average concentrations of lead in surface samples along Geddes Brook and Ninemile Creek were 55.7 mg/kg and 41.2 mg/kg, respectively. The average concentration along upper Ninemile Creek (37 mg/kg) was less than that along lower Ninemile Creek (41.9 mg/kg) and lower Geddes Brook (52.7 mg/kg).

- **Manganese** – Manganese was detected in all samples along all reaches of both Geddes Brook and Ninemile Creek. Concentrations along Ninemile Creek ranged from 18.3 mg/kg at Station FN-13-1 to 643 mg/kg at Station FN-7-6, and averaged 362 mg/kg. Concentrations along Geddes Brook ranged from 252 mg/kg at Station FG-2-2 to 516 mg/kg at Station GB1b, and averaged 369 mg/kg (Appendix I and Figure K-47). In surface samples (0 to 0.15 m), the average concentrations along upper and lower Ninemile Creek were 439 and 374 mg/kg, and along upper and lower Geddes Brook were 384 and 369 mg/kg, respectively.

- **Nickel** – Nickel was detected in all samples along all reaches of both Geddes Brook and Ninemile Creek. Nickel concentrations in both surface and subsurface intervals (Figures 5-20 and K-48) were lower than the NYSDEC

SEL (50 mg/kg). Concentrations exceeding the NYSDEC LEL of 16 mg/kg occurred at several stations along both streams. Concentrations along Ninemile Creek ranged from 8.9 mg/kg at Station S381 to 40 mg/kg at Station NM4c, and averaged 18.8 mg/kg. Concentrations along Geddes Brook ranged from 12.2 mg/kg at Station FG-1-3 to 32.4 mg/kg at Station FG-2-4, and averaged 19.8 mg/kg (Appendix I).

In surface samples (0 to 0.15 m), the average nickel concentrations along upper and lower Ninemile Creek were 24.2 and 18.4 mg/kg, and along upper and lower Geddes Brook were 17.8 and 19.8 mg/kg, respectively. At stations where upper and lower intervals were sampled along the Geddes Brook floodplain, the differences in average concentrations in the surface interval (22 mg/kg) and the deeper interval (21 mg/kg) were negligible. At stations where upper and lower intervals were sampled along the Ninemile Creek floodplain, the differences in average concentrations in the surface interval (18 mg/kg) and the deeper interval (19 mg/kg) were also negligible.

- **Selenium** – Selenium was detected in 2 of 8 samples in 2000 and 108 of the 130 soil samples collected in 2001, but was not detected in any of the 26 samples from 1998 (Appendix I). The detection limit in 1998 ranged from 0.92 to 1.7 mg/kg, and averaged 1.0 mg/kg. Selenium was detected only in the lower reaches of both Geddes Brook and Ninemile Creek. Concentrations in lower Ninemile Creek samples ranged from 0.36 mg/kg at Station FN-8-4 to 2.9 mg/kg at Station FN-13-3, and averaged 1.02 mg/kg. Concentrations in lower Geddes Brook ranged from 0.34 mg/kg at Station FG-2-2 to 1.30 mg/kg at Station FG-2-5, and averaged 0.61 mg/kg (see Appendix I and Figure K-49). Two samples exceeded the NYSDEC TAGM #4046 RSCO of 2.0 mg/kg.

- **Thallium** – Thallium was detected in 15 of the 164 soil and wetland sediment samples from along Geddes Brook and Ninemile Creek. Only samples along Ninemile Creek had detectable concentrations, which ranged from less than 0.51 mg/kg at Station TN-14-2 to 3.2 mg/kg at Station S379, and averaged 1.15 mg/kg (Appendix I).

- **Vanadium** – Vanadium was detected in all soil and wetland sediment samples from all reaches along both Geddes Brook and Ninemile Creek. Concentrations along Ninemile Creek ranged from 4.7 mg/kg at Station S380 to 48.5 mg/kg at Station NM4c, and averaged 15.8 mg/kg. Concentrations along Geddes Brook ranged from 10.9 mg/kg at Station FG-2-4 to 34.8 mg/kg at Station FG-2-5, and averaged 16 mg/kg (Appendix I).

The average concentrations of vanadium in surface samples (0 to 0.15 m) along upper and lower Ninemile Creek were 23.0 and 15.3 mg/kg, and along upper and lower Geddes Brook were 16.6 and 15.6 mg/kg, respectively. At stations where surface and deeper intervals were sampled from the Geddes Brook floodplain, the differences in average concentrations in the surface interval (22 mg/kg) and the deeper interval (21 mg/kg) were negligible. Similarly, at stations where surface and deeper intervals were sampled from the Ninemile Creek floodplain, the differences in average concentration in the surface interval (18 mg/kg) and the deeper interval (19 mg/kg) were also negligible.

- **Zinc** – Zinc was detected in all soil samples from all reaches of both Geddes Brook and Ninemile Creek. In surface soil (0 to 0.15 m), all samples exceeded the NYSDEC TAGM #4046 RSCO of 20 mg/kg. Concentrations of zinc exceeding the NYSDEC LEL of 120 mg/kg occurred in 20 samples located in lower Geddes Brook and Reach CD of Ninemile Creek (Figures 5-21 and K-50). Below 0.15 m, only five samples equaled or exceeded the NYSDEC LEL. Concentrations along Ninemile Creek ranged from 14.0 mg/kg at Station FN-13-1 to 186 mg/kg at Station NM5b, and averaged 82.3 mg/kg. Concentrations along Geddes Brook ranged from 28.6 mg/kg at Station FG-1-3 to 208 mg/kg at Station GB1a, and averaged 104 mg/kg.

  In surface samples, the average zinc concentrations along upper and lower Ninemile Creek were 108 and 85.6 mg/kg, and along upper and lower Geddes Brook were 154 and 105 mg/kg, respectively. At stations where surface and deeper intervals were sampled from the Geddes Brook floodplain, the differences in average concentration in the surface interval (84 mg/kg) and the deeper interval (75 mg/kg) were small. Similarly, at stations where surface and deeper intervals were sampled from the Ninemile Creek floodplain, the differences in average concentration in the surface interval (83 mg/kg) and the deeper interval (74 mg/kg) were also small.

5.3.3 Organic Contaminants

The BERA and HHRA (TAMS, 2003a,b) identified numerous organic contaminants as CPOIs based on screening soil data against risk-based criteria and guidance values, as summarized in Chapter 1, Table 1-1. Contaminant distribution maps for hexachlorobenzene, PAHs, Aroclors 1254 and 1268, and PCDD/PCDFs are presented in Figure 5-22 through 5-26. Depth profile figures for these organic CPOIs, along with other organics detected in the floodplain, are presented in Appendix K, Figures K-51 to K-68. Statistical summaries are presented in Appendix I and screening results are summarized in Appendix J.

5.3.3.1 Semivolatile Organic Compounds

Several SVOCs (i.e., dichlorobenzenes, hexachlorobenzene, PAHs, phenol, 3-nitroaniline, and N-nitroso-di-*n*-propylamine) were identified as CPOIs for soil in the risk assessments, as summarized in Chapter 1, Table 1-1, as follows:

- **Dichlorobenzenes –** Dichlorobenzenes were not detected in 1998 and were detected infrequently in 2001. 1,2-Dichlorobenzene was detected once in 2001 in the 0 to 0.15 m interval at Station FG-1-1 in lower Geddes Brook (56 µg/kg). 1,3-Dichlorobenzene was detected three times in 2001 at Stations FN-6-4, FN-6-5, and FN-6-6 in lower Ninemile Creek (concentration range of 52 to 90 µg/kg). 1,4-Dichlorobenzene was detected four times in 2001 at Stations FN-10-4, FN-12-7, and FN-8-3 in lower Ninemile Creek (concentration range of 69 to 85 µg/kg). Dichlorobenzenes were not detected at the single soil station sampled in the data collected independently of this RI (BBL, 1999). Only three dichlorobenzene soil samples exceeded the NYSDEC TAGM #4046 RSCO (Appendix J).

- **Hexachlorobenzene** – Hexachlorobenzene was detected at numerous floodplain locations along both Geddes Brook and Ninemile Creek. Figure 5-22 presents the contaminant distribution map for the averages of the MS and ECD results, and the profiles are presented in Figures K-52 and K-53. In surface soils and wetland sediment (0 to 0.15 m), concentrations generally exceeded the NYSDEC human health criterion of 3.2 µg/kg. The highest concentrations in surface samples exceeded 1,000 µg/kg at Station FG-2-4 in lower Geddes Brook. From 0.15 to 0.3 m, concentrations exceeded 1,000 µg/kg at Stations FG-1-4 and FG-2-4 in lower Geddes Brook, and Station FN-8-1 in lower Ninemile Creek. Below 0.3 m, there were generally fewer samples collected, but concentrations at Station NMFP-T-03-5 along Reach CD of Ninemile Creek remained above the NYSDEC TAGM #4046 RSCO (410 µg/kg), with values of 6,400 µg/kg at 0.3 to 0.6 m and 870 µg/kg at 0.6 to 0.9 m.

- **PAHs –** As with the sediment data, the individual PAHs were summed and total PAHs are presented in the contaminant distribution map (Figure 5-23) and in profiles (Figure K-54). Concentrations of total PAHs in surface samples exceeded 1,000 µg/kg at many locations, with the highest values occurring along the right bank of Reach CD of Ninemile Creek at Transect NMFP-T-01 (11,840 to 59,620 µg/kg) and along Transect NMFP-T-03 (173,980 µg/kg at 330 feet [100 m] from the bank). Elevated concentrations were also detected in surface soil along lower Geddes Brook at concentrations up to 138,400 µg/kg at Transect FG-1. From 0.15 to 0.30 m, concentrations continued to exceed 10,000 µg/kg along the right bank of Reach CD of Ninemile Creek at Transect NMFP-T-01 (26,130 to 46,490 µg/kg) and at Transect NMFP-T-03 (283,060 µg/kg at 330 feet [100 m] from the bank). Below 0.6 m, there were fewer samples, but concentrations exceeded 1,000 µg/kg in some stations along all reaches of Ninemile Creek. In particular, Transect NMFP-T-01 had concentrations exceeding 10,000 µg/kg to a depth of 0.9 m.

- **Phenol** – Phenol was detected ten times along lower Ninemile Creek, at Stations FN-4-6, FN-6-1, FN-6-2, FN-13-1, FN-13-2, FN-13-3, and NM9 at concentrations ranging from 44 to 120 µg/kg (see Figure K-56). Phenol was not detected in island soil.

- **3-Nitroaniline** – 3-Nitroaniline was detected once, at a concentration of 610 µg/kg at Station FN-13-2 along lower Ninemile Creek at the surface interval (0 to 0.15 m). Detection limits for 3-nitroaniline were 1,000 to 1,400 µg/kg. 3-Nitroaniline was not detected in island soil.

- **N-nitroso-di-*n*-propylamine** – N-nitroso-di-*n*-propylamine was detected once, at a concentration of 100 µg/kg at Station FN-12-9 along lower Ninemile Creek at the 0.15 to 0.30 m depth interval. Detection limits for N-nitroso-di-*n*-propylamine were 40 to 920 µg/kg.

5.3.3.2 Pesticides

Numerous pesticides were identified as CPOIs in floodplain soil and wetland sediment for the risk assessments (Chapter 1, Table 1-1). With the exception of endrin, heptachlor epoxide, and 4,4′-DDT, pesticide CPOIs were only sporadically detected in the 1998, 2000, and 2001 data (pesticides were not analyzed in 2002); however, for these detections, there were numerous exceedances of NYSDEC soil and wetland sediment screening criteria (Appendix J). Most detections in 1998, 2000, and 2001 were at or below the detection limits reported for other samples (Figures K-57 to K-64).

The highest concentrations for chlordanes, endrin, dieldrin, heptachlor epoxide, and 4,4′-DDT were found along Geddes Brook. The floodplain surface (0 to 0.15 m) samples at Transect GB1 contained α-chlordane at 82 and 45 µg/kg, γ-chlordane at 64 and 10 µg/kg, endrin at 46 and 28 µg/kg, dieldrin at 4,500 and 2,300 µg/kg, and 4,4′-DDT at 15 µg/kg. Lower Geddes Brook samples contained endrin at 7.5 µg/kg (Transect GB6), heptachlor epoxide at 7.0 and 5.2 µg/kg (Stations FG-1-5 and FG-1-6), and 4,4′-DDT at concentrations ranging from 1.1 to 18 µg/kg (cores 1, 4, 5, and 6 at Transect FG-1 and cores 2 and 4 at Transect FG-2). The highest 4,4′-DDT concentration in Geddes Brook was at Station FG-1-5 at the 0.15 to 0.30 m depth interval.

Along Ninemile Creek, the highest concentration of endrin (13 µg/kg) was at Station FN-4-2. Concentrations were 10 µg/kg or less at all other stations where endrin was detected. The highest concentration of heptachlor epoxide (4.2 µg/kg) was at Station TN-14-2; all other detected concentrations were less than 4 µg/kg. 4,4′-DDT concentrations were greater than 10 µg/kg at Stations FN-8-3 (11 µg/kg), FN-10-6 (11 µg/kg), and FN-12-12 (14 µg/kg). All other detections of 4,4′-DDT were less than 10 µg/kg.

Pesticides were occasionally detected in island soil. The detection of 4,4′-DDD in island surface soil at Station TN-14-2 (31 µg/kg) was inconsistent with floodplain soils in the area. This concentration was much higher than any detected value in samples collected along the bank; however, 4,4′-DDD was not detected (detection limit of 4.9 µg/kg) in the field duplicate at the same location.

5.3.3.3 Polychlorinated Biphenyls

Individual and total PCBs (sum of Aroclors) were identified as CPOIs in floodplain soil and wetland sediment in the risk assessments. Total PCBs exceeded NYSDEC soil and sediment screening criteria (Appendix J). The data collected independently of this RI (BBL, 1999) included one detection of Aroclor 1248. Aroclors 1248 and 1260 were not detected in 1998, but were sometimes detected in 2001. The highest values for Aroclor 1248 were at Stations FN-12-11 (100 µg/kg), FN-12-2 (200 µg/kg), and FN-12-3 (900 and 200 µg/kg) in lower Ninemile Creek and Station FG-1-5 (100 and 300 µg/kg) in lower Geddes Brook. All other detected values were less than 100 µg/kg. The highest value for Aroclor 1260 was 269 µg/kg, detected at Stations S381 in lower Ninemile Creek. Since Aroclors 1254 and 1268 were detected more frequently in soil and wetland sediment, concentration distribution maps and profiles were prepared (Figures 5-24, 5-25, K-65, and K-66).

In surface samples (Figures 5-24 and K-65), detections of Aroclor 1254 exceeded the NYSDEC human health criterion for total PCBs of 0.017 µg/kg (based on 2.1 percent TOC), with 24 percent of the detected values, the majority of which are located along Geddes Brook and Reach CD of Ninemile Creek, exceeding the wildlife bioaccumulation criterion for total PCBs of 29.4 µg/kg (based on 2.1 percent TOC). The highest surface concentration of Aroclor 1254 occurred at Station GB6c (130 µg/kg). Below 0.15 m, concentrations of Aroclor 1254 were higher relative to the surface interval, with 80 percent of the detected values exceeding the wildlife bioaccumulation criterion for total PCBs. The highest subsurface concentrations of Aroclor 1254 occurred at Stations FN-4-3 (300 µg/kg) and FN-8-3 (100 µg/kg).

In surface samples (Figures 5-25 and K-66), detections of Aroclor 1268 exceeded the NYSDEC human health criterion for total PCBs of 0.017 µg/kg (based on 2.1 percent TOC), with approximately 30 percent of the detected values, the majority of which are located along Geddes Brook and Reach CD of Ninemile Creek, exceeding the wildlife value for total PCBs of 29.4 µg/kg (based on 2.1 percent TOC), and one station (FN-4-3) exceeding the chronic toxicity criterion for total PCBs of 405 µg/kg. Below 0.15 m, concentrations of Aroclor 1268 generally continue to exceed the wildlife criterion for total PCBs. In particular, the concentration at Station FN-4-3, which had the highest concentration in surface samples (500 µg/kg), decreased to 300 µg/kg, while Station FN-10-6 increased from a surface concentration of 200 µg/kg to 700 µg/kg.

5.3.3.4 Dioxins and Furans

PCDD/PCDFs (Figures 5-26a and 5-26b) were assessed using the TEQ approach as described for sediment. In surface soils, human/mammalian TEQ values exceeded the NYSDEC wildlife bioaccumulation criterion of 4.2 ng/kg (based on 2.1 percent TOC) at several locations (Figures 5-26a and K-67), with the highest values occurring at Stations GB1a (67.6 ng/kg), GB1b (39.4 ng/kg), and NM5b (39.8 ng/kg). From 0.15 to 0.30 m, concentrations in several stations continued to exceed the NYSDEC wildlife criterion, especially on the right bank of Reach CD of Ninemile Creek and wetland stations closer to the mouth of Ninemile Creek. Values were higher at the 0.15 to 0.30 m interval than at the surface for Transect FG-1 (cores 4, 5, and 6: 48.3, 62.4, and 25.4 ng/kg, respectively) and Station NMFP-T-01-25 (62 ng/kg). Below 0.30 m, TEQ values generally decreased, but a value exceeding the NYSDEC human health criterion of 210 ng/kg (based on 2.1 percent TOC) occurred at Station NMFP-T-03-50 (383.5 ng/kg) to a depth of 0.9 m. Avian TEQ values ranged from 0.28 to 420 ng/kg, with the maximum occurring at Station NMFP-T-3-5 in the 0.60 to 0.90 m depth interval (Figures 5-26b and K-68).

5.3.4 Conventional Properties

Conventional properties of floodplain soil and wetland sediment that were analyzed in 1998 and 2001 include calcium and TOC. Calcium data are reported with the metals but are discussed here, since calcium is considered a marker for Solvay waste materials. Along Geddes Brook, calcium concentrations ranged from 31,100 mg/kg at Station FG-2-5 to 289,000 mg/kg at Station FG-2-4, with an average concentration of 129,800 mg/kg. Along Ninemile Creek, calcium concentrations ranged from 2,820 mg/kg at Station FN-13-1 to 335,000 mg/kg at Station S380, with an average concentration of 107,000 mg/kg.

The average calcium concentrations in surface floodplain soil and wetland sediment were 97,000 mg/kg in upper Geddes Brook and 135,000 mg/kg in lower Geddes Brook. The average calcium concentrations in surface floodplain soil were 69,700 mg/kg along upper Ninemile Creek and 103,000 mg/kg along lower Ninemile Creek.

Along Ninemile Creek, TOC concentrations ranged from 1,310 mg/kg at Station NMFP-T-08 to 649,000 mg/kg at Station FN-13-1, with an average concentration of 39,400 mg/kg. Along Geddes Brook, TOC concentrations ranged from 5,370 mg/kg at Station FG-1-1 to 68,100 mg/kg at Station FG-2-2, with an average concentration of 24,900 mg/kg.

5.3.5 Summary of Data Collected for the Geddes Brook Interim Remedial Measure Study

As noted in Chapter 2, floodplain soil was sampled along lower Geddes Brook below the confluence with the West Flume in December 2002 as part of the Geddes Brook IRM. The data and sample location maps, as provided by Honeywell, are included in Appendix M, and summary statistics are included in Appendix I. Mercury was detected in all of the 222 samples, and elevated levels were detected to depths of at least 0.9 m. In some locations, concentrations increased with depth, with two of the highest detections, 269 and 156 mg/kg, occurring at depths of 0.3 to 0.6 and 0.6 to 0.9 m, respectively, at Station SB-06, located on the left bank (facing downstream), above the culverts. A summary of the mercury levels in each of the four depth intervals, along with the number of exceedances of 10 mg/kg (presented as a general frame of reference since this value is approximately an order-of-magnitude greater than the SEL) is provided below:

- In surface soil (0 to 0.15 m), concentrations ranged from 0.13 to 15.7 mg/kg, with an average of 3.98 mg/kg. The maximum surface soil concentration was observed at Station SB-24, located on the right side of the brook (facing downstream) near the confluence with Ninemile Creek. Six of the 58 surface soil samples exceeded 10 mg/kg.

- Within the depth interval of 0.15 to 0.30 m, mercury ranged from 0.04 to 39.1 mg/kg, with an average of 6.13 mg/kg. The maximum concentration in this interval was detected at Station SB-17, located on the right side of the channel (facing downstream). Eleven of the 56 samples from this interval exceeded 10 mg/kg.

- Within the 0.30 to 0.60 m depth interval, mercury ranged from 0.05 to 269 mg/kg, with an average of 14.2 mg/kg. The highest concentration was observed at Station SB-06, and 13 of the 44 samples in this interval exceeded 10 mg/kg.

- Within the 0.60 to 0.90 m depth interval, mercury ranged from 0.02 mg/kg to 156 mg/kg, with an average of 7.2 mg/kg. The highest concentration for this interval was also detected at Station SB-06.

Mercury concentrations were generally consistent within the same depth intervals that were sampled in the 1998 and 2001 investigations (0 to 0.15 and 0.15 to 0.30 m). No samples deeper than 0.3 m were collected in 1998 and 2001.

As discussed above, there are high concentrations of mercury, including the highest found on the site, in the soil adjacent to lower Geddes Brook. In certain locations, these concentrations are significantly higher than the mercury concentrations found in the sediment of Geddes Brook. This is especially true in the low-lying area to the right (facing downstream) of the confluence of Geddes Brook and Ninemile Creek, in the mounded areas on the left bank of lower Geddes Brook along the access road, and along both banks of Geddes Brook between the discharge point of the West Flume and the culvert (see Figure 5-15 and Appendix M). In many of these locations, mercury is elevated down to the depth of the core (0.9 m). As discussed in Chapter 3 and below in Section 5.4, patterns such as these are likely associated with artificial modification of the stream bed. In lower Geddes Brook, it seems likely that the channel was deepened at some point by removal of sediment, with the sediment disposed of near the banks of the brook. It is likely that the distribution of mercury, with relatively lower concentrations (generally less than 10 mg/kg, with an average of 2.6 mg/kg in surface sediments) in the sediment of lower Geddes Brook and significantly higher concentrations in the floodplain subsurface soil, is due to these modifications.

Mercury was also analyzed in soil samples that were collected from within Geddes Brook under the sediment. In these samples, concentrations were significantly lower than those observed in the floodplain soil, ranging from 0.02 to 1.8 mg/kg, with an average of 0.33 mg/kg.

PAHs and hexachlorobenzene were analyzed in the 2002 Geddes Brook IRM samples, but at significantly fewer locations than mercury. Summary statistics for individual PAHs are included in Appendix I, and maps presenting the concentrations of individual PAH compounds, as provided by Honeywell, are included in Appendix M. Total PAHs ranged from 49 to 40,700 µg/kg, with an average of 3,900 µg/kg, for all depth intervals combined. The maximum concentration was observed at Station SB-18 in the 0.30 to 0.60 m depth interval. Hexachlorobenzene was detected in 17 of the 52 samples analyzed; however, it should be noted that there were some high detection limits reported, ranging from 390 to 24,000 μg/kg. In surface soils (0 to 0.15 m), concentrations ranged from 75 to 880 μg/kg, with an average of 343 μg/kg. The maximum concentration was detected at Station SB-03. Concentrations in the deeper soils (0.15 to 0.90 m) ranged from 73 to 8,100 μg/kg, with an average of 1,010 μg/kg. The maximum concentration was also detected at Station SB-03. The PAH and hexachlorobenzene 2002 IRM data are generally consistent with data from the 1998 and 2001 investigations.

PCDD/PCDFs were analyzed in the floodplain soil samples to a depth of 0.30 m. TEQs were calculated using half the detection limits for non-detects and WHO TEFs (Van den Berg et al., 1998). Mammal TEQ concentrations in surface soil ranged from 0.43 to 51.2 ng/kg, with an average of 9.91 ng/kg. Avian TEQs in surface soil ranged from 0.58 to 224 ng/kg. In the 0.15 to 0.30 m interval, mammal TEQs ranged from 0.23 to 136 ng/kg and avian TEQs ranged from 0.36 to 378 ng/kg. The highest TEQ concentrations in the 0 to 0.15 and 0.15 to 0.30 m intervals were observed at Station SB-03, located on the right bank (facing downstream), upstream of the culvert. The PCDD/PCDF 2002 IRM data are generally consistent with data from the 1998 and 2001 investigations.

5.4 Mercury Patterns in Sediment and Floodplain Soil

In the review of the extent of CPOIs and conventional parameters, including ionic waste constituents, in sediment and floodplain soil, there are relationships apparent between Solvay waste, mercury, and the bathymetry/topography of Ninemile Creek, Geddes Brook, and associated floodplains, as illustrated in Figure 5-2. These relationships are most complex in Reach CD of Ninemile Creek, which is the reach containing the islands. This section presents a discussion combining the sediment and soil mercury distributions and includes a short introduction to and a detailed discussion of Figure 5-2.

5.4.1 Introduction

Historically, Solvay waste was discharged to Ninemile Creek directly from Wastebeds 9 to 11 and from Geddes Brook, and was deposited throughout lower Ninemile Creek. During Honeywell's operations, water flows in the creek were about two times the current flows. As a result, the creek likely occupied a larger area historically than it does today. The high-water mark in this area corresponds to the 113.4 m (372 ft) elevation at the USGS station at Lakeland, and the historic high-water mark mapped during Tropical Storm Agnes (1972) is consistent with this elevation.

Solvay waste deposits have been logged throughout Reach CD; specifically, between the islands and the right bank. Solvay waste, as described from field notes, is not a consistent material, as there are color and texture differences. In this discussion, the following descriptions from the 2001 sediment probing logs have been interpreted as Solvay waste: "crust (hard or soft)," "Solvay waste," and "calcite."

The left side of Reach CD, which borders Wastebeds 10 and 11, has a steep slope rising from the bank. The steep slope off the creek bank is not always consistent, as there are occasional flat areas next to the creek. The topography along the right bank is more complex. From the confluence with

Geddes Brook to the boundary with Reach BC, the floodplain is characterized by step-like topography. There is a gradual slope adjacent to the bank that extends onto relatively large, flat areas. In some areas, the slope off the bank is steep.

Exponent (2001c, Appendix H herein) found that the area between the islands and the left bank is strongly erosional, while the area between the islands and the right bank is quiescent (depositional). They also note that complete mixing in this reach is impeded by the islands. Solvay waste deposits were logged in the sediment transects collected along the right bank. As noted in Section 5.2, mercury contamination is extensive in the sediment along the right bank in this reach of the creek. Mercury concentrations are presented in terms of ranges that are based on the NYSDEC sediment screening criteria (i.e., LEL of 0.15 mg/kg and SEL of 1.3 mg/kg), as shown on Figure 5-2 and discussed below.

5.4.2 Transect Descriptions

Figure 5-2 presents cross sections of Ninemile Creek sediment and floodplain areas, based on creek bathymetry and floodplain topography, as well as mercury contamination profiles, for both sediment and soil. Cross sections for each of the three reaches of lower Ninemile Creek (i.e., Reaches CD, BC, and AB) are shown on Figure 5-2. Descriptions of the transects in each of the three reaches are provided below, from the upstream reach just below Geddes Brook (Reach CD) to the most downstream reach (Reach AB). In the descriptions of the cross sections below, left and right banks are designated as facing in a downstream direction. Transects and/or stations that are in close proximity are grouped together in Figure 5-2 and in the discussions below.

5.4.2.1 Reach CD

Reach CD of lower Ninemile Creek begins at the confluence with Geddes Brook and extends to the first bend in the creek, downstream of the islands (Figure 5-2). Relevant transects are described as follows:

- **Transect FN-13 (floodplain)** – Transect FN-13 is located just downstream of the confluence with Geddes Brook, where fast rapids were noted during the 2001 sediment probing study. The samples collected along the right bank have elevated mercury concentrations (1.3 to 3.2 mg/kg). These samples were collected in a relatively flat area adjacent to the creek. The samples collected on the incline on the left bank are also elevated (0.32 to 1.3 mg/kg). The soil samples extend to a depth of 0.3 m.

- **Transects TN-15 (sediment) and NMFP-T-1 (floodplain)** – Transect TN-15 is located just before the upstream end of the large island. Three samples were collected at this transect. The left and middle channel samples do not show mercury contamination (less than 0.15 mg/kg) at the surface or at depth. The right channel samples show mercury contamination (3.2 to greater than 32 mg/kg) to a depth of 1.65 m, and calcite and slag were noted in the sample logs down to 1 m. Transect NMFP-T-1 is located adjacent to Ninemile Creek, slightly downstream of Transect TN-15 (they are shown on the same cross section). Elevated mercury concentrations are present to depth in this transect, averaging about 0.40 mg/kg. Three out of four floodplain cores were collected at elevations greater than 372 ft (113.4 m), in a dry area characterized by cobbles and debris.

- **Transect FN-12 (floodplain) –** This is the first transect to traverse the large island. The mercury concentrations within the island sediments are between 0.32 and 1.3 mg/kg. The sample adjacent to the left bank has slightly higher mercury concentrations (1.3 to 3.2 mg/kg), and concentrations decline up the bank. There is a flat area adjacent to the right bank with elevated mercury concentrations (1.3 to 10 mg/kg), with the deeper (0.15 to 0.30 m) samples having the highest concentrations. The 2001 BBL field notes indicate a hard, crusty layer (Solvay waste) along the right bank, adjacent to the large island.

- **Transect NM5 (sediment and floodplain) and Station TN-14-3 (sediment)** – The sediment Station NM5 is located between the large island and the left bank. Elevated mercury levels (1.3 to 3.2 mg/kg) were encountered in the surface sample collected in the left channel. Station TN-14-3 is located adjacent to the large island along the right bank. Solvay waste is noted in the sediment log to a depth of 1.65 m, coincident with high mercury concentrations (greater than 10 mg/kg). The field log also notes a hard, crusty layer (Solvay waste) along the right bank, adjacent to the large island. There were three surface soil samples collected adjacent to Ninemile Creek in the flat area along the right bank at Stations NM5a, b, and c. Station NM5a is farthest from Ninemile Creek and has elevated mercury concentrations (0.32 to 1.3 mg/kg); however, this concentration is low relative to those measured at Stations NM5b (greater than 32 mg/kg) and NM5c (3.2 to 10 mg/kg).

- **Transects TN-14 (sediment), MN-2 (sediment), and NMFP-T-2 (floodplain)** – Station TN-14-1 is located between the large island and the left bank and shows low levels of mercury (less than 0.15 mg/kg). Station TN-14-2 is located on the large island and has elevated mercury levels (0.32 to 1.3 mg/kg) at the surface that decline with depth. Station MN-2 is located adjacent to the large island on the south side, near a downed tree. There was an oil sheen noted in the field log for this station in the 0.45 to 0.75 m depth interval. The upper samples at Station MN-2 have high mercury concentrations (greater than 10 mg/kg) that decline at depth (less than 0.15 mg/kg). Station NMFP-T-2-5 is located in the flat area along the right bank and shows elevated mercury concentrations (0.32 to 1.3 mg/kg) down to a 0.9 m depth.

- **Transect FN-11 (floodplain) and Station NMFP-T-2-25 (floodplain) –** The floodplain samples collected in Transect FN-11 from the left bank of the creek show elevated mercury concentrations (0.32 to 1.3 mg/kg). The samples collected on the left side of the large island show the same concentration range (0.32 to 1.3 mg/kg). The samples collected on the right side of the island show higher concentrations (1.3 to 3.2 mg/kg). The samples collected adjacent to the right bank (note that the slope off the creek is steeper in this area) show surface concentrations in the 1.3 to 3.2 mg/kg range. The mercury concentration in the bordering sample increases up to 10 mg/kg at the 0.15 to 0.30 m depth interval, and the concentrations in the sample farther out decline at this depth. The field notes indicate a crusty layer (Solvay waste) extending from the right bank to the large island in this area. Station NMFP-T-2-25 is located at a higher elevation in a dry, flat area characterized by debris. Low mercury (less than 0.15 mg/kg) concentrations were measured at this station.

- **Transect TN-13 (sediment)** – Station TN-13-1 is located between the left bank and the large island, and shows low mercury concentrations (less than 0.15 mg/kg). Station TN-13-2 is located on the large island and shows elevated mercury concentrations (0.32 to 3.2 mg/kg) in the surface samples, and concentrations decline with depth. Station TN-13-3 has high mercury concentrations to a depth of approximately 2 m. Solvay waste and associated calcite are noted in the sediment log down to the 0.45 m interval. The field notes mention a crusty layer (Solvay waste) extending from the right bank to the large island in this area, as well as a similar layer adjacent to the large island along the left bank.

- **Stations NM6 (sediment) and NMFP-T-2-180 (floodplain)** – Only two sediment samples were collected at Station NM6, at the 0 to 0.15 and 0.15 to 0.30 m depth intervals, and both show high levels of mercury, between 10 to 32 and 3.2 to 10 mg/kg, respectively. The soil sample at Station NMFP-T-2-180 was collected at a higher elevation in a dry, flat area characterized by cobbles/debris with lower levels of mercury (0.15 to 0.32 mg/kg).

- **Stations CN-1 (sediment) and NMFP-T-2-330 (floodplain)** – Station CN-1 is located between the large island and the middle island. Mercury concentrations detected at this location were low (less than 0.15 mg/kg). The field notes indicate a crusty layer (Solvay waste) in the two samples collected along the right side of the creek. Station NMFP-T-2-330 is located at a higher elevation in a dry, flat area characterized by cobbles/debris, and has low levels of mercury (less than 0.32 mg/kg).

- **Transects TN-12 (sediment) and NMFP-T-3 (floodplain)**– Samples from Stations TN-12-1 and TN-12-2, the left and mid-channel stations, respectively, both have low mercury concentrations, generally less than 0.15 mg/kg. Station TN-12-3 is located adjacent to the right bank and has high mercury concentrations (greater than 10 mg/kg) to a depth of 0.75 m. Calcite was noted in the sediment log from 0.15 to 0.45 m depth, as well as several crusty layers in the two right-most probing locations. The mercury concentrations are also elevated in the floodplain soils in this area. Station NMFP-T-3-5 has elevated mercury concentrations (greater than 10 mg/kg) at depth (0.30 to 0.60 and 0.60 to 0.90 m). The two surface samples show contamination in the 1.3 to 3.2 mg/kg range. Station NMFP-T-3-25 has higher mercury concentrations near the surface (3.2 to 10 mg/kg). Station NMFP-T-3-50 is located along an incline and had lower mercury concentrations on the order of 0.32 to 1.3 mg/kg. Station NMFP-T-3-330 is at a higher elevation in a dry, flat area characterized by cobbles/debris and has low mercury concentrations (less than 0.32 mg/kg). It should be noted that at Stations NMFP-T-3-5 and TN-12-3, the higher mercury concentrations were detected at approximately the same elevation.

- **Transect FN-10 (floodplain)** – Transect FN-10 is located at the upstream end of the middle island and is near Transect NMFP-T-3. The surface sample, collected adjacent to the left bank, showed elevated mercury concentrations (0.32 to 1.3 mg/kg), while the deeper (0.15 to 0.30 m) sample showed higher mercury levels (3.2 to 10 mg/kg). This sample was collected in a flat area adjacent to the creek. The samples farther up the incline from the left bank had low mercury concentrations (less than 0.15 mg/kg). The samples collected along the right side of the creek show elevated mercury levels. The probing log notes crusty layers (Solvay waste) on the right side of the creek.

- **Transect TN-11 (sediment)** – Transect TN-11 is located at the center of the middle island. Solvay waste was noted in the field log for Station TN-11-1, along the left bank, at a depth of 0.15 to 0.45 m. Elevated mercury concentrations were detected in the surface (0 to 0.30 m) samples at this station. Station TN-11-2 is located on the middle island. The mercury concentration detected in the 0.15 to 0.45 m sample from this station was the highest measured on any of the islands (3.2 to 10 mg/kg), and declined below this depth. Station TN-11-3 in the right channel had elevated mercury concentrations (1.3 to 3.2 mg/kg), while floodplain samples collected along the right bank in this area had lower concentrations. Crusty layers (Solvay waste) extending from the right bank to the large island were noted in this area. In addition, a calcite mound was noted between the middle island and the right bank.

- **Station CN-2 (sediment) and Transect NMFP-T-5 (floodplain)** – Station CN-2 is located between the middle island and the most downstream island. The sediment log notes calcite from 0 to 0.45 m depth, corresponding to elevated mercury concentrations (0.32 to 10 mg/kg). The mercury concentrations declined with depth. The field notes indicate a thick crust (Solvay waste) at the right bank in this area. Station NMFP-T-5-5 is located in a marshy, flat area adjacent to Ninemile Creek where high mercury concentrations (3.2 to 32 mg/kg) were detected to the 0.90 m depth. Stations

NMFP-T-5-25 and NMFP-T-5-50 are located at higher elevations, along a gradual incline. The surface concentrations (0 to 0.30 m) detected were lower than those detected adjacent to the creek, but were still elevated (0.32 to 1.3 mg/kg). The mercury concentrations in these samples declined with depth. Stations NMFP-T-5-150 and NMFP-T-5-200 are located in a large, flat area at higher elevations (but still below 372 ft [113.4 m]). These samples had high mercury concentrations (1.3 to 10 mg/kg) at the surface (0 to 0.30 m). It is noted that the mercury concentrations in the samples collected in a marshy area at approximately 150 and 200 ft (45 and 60 m) from the bank were higher than those detected at 25 and 50 ft (7.6 and 15.2 m) from the bank.

- **Transects TN-10 (sediment) and FN-9 (floodplain)** – Transects TN-10 and FN-9 are located along the downstream island. The floodplain samples off the left bank had elevated mercury concentrations. Notably, the sample adjacent to the creek had low mercury concentrations (less than 0.15 mg/kg), while the two up-slope samples had higher concentrations (0.32 to 1.3 mg/kg). Station TN-10-1 is located adjacent to the downstream island along the left bank and had low mercury concentrations (less than 0.15 mg/kg). Station TN-10-2 is located adjacent to the downstream island on the right side, and the surface sample (0 to 0.15 m) showed elevated mercury concentrations. Lower levels of mercury were detected at depth. Station TN-10-3 is located between Station TN-10-2 and the right bank and had elevated mercury concentrations to a depth of 1.05 m. The concentrations abruptly declined to less than 0.15 mg/kg at depth. Solvay waste and associated calcite were noted in the sediment log at about 0.45 m. The floodplain samples collected adjacent to the right bank also showed high mercury concentrations (3.2 to 32 mg/kg). Again, these concentrations were higher at depth (0.15 to 0.30 m). These samples were collected in a flat area adjacent to the creek.

- **Transect TN-9 (sediment) and Station NM7 (sediment)** – Stations TN-9-1 and NM7 are located on the left side of the channel and showed elevated mercury concentrations. Station TN-9-2 is located at the approximate center of the channel and also showed elevated mercury concentrations (0.32 to 3.2 mg/kg). Station TN-9-3 is located along the right bank and had elevated concentrations (up to 8 mg/kg) to a depth of 1.65 m, below which concentrations began to decline. Solvay waste was noted in the field log for Station TN-9-3 from 0 to 0.75 m depth.

- **Transects TN-8 (sediment), NMFP-T-6 (floodplain), and NMFP-T-7 (floodplain)** – Transect NMFP-T-7 is located on the left bank of Ninemile Creek. The samples collected adjacent to the creek had elevated mercury concentrations (0.32 to 1.3 mg/kg). The samples collected along the incline had lower mercury concentrations (less than 0.32 mg/kg). Station TN-8-1 had elevated mercury concentrations (1.3 to 3.2 mg/kg) at the surface; these concentrations declined (0.32 to 1.3 mg/kg) at depth. Station TN-8-2 had the highest mercury concentrations measured in this transect (10 to 32 mg/kg). Station TN-8C had elevated mercury concentrations that increased to 8.8 mg/kg at a depth of 3 m, and then declined to less than 0.15 mg/kg. In the sediment log, Solvay waste was noted from 2.4 to 4 m, corresponding to the high mercury concentrations. Transect NMFP-T-6 is located perpendicular to the right bank in a relatively flat area (although there is a gradual incline). The mercury concentrations were consistently elevated (0.32 to 1.3 mg/kg) at this transect to a depth of 0.9 m. The probing log noted crusty layers (Solvay waste) on the right side of the creek, with an oil sheen and odor noted in the 1 to 1.2 m depth interval.

5.4.2.2 Reach BC

As discussed in Chapter 3, Reach BC (see Figure 5-2) was rerouted to accommodate the construction of I-690 and New York State Route 695 (Route 695). Solvay waste deposits were also noted in this reach. Exponent (2001c) found that the majority of this reach is depositional. In general, Reach BC has the lowest overall mercury concentrations in lower Ninemile Creek. With the exception of sediment Transect TN-7, concentrations greater than 10 mg/kg were not observed and the majority of the data were less than 3.2 mg/kg. There are three sediment transects located in Reach BC: Transects TN-6, TN-7, and MN-1/NM8. These transects are all characterized by elevated mercury concentrations in the 0 to 0.30 m depth interval (0.32 to 3.2 mg/kg) that declined with depth. The floodplain concentrations in this reach were comparable to the sediment concentrations, and floodplain samples collected adjacent to the creek and at lower elevations typically had higher mercury concentrations. Concentrations decreased with distance from the bank along either side of the creek. It should be noted that there are limited data at depth in the floodplain adjacent to the creek.

5.4.2.3 Reach AB

As discussed in Chapter 3, Reach AB (see Figure 5-2) appears to have been dredged in the 1960s by Honeywell and Onondaga County, and the majority of the Solvay waste in the creek near its mouth appears to have been removed at that time, except for what has been described in the coring logs as a calcite shelf along the right bank. Solvay waste was noted in sediment and soil cores throughout this reach, which is strongly depositional and is relatively deep (5 [1.5 m] to 10 ft [3.0 m]). The channel sediments are characterized by elevated surficial mercury concentrations (0.32 to 32 mg/kg range) that declined (typically less than 0.15 mg/kg) at depth.

The floodplain at the mouth of Ninemile Creek is flat on either side of the creek, extending to Transect TN-1, where it is flat along the left bank. Mercury concentrations in this area are among the highest measured in the floodplain. With the exception of the samples adjacent to the mouth of Ninemile Creek (Transect NMFP-T-13), the contamination appears to diminish at a depth of about 1 m. Farther upstream (Transect NMFP-T-12), the concentrations along the left bank diminished with depth; however, this trend is only apparent in stations located greater than 60 m (200 ft) from the left bank. Adjacent to Ninemile Creek, the concentrations remained elevated at depth. In this same area along the left bank, limited data show high mercury concentrations at the surface intervals (0 to 0.30 m). Farther upstream (Transects NMFP-T-11 to FN-5), the bank is characterized by steep inclines on either side. Where there is a flat area adjacent to the creek, there were higher mercury concentrations. Moving up the incline to higher elevations, the mercury concentrations diminished. It should be noted that along the right bank, even at elevations greater than 372 ft (113 m), there were still high mercury concentrations. These stations are located adjacent to Wastebeds 1 to 8 and Solvay waste was noted in the soil log for many of these samples.

5.5 Surface Water Characterization

In 1998, for the Geddes Brook/Ninemile Creek RI, Exponent collected surface water samples during low flow in July and September from the following locations (Chapter 2, Figure 2-1):

- **Geddes Brook** – four stations: GB1, GB2, GB3, and GB8.
- **West Flume** – one station: GB4.
- **Unnamed tributary** – one station: GB5.
- **Ninemile Creek** – seven stations: NM1, NM2, NM3, NM4, NM6, NM8, and NM10.

Samples were analyzed for conventional analytes, TAL metals plus methylmercury, VOCs, SVOCs, pesticides, PCBs, and PCDD/PCDFs.

Figures 5-27 through 5-40 present concentrations of CPOIs detected in surface water in samples collected from Geddes Brook and Ninemile Creek, except for thallium and arsenic, which were detected infrequently and thus did not warrant illustration. Thallium was detected only once and arsenic was not detected in any of the Geddes Brook and Ninemile Creek samples. The West Flume (1990 Station CDR-20 and 1998 Station GB4) sample concentrations are illustrated on the figures for mercury (Figures 5-27a and 5-27b) and methylmercury (Figures 5-28a and 5-28b) only, and concentrations of other CPOIs at this station and the unnamed tributary station (GB5) are discussed in the text and are not shown on the figures. Concentrations of total chloride, calcium, sodium, and total dissolved solids (TDS) are presented in Figures 5-41 to 5-44.

As discussed in Chapter 2, Section 2.13, there have been other historical sampling programs in the Geddes Brook/Ninemile Creek system. The data from these studies are presented in Appendix L. Of particular note, the CDR (1991) sampling in 1990 also included two sampling events at base-flow for low-level mercury with 22 stations, and the 1995 mercury sampling (PTI, 1996) was the only program to effectively capture a storm-related high-flow event. The sampling programs by Honeywell/PTI in 1992 (PTI, 1993) and recent sampling by Onondaga County (K. Murphy, pers. comm., 2002) also provide low-level mercury analysis, but were much more limited in the number of sampling locations.

5.5.1 Mercury

The total mercury concentrations in surface water for CDR's 1990 sampling data and Exponent's 1998 RI data are displayed in Figures 5-27a and 5-27b, respectively. The average unfiltered total mercury concentrations were 1.99 and 22.3 ng/L in upper and lower Geddes Brook, respectively, and 3.9 and 9.2 ng/L in upper and lower Ninemile Creek, respectively in 1998 (Appendix I). Samples collected at the mouth of the West Flume (Station GB4) had the highest concentrations of unfiltered total mercury (815 ng/L in July and 1,090 ng/L in September). Unfiltered total mercury was not detected (less than 0.63 ng/L) in the unnamed tributary (Station GB5) during either July or September sampling.

In Ninemile Creek in 1998, the lowest concentrations during each of the two sampling events were from Stations NM3 and NM4, located upstream of the confluence with Geddes Brook. The highest concentrations were from Stations NM8 (5.99 and 9.4 ng/L) and NM10 (6.77 and 7.55 ng/L in July [sample and field duplicate] and 26.9 ng/L in September), both located downstream of the Geddes Brook confluence. A similar pattern was observed by CDR (1991), although the absolute concentrations differed.

Dissolved (filtered) total mercury concentrations were detected at only two locations: Stations GB4 (the West Flume) (56.8 ng/L in July and 41.4 ng/L in September) and GB8 (1.33 and 1.41 ng/L [sample and field duplicate] in July). The fraction of the total mercury associated with particles can be estimated by comparing the total mercury (unfiltered) with the total dissolved mercury concentrations. Most of the results for total dissolved mercury analysis were reported as undetected, and the full detection limit was used in the calculations. This approach may result in underestimation of the fraction of total mercury associated with particles and the concentration of total mercury on particles. For all water samples collected in July and September of 1998, the fraction of total mercury associated with particles ranged from 75 to 99 percent, with an average of 91 percent (Table 5-3). The lowest fractions (75 to 77 percent) were observed in upper Geddes Brook, while the highest fractions (98 and 99 percent) were observed at the most downstream Ninemile Creek stations (NM8 and NM10).

The concentration of total mercury on particles (i.e., particulate total mercury concentration) was calculated based on the percent of total mercury associated with particles and the total suspended solids (TSS) content of each sample (Table 5-3). The highest concentrations of mercury on suspended particles (30 and 58 mg/kg) were in samples from the West Flume. With the exception of lower Geddes Brook samples (6.6 and 2.66 mg/kg) and the September sample from Ninemile Creek Station NM10 (2 mg/kg), all other particulate total mercury concentrations were less than 1.0 mg/kg. In July, particulate total mercury concentrations were lower in upper reaches of both Geddes Brook and Ninemile Creek than in lower reaches. In September, non-detections of both unfiltered and dissolved total mercury in Geddes Brook precluded most calculations. In Ninemile Creek, particulate total mercury concentrations were lower in the upper reach than in the lower reach, with the exception of Station NM6.

Methylmercury concentrations in surface water for CDR's 1990 (unfiltered) and Exponent's 1998 (dissolved) data are presented in Figures 5-28a and 5-28b. The 1998 average dissolved methylmercury concentrations were 0.027 and 0.037 ng/L in upper and lower Geddes Brook, respectively, and 0.039 and 0.021 ng/L in upper and lower Ninemile Creek, respectively (Appendix I). Samples collected at the mouth of the West Flume (Station GB4) had the highest concentrations of dissolved methylmercury (1.14 ng/L in July and 1.26 ng/L in September). Dissolved methylmercury was detected (0.101 ng/L) in the unnamed tributary (Station GB5) during the September sampling only. There was little change in the dissolved methylmercury concentrations along the length of Ninemile Creek.

The high-flow sampling conducted in 1995 (PTI, 1996) included sampling stations in upper Ninemile Creek just above the confluence with Geddes Brook, in lower Ninemile Creek at State Fair Boulevard, and at the mouth of Geddes Brook. The total mercury concentrations ranged from 1.34 to 11.1 ng/L in upper Ninemile Creek, from 27.6 to 455 ng/L in lower Ninemile Creek, and from 169 to 615 ng/L in lower Geddes Brook. Methylmercury concentrations ranged from 0.051 to 0.164 ng/L in upper Ninemile Creek, from 0.120 to 1.65 ng/L in lower Ninemile Creek, and from 0.325 to 3.0 ng/L in Geddes Brook.

Figures 5-29 to 5-31 present total mercury concentrations in the base-flow surface water from 1990 to 2001 for the five major reaches of the Geddes Brook/Ninemile Creek system (West Flume [Figure 5-29], upper and lower Geddes Brook [Figure 5-30], and upper and lower Ninemile Creek [Figure 5-31]). These data for base-flow conditions were taken from the sampling conducted by CDR in 1990 (CDR, 1991), by PTI in 1992 (PTI, 1993), and Exponent in 1998 (Exponent, 2001c), as well as from data collected by Onondaga County between 1999 and 2001 (K. Murphy, pers. comm., 2002). Total mercury concentrations in the West Flume have declined between 1990 and 1998, with concentrations in 1998 about 85 percent lower than concentrations in 1990 (Figure 5-29). Total mercury concentrations also declined from 1990 to 2001 in lower Geddes Brook (Figure 5-30) and lower Ninemile Creek (Figure 5-31). Concentrations in lower Geddes Brook and lower Ninemile Creek in 1998 were about 90 and 77 percent lower than the corresponding concentrations in 1990, respectively. The Onondaga County data from 1999 to 2001 did not differ significantly from the 1998 data. This decline was not evident in upper Geddes Brook (Figure 5-30) and upper Ninemile Creek (Figure 5-31), although concentrations were much lower in the upper reaches compared to the lower reaches.

The patterns of methylmercury over time are slightly different from those of total mercury (Figures 5-32 to 5-34). A decline in methylmercury is evident in the West Flume (Figure 5-32) and, to a lesser degree, in lower Geddes Brook (Figure 5-33). However, no decline in methylmercury is evident in upper or lower Ninemile Creek (Figure 5-34) or in upper Geddes Brook (Figure 5-33).

5.5.2 Other Metals

Four metals other than mercury were detected in surface water at concentrations exceeding ecological screening criteria and were thus retained as ecological chemicals of concern, including aluminum, barium, iron, and manganese (TAMS, 2003a). The HHRA identified six metals (antimony, cadmium, chromium, lead, manganese, and thallium) in surface water as human health COPCs (TAMS, 2003b). The CPOI metals were analyzed in both unfiltered and filtered (dissolved) samples and are discussed below.

- **Aluminum** – Unfiltered aluminum was detected at least once at all but two sampling locations (Stations GB8 and GB5) (detection limits of 37.4 and 43.8 µg/L for Station GB8 and 26 and 42.6 µg/L for Station GB5), including the most upstream locations (Figure 5-35). Detected concentrations ranged from 91.8 to 401 µg/L, with the highest concentration occurring at Station NM1 during the July sampling. Dissolved aluminum was not detected in the 1998 sampling.

- **Antimony** – Unfiltered antimony was detected in 6 of the 13 surface water stations (with a detection limit of 1.4 µg/L) in 1998 (Figure 5-36). The highest concentration (3.7 µg/L, unfiltered) was observed at Station NM1 during the July sampling. Dissolved antimony was detected in 4 of the 13 stations with the highest concentration (3.1 µg/L) at Station NM3 in July.

- **Barium** – Unfiltered barium was detected at all locations, with concentrations ranging from 38.4 to 127 µg/L (Figure 5-37). Dissolved barium was detected at all locations, with concentrations ranging from 39 to 126 µg/L. The highest concentrations were at the West Flume (Station GB4).

- **Cadmium** – Unfiltered and dissolved cadmium were not detected at any of the stations in 1998.

- **Chromium** – Unfiltered and dissolved chromium were not detected at any of the stations in 1998.

- **Iron** – Unfiltered iron was detected at all locations, with concentrations ranging from 49 to 6,790 µg/L (Figure 5-38), and the highest concentration at Station GB5 (the unnamed tributary). The iron concentration at Station GB5 was nearly an order-of-magnitude higher than all other samples during both sampling events. Dissolved iron was detected at 3 of the 13 surface water stations in the 1998 sampling.

- **Lead** – Unfiltered lead was detected at 5 of the 13 stations (Figure 5-39), with the highest concentration (2.5 µg/L) at the West Flume (Station GB4) in September. Dissolved lead was detected in 4 of the 13 stations, with the highest concentration (6 µg/L) at Station NM2 in July.

- **Manganese** – Unfiltered manganese was detected at all locations, with concentrations ranging from 4 to 1,260 µg/L (Figure 5-40), with the highest concentration found at the unnamed tributary (Station GB5) in July. It should be noted that the concentrations in the unnamed tributary were an order-of-magnitude higher than other locations. Filtered manganese concentrations were detected at all locations, with concentrations ranging from 2.9 µg/L (note that the September sample at this location, Station GB1, was non-detect) to 1,210 µg/L in July at Station GB5 (the unnamed tributary).

- **Thallium –** Thallium was detected once at Station GB4 (5.2 µg/L, filtered, September) and once at Station GB8 (12.3 µg/L, unfiltered, July). All other samples were below the detection limit of 4.7 µg/L.

Average detected metal concentrations for upper and lower reaches of both Geddes Brook and Ninemile Creek surface water are presented in Appendix I. For Geddes Brook, lead concentrations are higher in upper reaches than in lower reaches; barium, copper, and magnesium concentrations are approximately the same in upper and lower reaches; and antimony, iron, manganese, potassium, sodium, and vanadium concentrations are higher in lower reaches than in upper reaches (approximately 1.3 to 4.3 times higher). For Ninemile Creek, concentrations of four metals (i.e., aluminum, antimony, copper, and lead) are higher in upper reaches than in lower reaches, while vanadium concentrations are similar. Concentrations of barium, iron, magnesium, manganese, potassium, and sodium are higher (by approximately 1.2 to 3 times) in lower than in upper reaches of Ninemile Creek.

5.5.3 Organic Contaminants

PCDD/PCDFs were the organic contaminants that were identified as human health COPCs based on screening in the HHRA (TAMS, 2003b). In 1998, PCDD/PCDFs were detected in surface water only at three stations: GB2 and GB4 in September and NM2 in July, at concentrations up to 39.9 pg/L for total PCDD/PCDFs at Station NM2.

The only other organic contaminants detected in surface water in 1998 were chlorobenzene in the unnamed tributary and upper and lower Ninemile Creek, and diethylphthalate in upper Ninemile Creek. Chlorobenzene was detected in all Ninemile Creek samples downstream of Station NM2 (1.2 to 2.2 µg/L) and at Station GB5 (the unnamed tributary) (5.5 and 4.8 µg/L). One of the chlorobenzene concentrations (5.5 µg/L) in the unnamed tributary exceeded the NYSDEC chronic value for protection of aquatic life (5 µg/L).

Surface water data collected independently of this RI for unfiltered organic contaminants consist mostly of isolated occurrences at estimated concentrations below detection limits for other samples (Appendix L). NYSDEC (1989, 1992) reported detections of several VOCs and SVOCs in Geddes Brook and Ninemile Creek (see Appendix L, Tables L-2 and L-3). PTI (1993) reported one occurrence of an organic contaminant (toluene in Geddes Brook) (see Appendix L, Table L-7). BBL (1999) reported occasional detections of acetone, benzene, chlorobenzene, 1,4-dichlorobenzene, methylene chloride, phenol, and toluene in Ninemile Creek (see Appendix L, Table L-9). Analysis of unfiltered samples rather than filtered samples may explain the occasional occurrence of some organic contaminants in data collected independently of this RI, but that do not occur in the current RI data set.

5.5.4 Ionic Waste Constituents

Ionic waste constituents of surface water measured in 1998 included calcium, conductivity, hardness, salinity, sodium, total chloride, and TDS (Appendix A, Tables A-1, A-2, A-8, and A-9). Figures 5-41 through 5-44 present the 1998 surface water concentrations of total chloride, calcium, sodium, and TDS, respectively. All of these constituents were identified as stressors of concern in the BERA, and all increased in concentration in both Geddes Brook and Ninemile Creek as water flowed downstream past the Solvay Wastebeds.

In Geddes Brook, the highest concentrations of these parameters were observed at Station GB8, downstream of the unnamed tributary. Concentrations of these parameters in the West Flume were less than in Geddes Brook upstream of the West Flume with the exception of total chloride, which was 195 mg/L in July and 226 mg/L in September at Station GB3 and 297 mg/L at Station GB4 in the West Flume in July. In contrast, the unnamed tributary had much higher concentrations of all ionic waste constituents than did any of the Geddes Brook stations. For example, TDS in the unnamed tributary was 14,400 mg/L in July, while upstream and downstream Geddes Brook stations (GB3 and GB8) were 1,550 and 2,340 mg/L. Similarly, total chloride and calcium concentrations in the unnamed tributary were 6,930 and 2,050 mg/L in July while the upstream station (GB3) had 195 and 308 mg/L of total chloride and calcium, respectively. The downstream station (GB8) had 490 and 396 mg/L of total chloride and calcium, respectively, reflecting the input of the unnamed tributary. Similar results were obtained by CDR (1991), which identified drainage carried by the unnamed tributary as contributing substantially to the loading of most dissolved conventional constituents in lower Geddes Brook.

The greatest increase in concentrations of ionic waste constituents along Ninemile Creek occurred between Stations NM3 and NM4, along Wastebeds 9 to 11. TDS increased from 1,430 to 2,810 mg/L, total chloride increased from 288 to 674 mg/L, and calcium increased from 216 to 354 mg/L between Stations NM3 and NM4 in July 1998. Concentrations did not increase substantially in the lower reaches of Ninemile Creek in 1998, similar to observations in 1990 by CDR (1991).

5.6 Fish Characterization

This section summarizes the measured occurrences of CPOIs in fish sampled in the Geddes Brook/Ninemile Creek site. Fish samples were collected in Geddes Brook and Ninemile Creek by Exponent in 1998 as part of the Geddes Brook/Ninemile Creek RI and in 2000 in lower Ninemile Creek as part of the Onondaga Lake RI. Supplemental YOY fish samples were collected in Ninemile Creek in 2002 by NYSDEC/TAMS.

Samples of adult fish and YOY fish were collected and analyzed during the RI in 1998. In July 1998, Exponent collected adult fish (34 individuals and one composite) from five locations in Ninemile Creek (Stations NM1, NM2, NM3, NM5, and NM9) and two locations in Geddes Brook (Stations GB3 and GB8). Composite YOY fish were only collected at two locations in Ninemile Creek (Stations NM2 and NM3) in 1998. The YOY fish were not sufficiently abundant at the other five stations sampled to meet the minimum sample volume requirement for any analysis. Fillet and remainder tissue (i.e., viscera) samples of adult fish were analyzed for total mercury, TAL metals and cyanide, pesticides and PCBs, TCL SVOCs, PCDD/PCDFs, and total solids, whenever possible. Summary statistics of 1998 adult and YOY fish data are presented in Appendix I.

Fish samples were also collected from lower Ninemile Creek and its mouth during the Onondaga Lake Phase 2A investigation in 2000 (TAMS, 2002c). Data from these samples are included in the following discussion; however, true comparison is difficult because of the limited number of samples and the variability in fish size and species. Summary statistics of the 2000 fish data are also presented in Appendix I.

In October 2002, NYSDEC and TAMS conducted a supplemental fish sampling program in the lower reaches of Ninemile Creek in order to supplement the 1998 YOY fish data collected by Honeywell upstream of Ninemile Creek. During the 2002 sampling, YOY fish were collected from three stations in Ninemile Creek downstream of Geddes Brook and were analyzed for total mercury, TAL metals and cyanide, pesticides and PCBs, TCL SVOCs, PCDD/PCDFs, and total solids. Summary statistics of the 2002 YOY fish data are also presented in Appendix I.

CPOIs in fish tissue were identified based on risk to consumers of fish (e.g., humans, piscivorous birds and mammals), and on risk to fish themselves. The HHRA considered only adult fish (fillets), while the BERA identified COCs based on both YOY and adult fish. Whole-body concentrations calculated from measured fillet and remainder fish tissue concentrations were used to model chemical intake by piscivorous wildlife in the BERA when whole-fish concentrations were not available (TAMS, 2003a). Calculation of whole-body concentrations is discussed in Chapter 8 of the BERA (TAMS, 2003a).

5.6.1 Mercury in Adult Fish Tissue

Mercury was detected in all adult fish samples in 1998 at concentrations ranging from 68.3 to 1,534 µg/kg wet weight in fillets and from 8.4 to 987.5 µg/kg wet weight in remainder tissues (Figure 5-45). Both the lowest and highest mercury concentrations were associated with fish collected from stations in Ninemile Creek; the lowest concentrations were found at Stations NM1 and NM9 and the highest concentrations were found at Station NM5.

In the 2000 data, mercury was detected in all adult fish samples at concentrations ranging from 467 to 904 µg/kg wet weight in fillets and from 312 to 734 µg/kg wet weight in remainder tissue. For both fillet and remainder tissue samples, concentrations of mercury in adult fish collected in 2000 fell within the range of concentrations detected in 1998.

5.6.2 Other Contaminants in Adult Fish Tissue

The BERA retained arsenic, selenium, and zinc as other inorganic COCs for the protection of fish (TAMS, 2003a). In addition to these three inorganic compounds, thallium was selected as an inorganic COC that piscivorous wildlife may be exposed to via the consumption of fish. In 1998, these metals were detected in adult fish (fillet and remainder) at the following concentrations:

- **Aluminum** – 21,000 µg/kg (fillet) (only one detection).
- **Arsenic** – 520 to 530 µg/kg (fillet) and 560 to 800 µg/kg (remainder) wet weight.

- **Chromium** – 220 to 330 µg/kg (fillet) and 200 to 760 µg/kg (remainder) wet weight (Figure 5-46).

- **Lead** – 1,000 µg/kg (only one detection in fillets) and 450 to 470 µg/kg (remainder) wet weight.

- **Selenium** – 960 to 1,300 µg/kg (fillet) and 940 to 1,800 µg/kg (remainder) wet weight (Figure 5-47).

- **Zinc** – 5,500 to 21,400 µg/kg (fillet) and 9,700 to 75,400 µg/kg (remainder) wet weight (Figure 5-48).

In 2000, these metals were detected in adult fish (fillet and remainder) at the following concentrations:

- **Aluminum** – 5,300 to 12,600 µg/kg (fillet), 5,500 to 19,900 µg/kg (remainder), and 5,300 to 115,000 µg/kg (whole fish) wet weight.

- **Arsenic** – 900 to 1,100 µg/kg (fillet) and 1,000 to 1,100 µg/kg (remainder) wet weight.

- **Chromium** – all samples were non-detects.

- **Lead** – 20 to 100 µg/kg (fillet) and 60 to 1,870 µg/kg (remainder) wet weight.

- **Selenium** – 1,200 to 2,400 µg/kg (fillet) and 1,100 to 1,870 µg/kg (remainder) wet weight.

- **Zinc** – 20,100 to 63,600 µg/kg (fillet) and 48,700 to 198,000 µg/kg (remainder) wet weight.

Hexachlorobenzene (ECD), dieldrin, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, heptachlor epoxide, PCBs, and PCDD/PCDFs exceeded human health screening criteria in the HHRA (TAMS, 2003b). Concentrations of DDT and metabolites, total PCBs (sum of Aroclors), and PCDD/PCDFs were selected as COCs for both the consumption of fish by wildlife receptors and the protection of fish in the BERA (TAMS, 2003a). In 1998, these compounds were detected in fish fillet and remainder samples in the following concentrations:

- **Hexachlorobenzene (ECD)** – 0.22 to 8.8 µg/kg (fillet) and 0.092 to 52 µg/kg (remainder) wet weight (Figure 5-49).

- **Dieldrin** – 1.1 µg/kg (only one detection in fillets) and 0.2 to 8.9 µg/kg (remainder) wet weight.

- **4,4′-DDD** – 0.23 to 1.3 μg/kg (fillet) and 0.53 to 12 μg/kg (remainder) wet weight (Figure 5-50).

- **4,4′-DDE** – 0.19 to 3.1 μg/kg (fillet) and 0.27 to 30 μg/kg (remainder) wet weight (Figure 5-51).

- **4,4′-DDT** – 0.24 to 0.48 μg/kg (fillet) and 0.30 to 4.5 μg/kg (remainder) wet weight (Figure 5-52).

- **Heptachlor epoxide** – 0.14 to 1.6 μg/kg (fillet) and 0.043 to 12 μg/kg (remainder) wet weight (Figure 5-53).

- **Endrin** – 0.33 to 0.73 μg/kg (fillet) and 0.23 to 2.5 μg/kg (remainder) wet weight.

- **PCBs** – Aroclor 1248: 23 to 57 μg/kg (fillet) and 54 to 450 μg/kg (remainder) wet weight (Figure 5-54). Aroclors 1248, 1254, and 1260 (Figure 5-55) were occasionally detected in fish tissue, while Aroclor 1242 and Aroclor 1268 were detected once at concentrations of 110 and 95 μg/kg, respectively, in a remainder sample at Station NM5. Other Aroclors were undetected (detection limit of 33 μg/kg).

- **PCDD/PCDFs** – PCDD/PCDFs were assessed using the TEQ approach (mammal and bird) as described for sediment (Figures 5-56 and 5-57). The highest TEQ concentrations were for fish samples at Station NM9 in Ninemile Creek for both fish fillet and remainder samples.

For the 1998 data, there is no apparent relationship between the magnitude of the chemical concentration of these compounds and the sample location. In general, the samples collected in 2000 from near the mouth of Ninemile Creek have higher concentrations of these compounds than those collected in 1998.

5.6.3 Mercury in Young-of-Year Fish Tissue

Composite YOY fish samples were collected in Ninemile Creek by Exponent in 1998 from Stations NM2 and NM3. The species collected in 1998 were tessellated darter (*Etheostoma olmstedi*), creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), blacknose dace (*Rhinichthys atratulus*), and longnose dace (*Rhinichthys cataractae*). The blacknose and longnose dace were composited at Station NM3 to fulfill the sample volume requirement for analysis. Although sampling in 1998 for YOY fish occurred at two stations in Geddes Brook and five stations in Ninemile Creek, YOY fish were not sufficiently abundant to meet the minimum volume requirement for any analysis, with the exception of Stations NM2 and NM3. Concentrations of mercury in YOY fish collected at these two upper Ninemile Creek stations ranged from 18.1 to 46.8

µg/kg wet weight. In species-to-species comparisons of the 1998 data, mercury concentrations in YOY fish collected at Station NM3 were twice those found at Station NM2.

Fish sampling was also conducted in lower Ninemile Creek at its mouth during the Onondaga Lake RI/FS Phase 2A investigation in 2000 (TAMS, 2002c). In 2000, YOY pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*) were collected, and mercury concentrations ranged from 144 to 224 µg/kg wet weight. Concentrations of all three samples collected in 2000 were higher than the maximum concentration of mercury in YOY fish collected in 1998. The highest mercury concentration in the 2000 YOY samples was found in the bluegill.

In the 2002 data, mercury was detected in Ninemile Creek in all YOY fish samples at concentrations ranging from 180 µg/kg at Station NM9 to 850 µg/kg wet weight at Station NMC at the Geddes Brook confluence. The maximum mercury concentration (850 µg/kg) reported in the 2002 data, which were obtained from samples collected downstream of the mercury source, is nearly 20 times greater than the maximum concentration (46.8 µg/kg) from the 1998 data, which were obtained from samples upstream of the source.

5.6.4 Other Contaminants in Young-of-Year Fish Tissue

Other than mercury, aluminum and zinc were the only contaminants exceeding ecological screening guidance criteria for composite samples of YOY fish (TAMS, 2003a). The 1998 samples contained concentrations of aluminum ranging from 18,400 to 133,000 µg/kg wet weight and concentrations of zinc ranging from 25,500 to 35,200 µg/kg wet weight. Concentrations of aluminum in the 2000 YOY fish were lower and ranged from 11,500 to 29,700 µg/kg wet weight. However, concentrations of zinc in the 2000 YOY fish were higher, with values ranging from 92,900 to 136,000 µg/kg wet weight. The 2002 samples contained concentrations of aluminum ranging from 5,700 to 13,000 µg/kg wet weight and concentrations of zinc ranging from 30,000 to 37,000 µg/kg wet weight. Total PCB concentrations in the 2002 YOY fish ranged from 250 to 300 µg/kg wet weight (Appendix I).

5.7 Summary

This chapter of the RI documents the nature and extent of contamination in the sediment, floodplain soils (including island soil and wetland sediment), surface water, and fish of the Geddes Brook/Ninemile Creek site. The RI data collected between 1998 and 2002, along with data collected independently of this RI, provide a comprehensive basis for understanding the current nature and extent of contaminants at the Geddes Brook/Ninemile Creek site.

Most CPOIs in the sediments at various locations within the site are present at concentrations exceeding NYSDEC sediment screening criteria. Mercury concentrations in sediment reflect the input of mercury from the West Flume to Geddes Brook and then from Geddes Brook to Ninemile Creek, the stream channel geomorphology, and historical changes to the stream channel. Concentrations of mercury were relatively high at stations located on the right side of Ninemile Creek, facing downstream, between Transects TN-15 and TN-10. This is a relatively quiescent (i.e., depositional) region within Reach CD where water entering Ninemile Creek from Geddes Brook does not readily mix across the entire Ninemile Creek cross section. These transects also contained the highest concentrations of methylmercury, arsenic, and nickel in Ninemile Creek. Higher concentrations of other metals at depth were mostly prevalent at Transects TN-5 and TN-6 in Ninemile Creek and, to a lesser extent, Transects TG-3 and TG-4 in Geddes Brook, with contamination extending to a depth of at least 3 m in some cases.

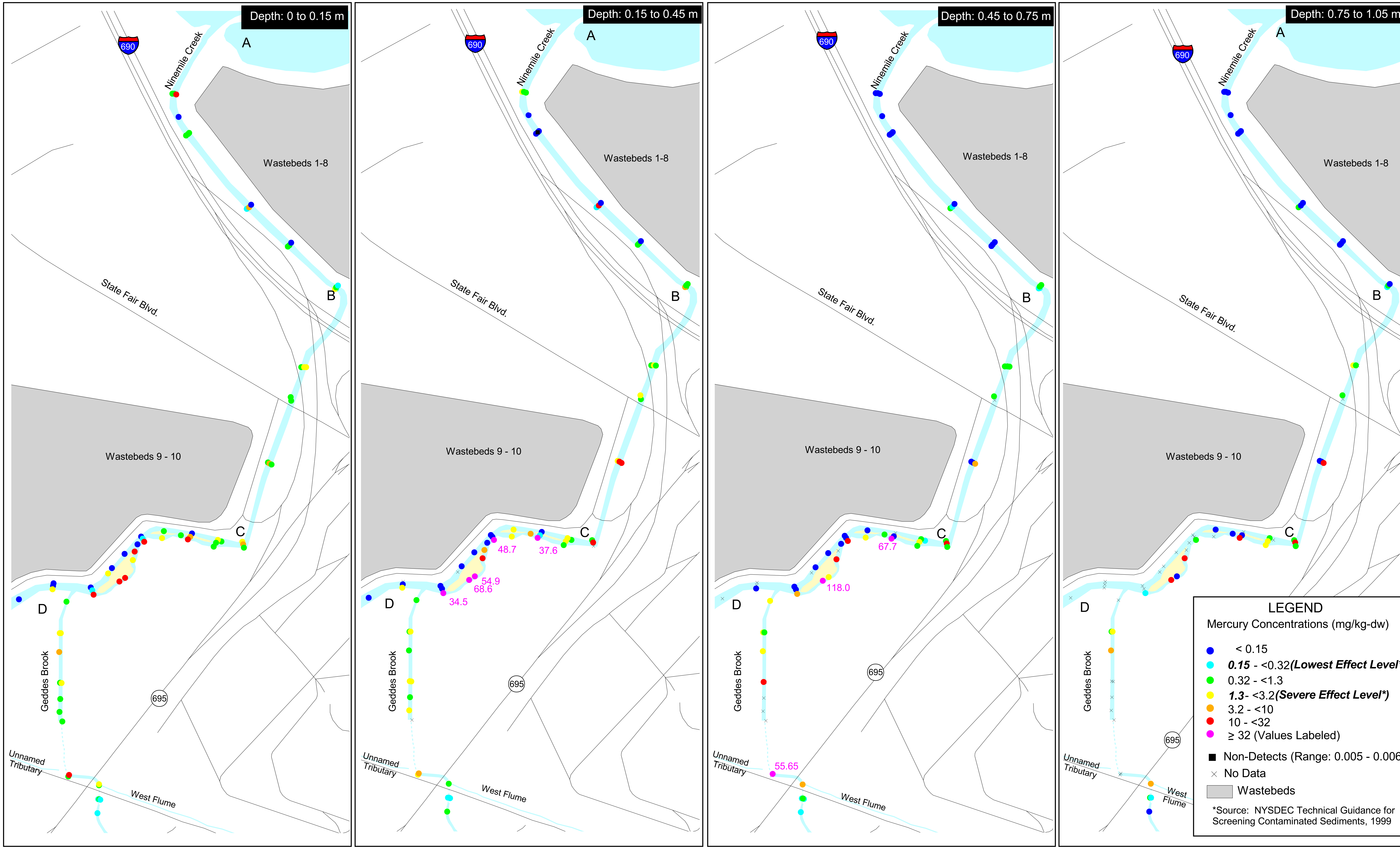
The highest concentrations of organic CPOIs in sediments were found in lower Ninemile Creek and lower Geddes Brook. There were several elevated concentrations (greater than 1,000 μg/kg) of hexachlorobenzene in lower Geddes Brook and Reach CD in Ninemile Creek. Concentrations of hexachlorobenzene exceeding 10,000 μg/kg occurred in Geddes Brook just below the discharge point of the West Flume to a depth of 1.28 m. Aroclors 1254 and 1268 also had elevated concentrations (greater than 1,000 μg/kg) at some stations in lower Geddes Brook and lower Ninemile Creek. Unlike Aroclor 1254, elevated concentrations of Aroclor 1268 occurred in deeper sediments in Reach CD of Ninemile Creek and in surface sediments in Reach AB of Ninemile Creek. The highest concentrations of PCDD/PCDFs and TEQs were found in Geddes Brook immediately below the confluence with the West Flume.

Mercury concentrations in floodplain soil and wetland sediment showed a distinct distribution pattern along Ninemile Creek, with elevated mercury concentrations exceeding 10 mg/kg in samples closer to the mouth of the creek in the Wetland SYW-10 area and along Reach CD. Deeper floodplain soils were collected during the 2002 supplemental floodplain sampling program in Ninemile Creek (Figure 5-15), at depth intervals ranging from 0.3 to 0.6 and 0.6 to 0.9 m. These data showed elevated levels of mercury as high as 76.9 mg/kg at the mouth Ninemile Creek in a low-lying wetland area (Reach AB) and 43.1 mg/kg on the right bank facing downstream between the two upstream islands in lower Ninemile Creek (Reach CD). It should be noted that the elevated concentrations of mercury at deeper intervals are localized in areas where Ninemile Creek is characterized as highly depositional at base flow. These elevated mercury concentrations at depth occur in the low-lying wetland area at the mouth of Ninemile Creek that has historically been exposed to flooding and in Reach CD where the elevated mercury concentrations in floodplain soil are adjacent to the sediments with elevated mercury concentrations at depth.

In surface water, total mercury concentrations reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek. Total mercury concentrations were higher in the lower reaches of both Geddes Brook and Ninemile Creek, relative to the upper reaches. Concentrations in the West Flume, lower Geddes Brook, and lower Ninemile Creek have declined since 1990, with concentrations in 1998 at least 77 percent lower than 1990 values in these areas of the site. Concentrations of the other inorganics and ionic waste constituents (e.g., chloride, calcium, sodium, and TDS) in surface water clearly indicate the impact of the wastebeds on Geddes Brook and Ninemile Creek.

In adult fish, mercury concentrations in 1998 ranged from 68.3 to 1,534 μg/kg wet weight in fillets and from 8.4 to 987.5 μg/kg wet weight in remainder tissues. In the 2000 data, mercury in adult fish ranged from 467 to 904 μg/kg wet weight in fillets and 379 to 734 μg/kg wet weight in remainder tissue. Mercury was detected in YOY fish from 18.1 to 46.8 μg/kg wet weight in 1998 in upper Ninemile Creek and 144 to 224 μg/kg wet weight in 2000 at the mouth of Ninemile Creek. In the

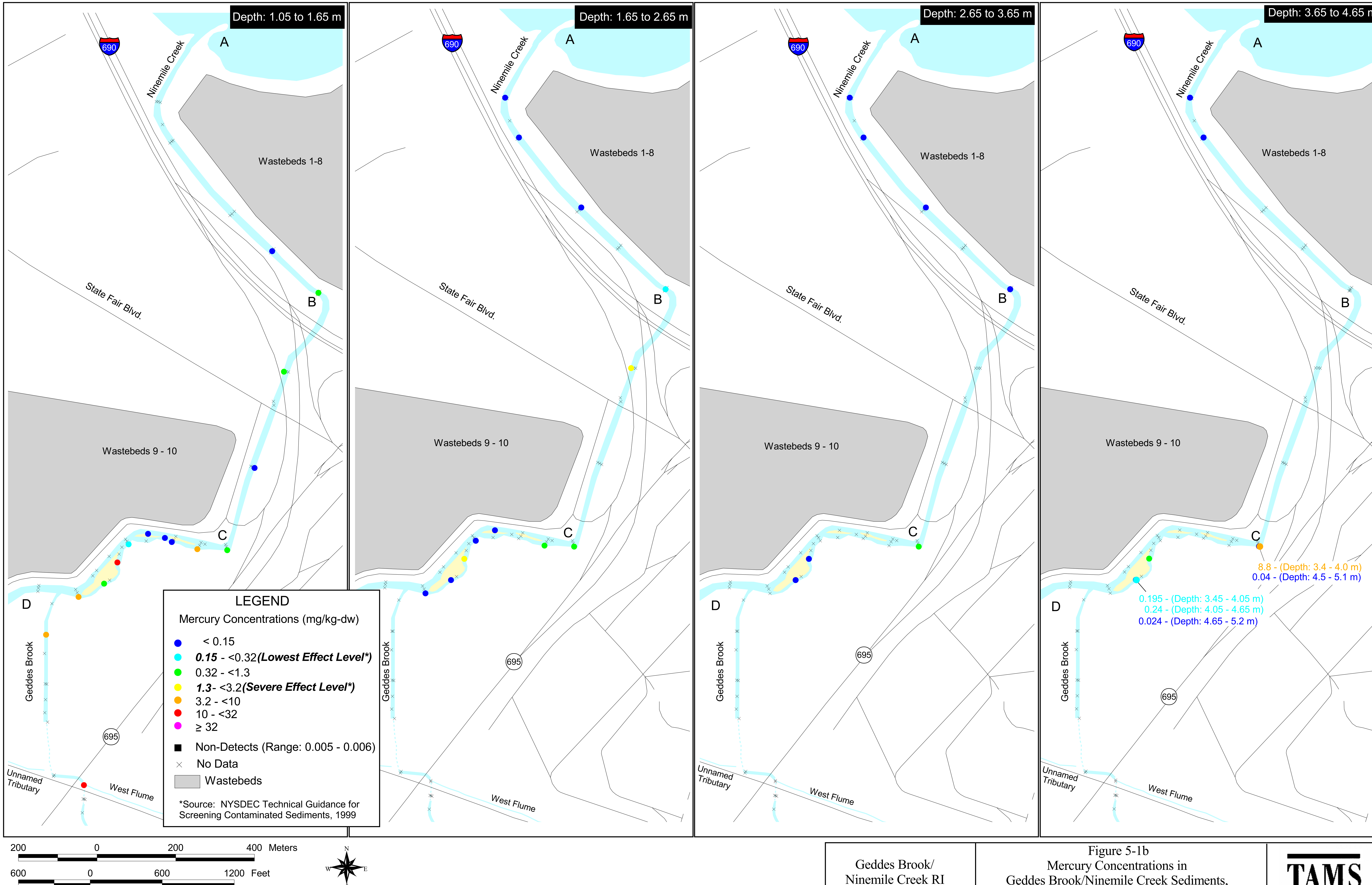
2002 data, mercury was detected in all YOY fish samples at concentrations ranging from 180 to 850 µg/kg wet weight at stations downstream of the source.



Geddes Brook/
Ninemile Creek RI

Figure 5-1a
Mercury Concentrations in
Geddes Brook/Ninemile Creek Sediments,
0 to 1.05 m Depth Intervals

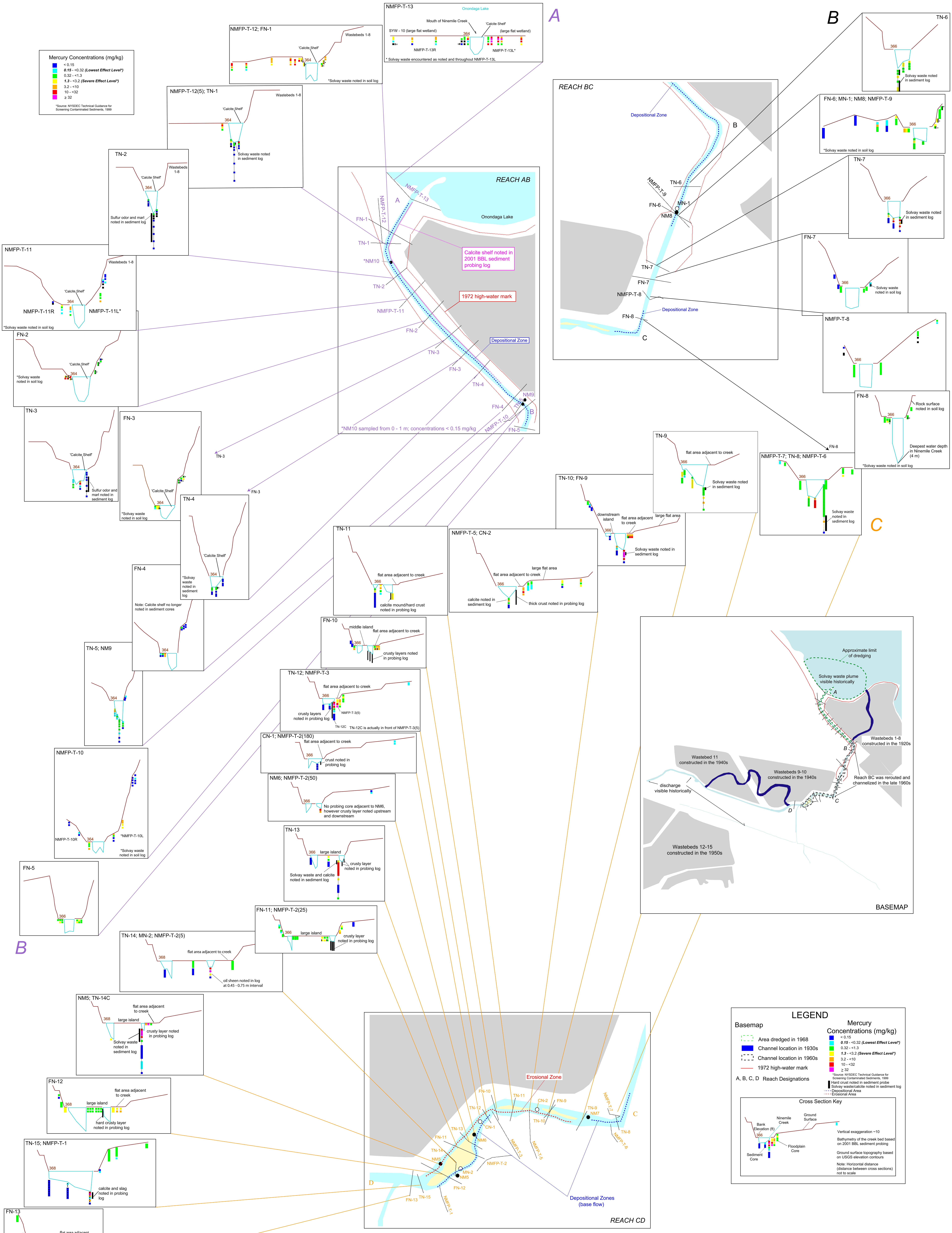
TAMS



Geddes Brook/ Ninemile Creek RI

Figure 5-1b
Mercury Concentrations in Geddes Brook/Ninemile Creek Sediments, 1.05 to 5 m Approximate Depth Intervals

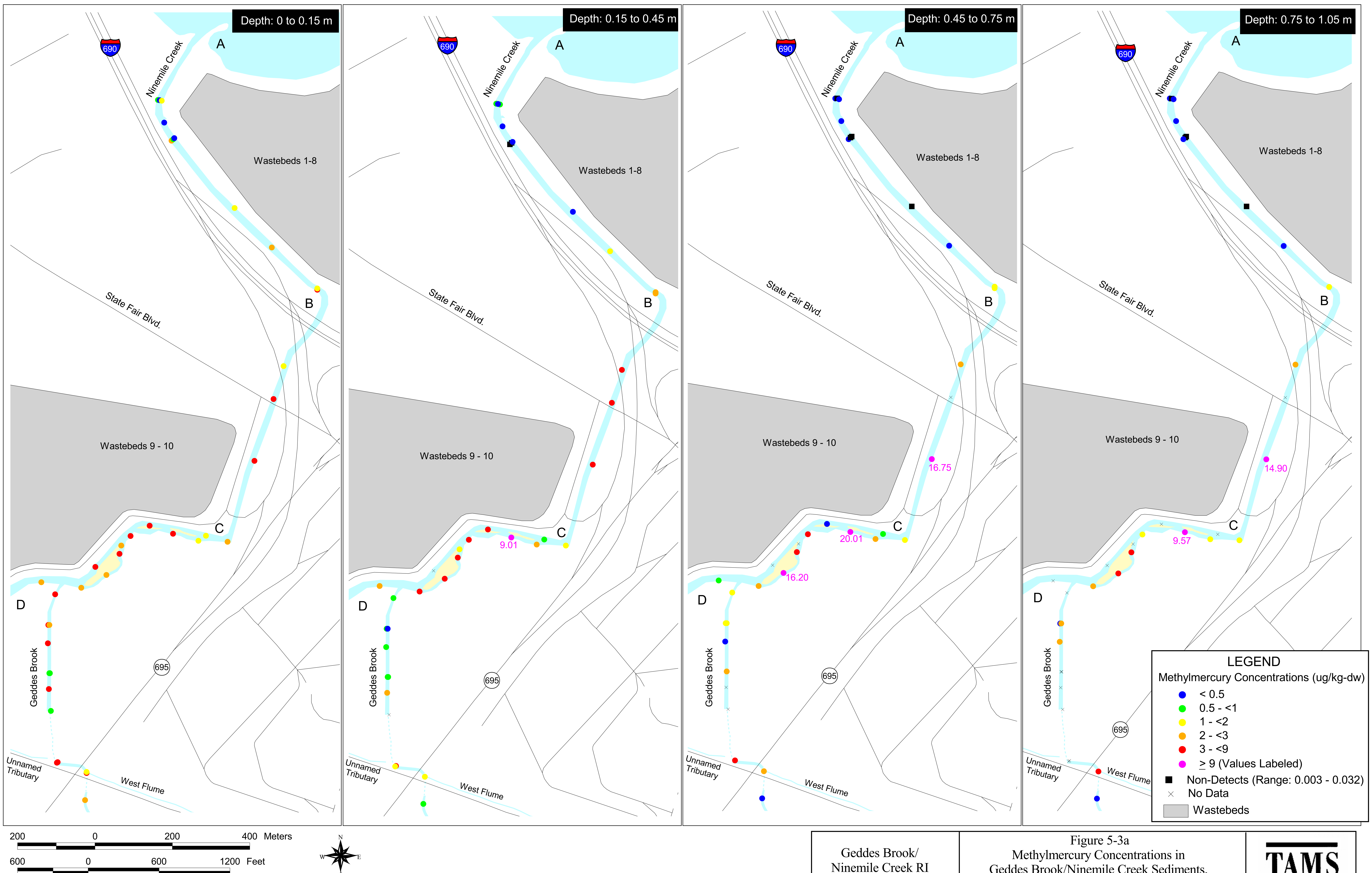
TAMS



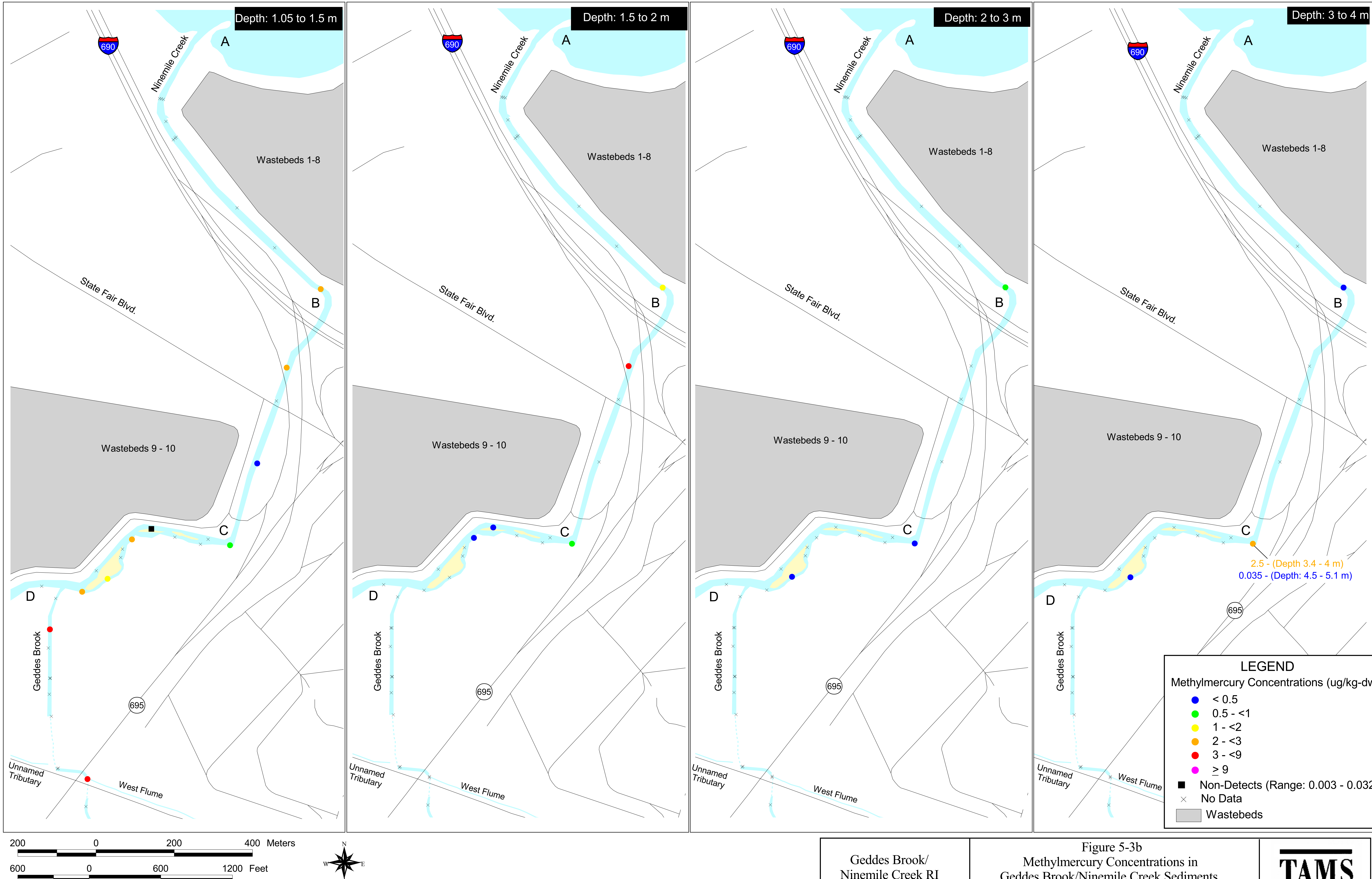
Geddes Brook/Ninemile Creek RI

Figure 5-2
Mercury Cross Sections and Historic Features in Lower Ninemile Creek

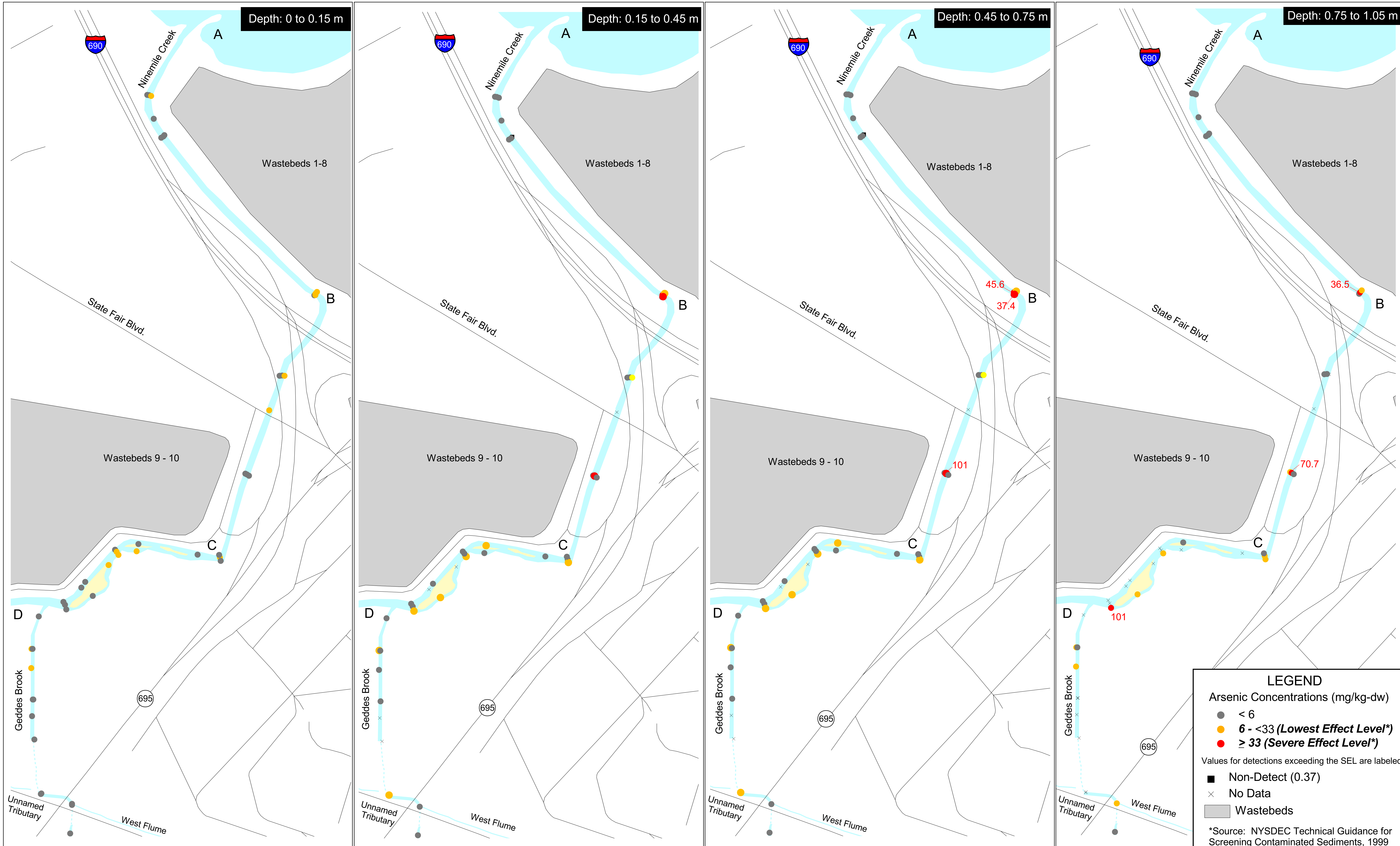
TAMS



Geddes Brook/ Ninemile Creek RI	Figure 5-3a Methylmercury Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 5-3b Methylmercury Concentrations in Geddes Brook/Ninemile Creek Sediments, 1.05 to 4 m Depth Intervals	TAMS



200 0 200 400 Meters

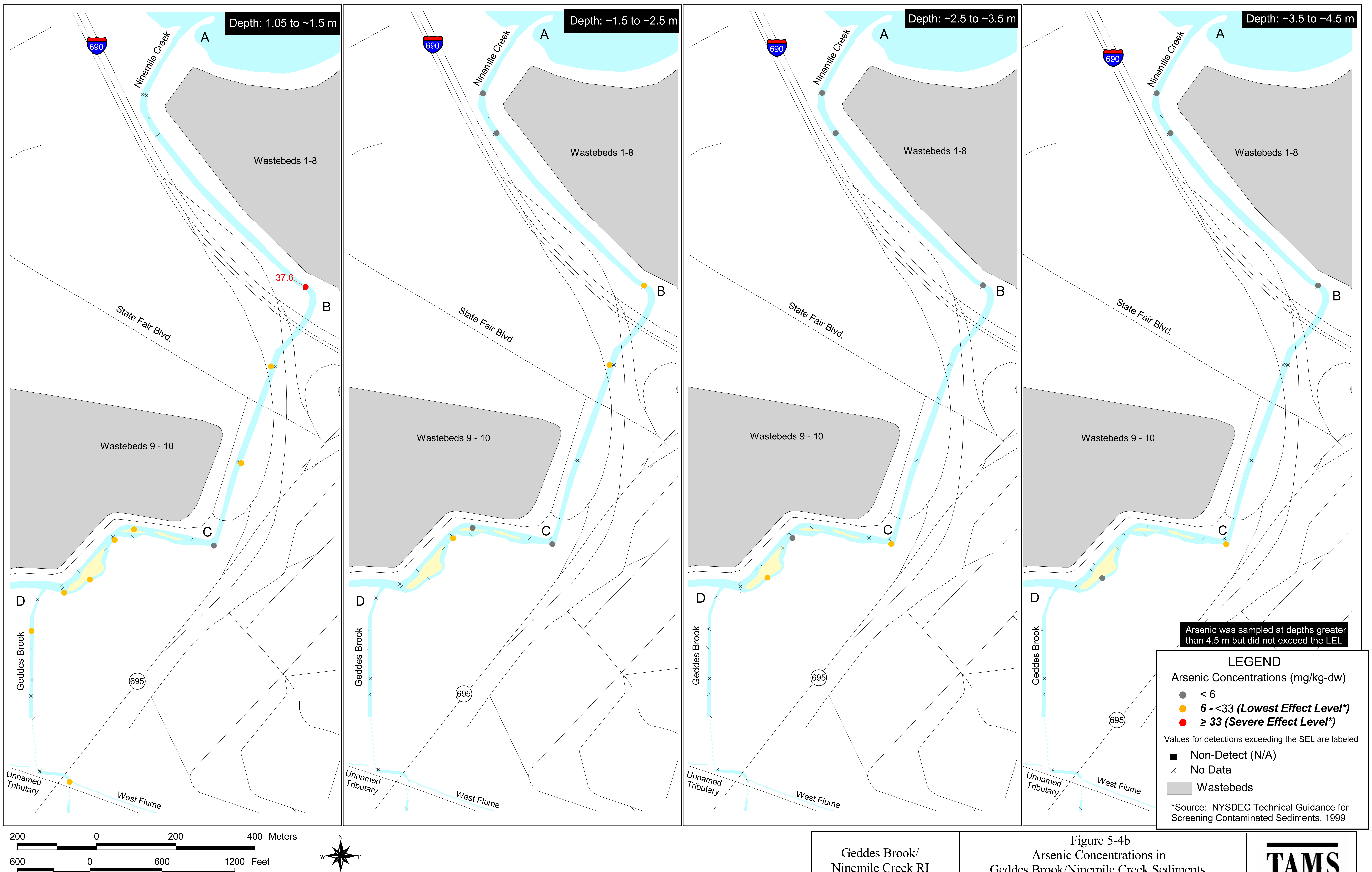
600 0 600 1200 Feet

N S E W

Geddes Brook/ Ninemile Creek RI

Figure 5-4a
Arsenic Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals

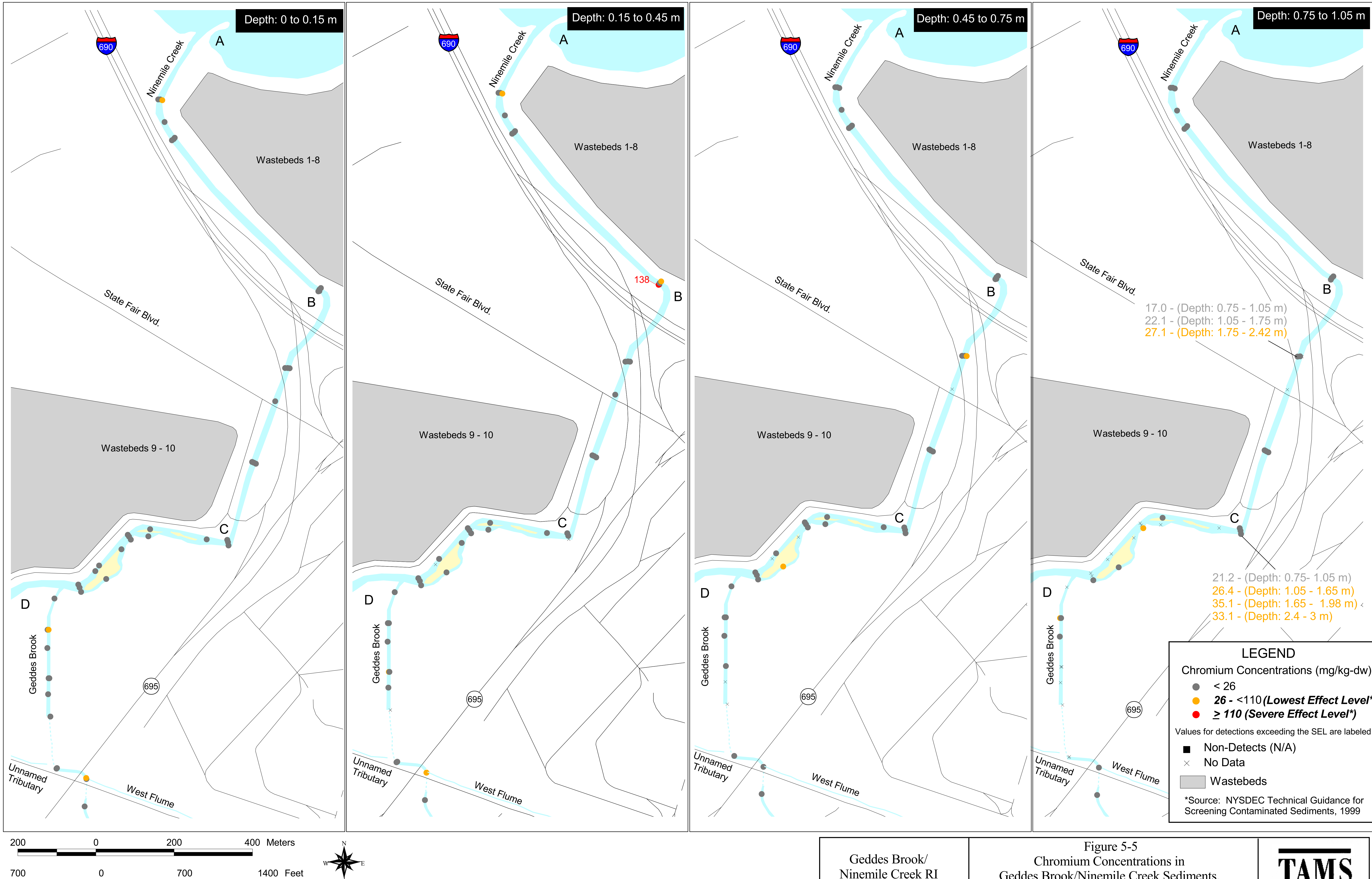
TAMS



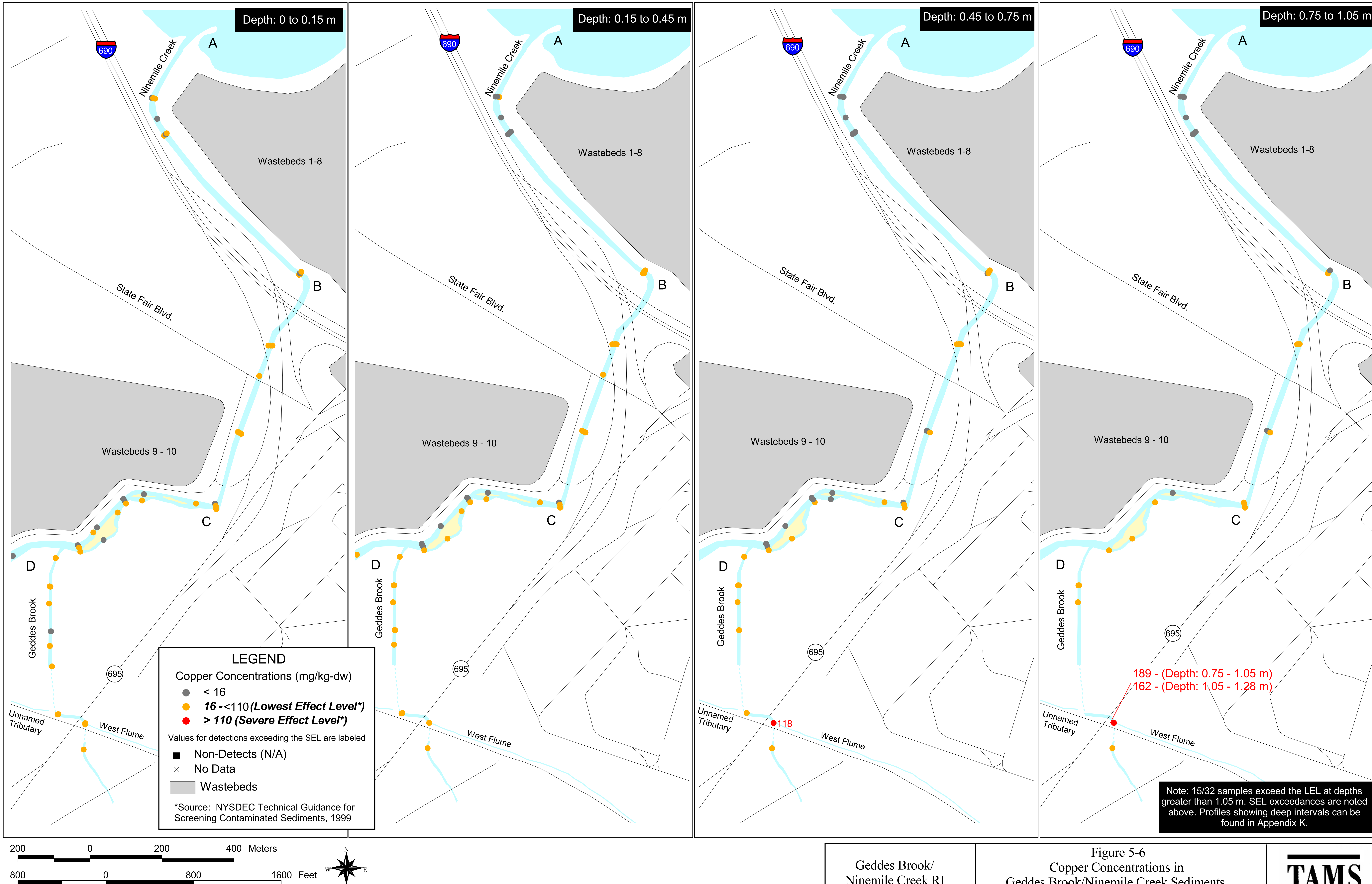
Geddes Brook/ Ninemile Creek RI

Figure 5-4b
Arsenic Concentrations in Geddes Brook/Ninemile Creek Sediments, 1.05 to 4.5 m Depth Intervals

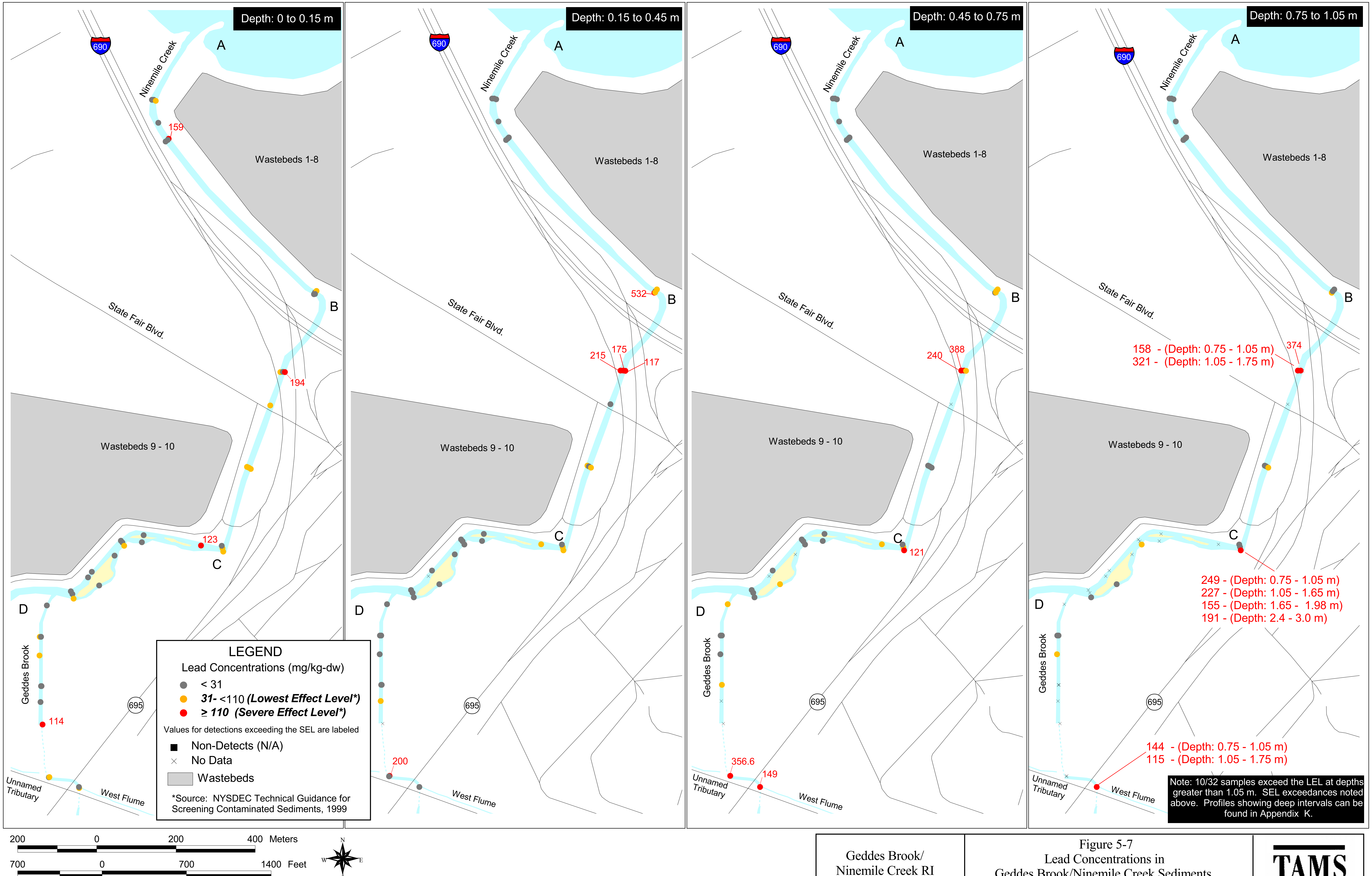
TAMS



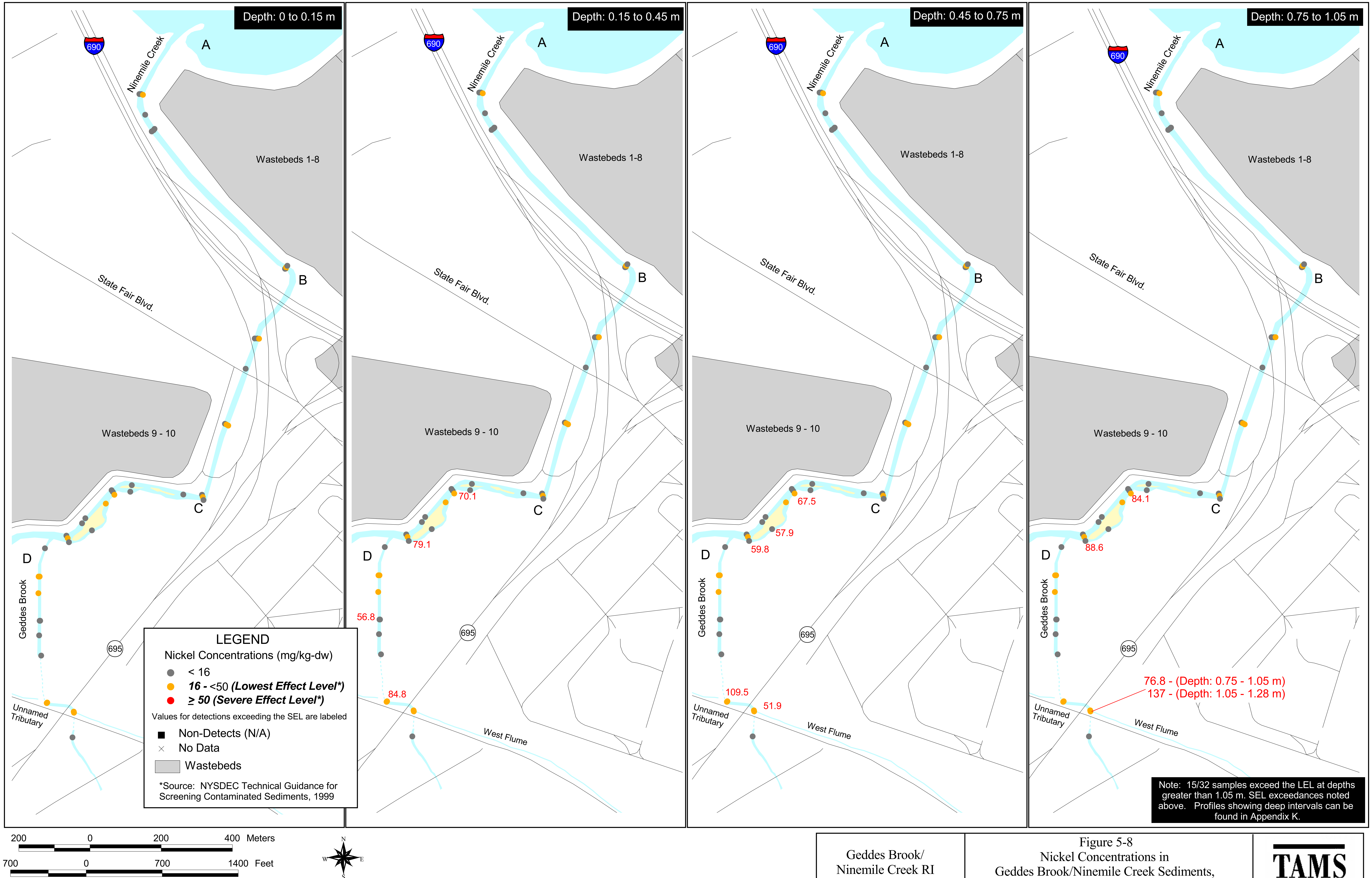
Geddes Brook/ Ninemile Creek RI	Figure 5-5 Chromium Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



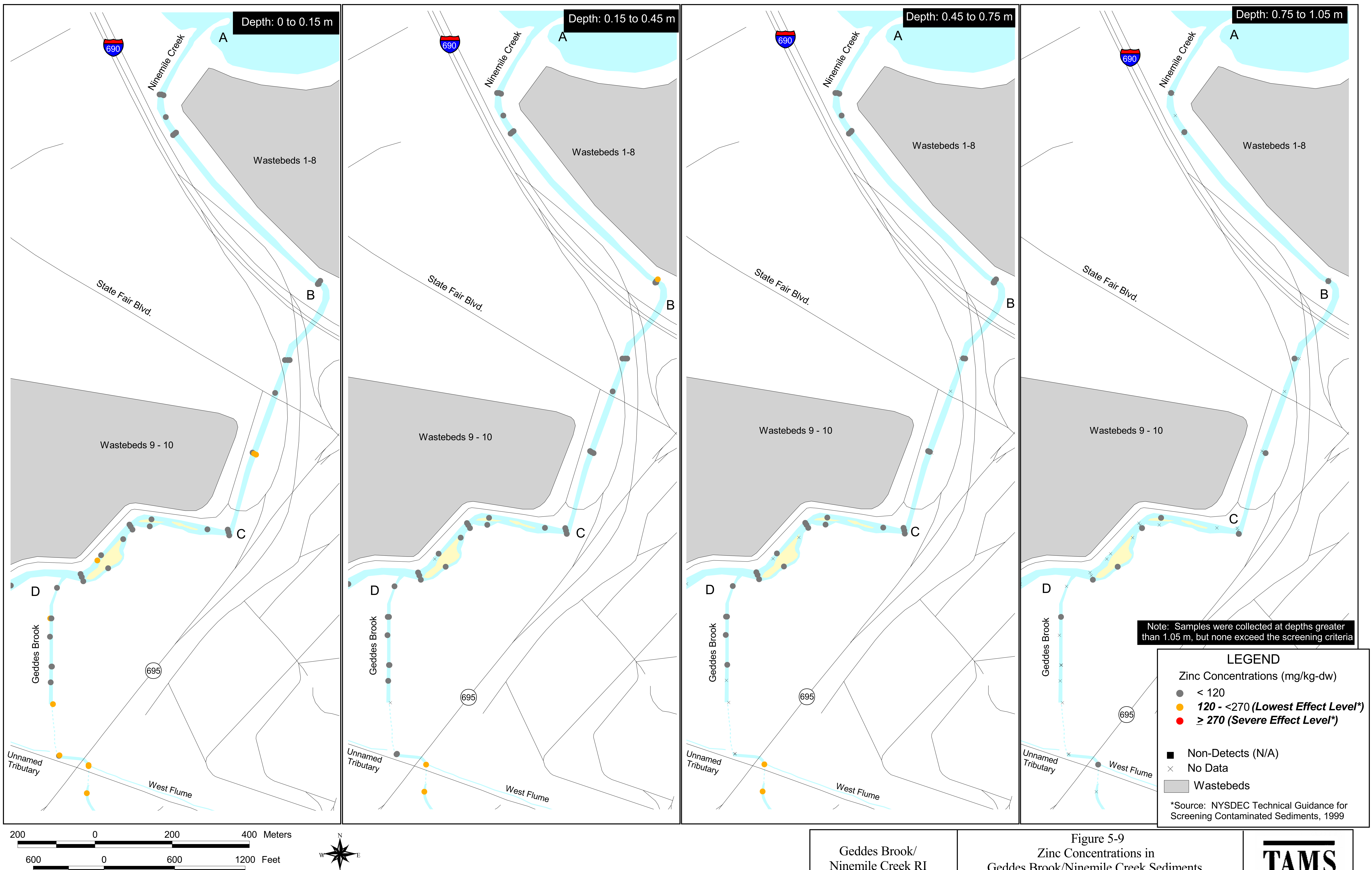
Geddes Brook/ Ninemile Creek RI	Figure 5-6 Copper Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 5-7 Lead Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



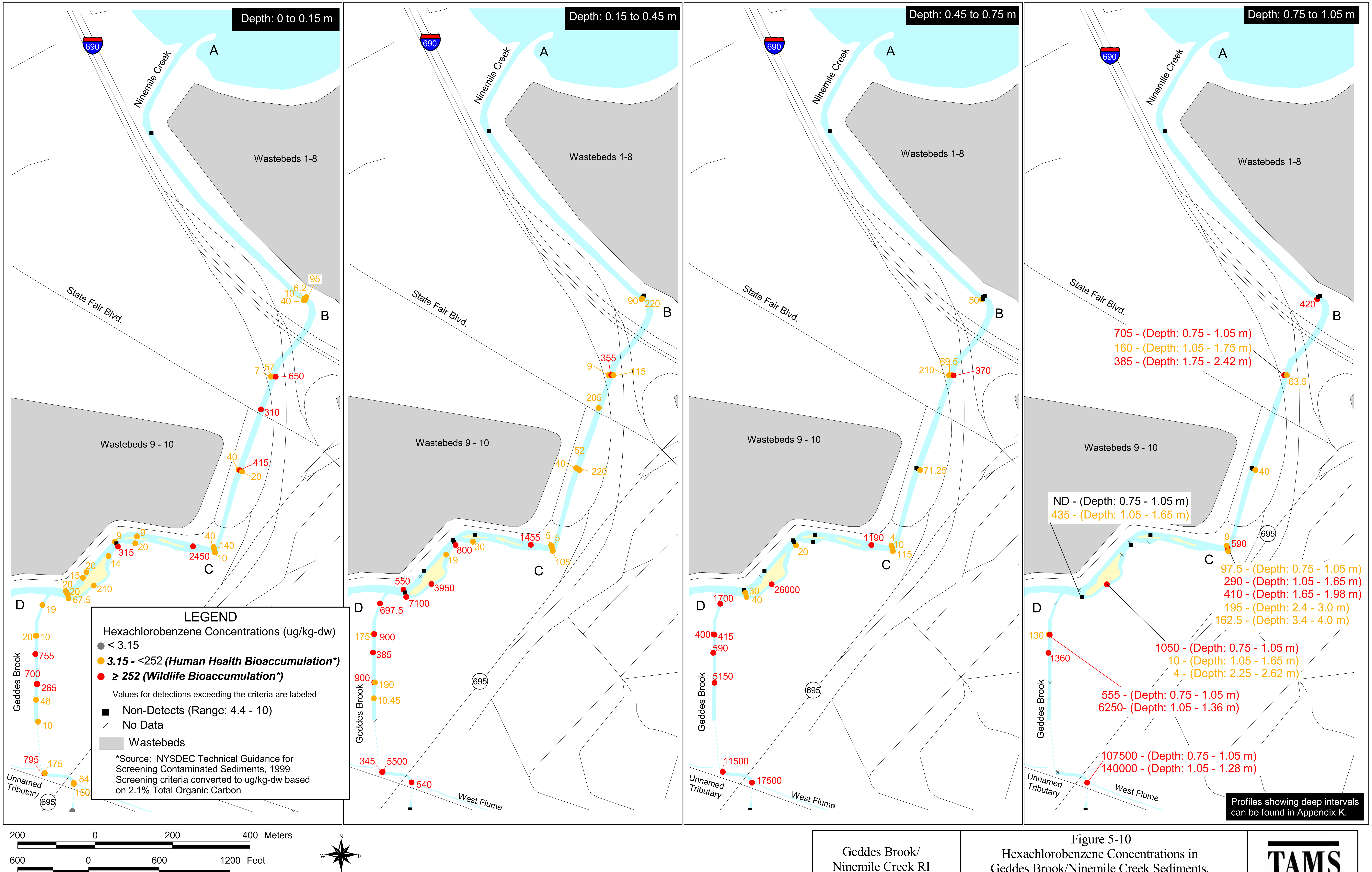
Geddes Brook/ Ninemile Creek RI	Figure 5-8 Nickel Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



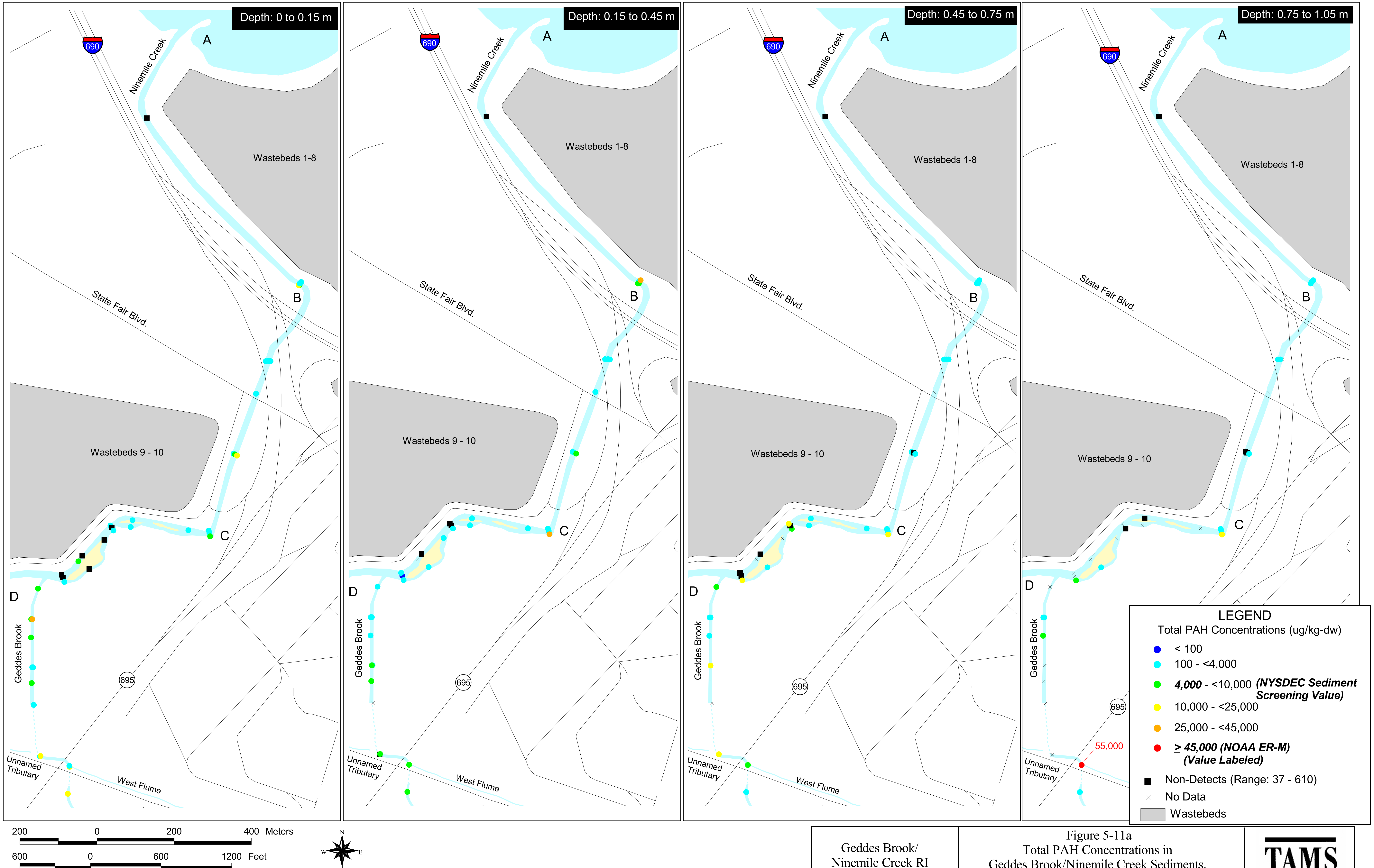
Geddes Brook/ Ninemile Creek RI

Figure 5-9
Zinc Concentrations in
Geddes Brook/Ninemile Creek Sediments,
0 to 1.05 m Depth Intervals

TAMS



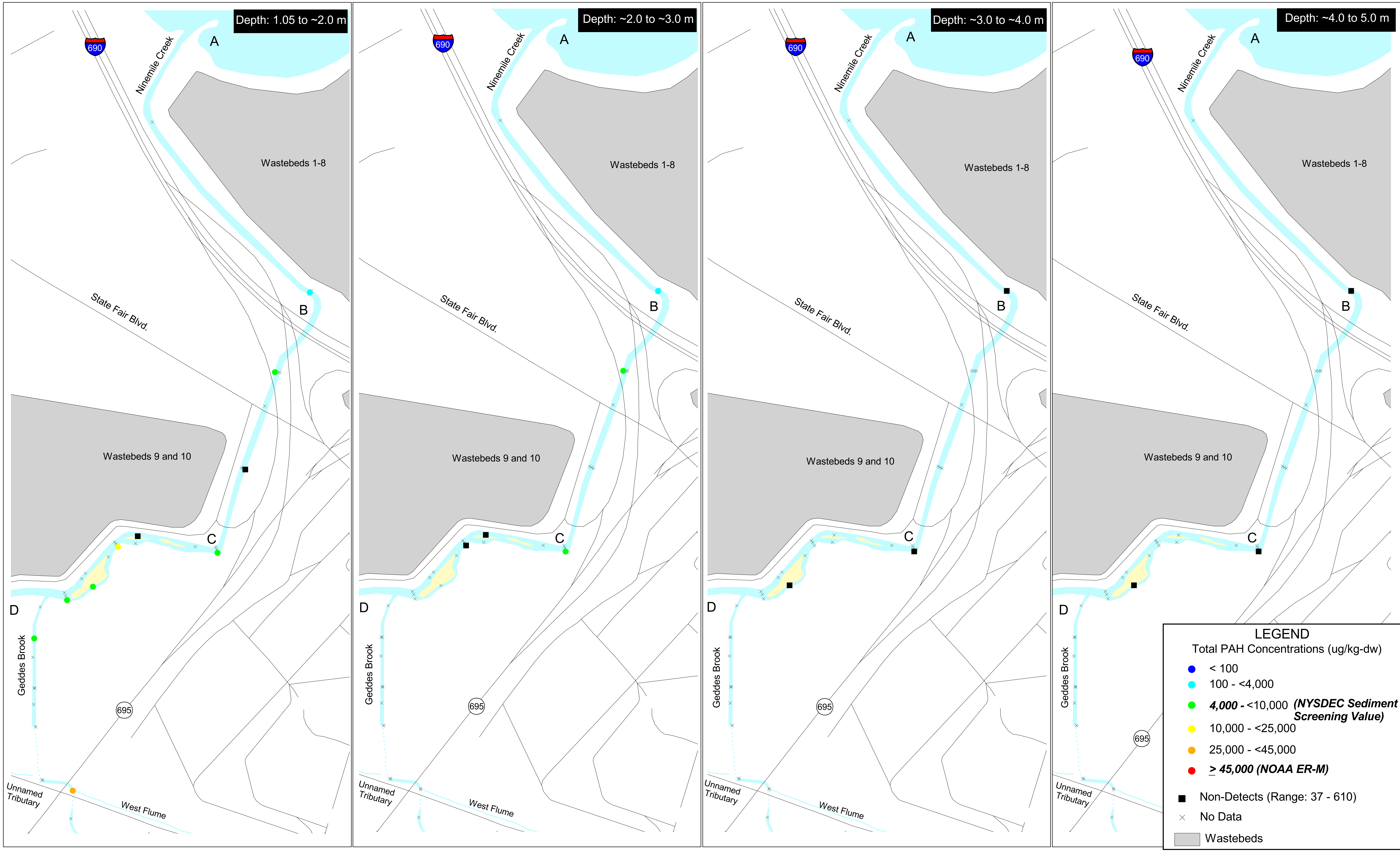
Geddes Brook/ Ninemile Creek RI	Figure 5-10 Hexachlorobenzene Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



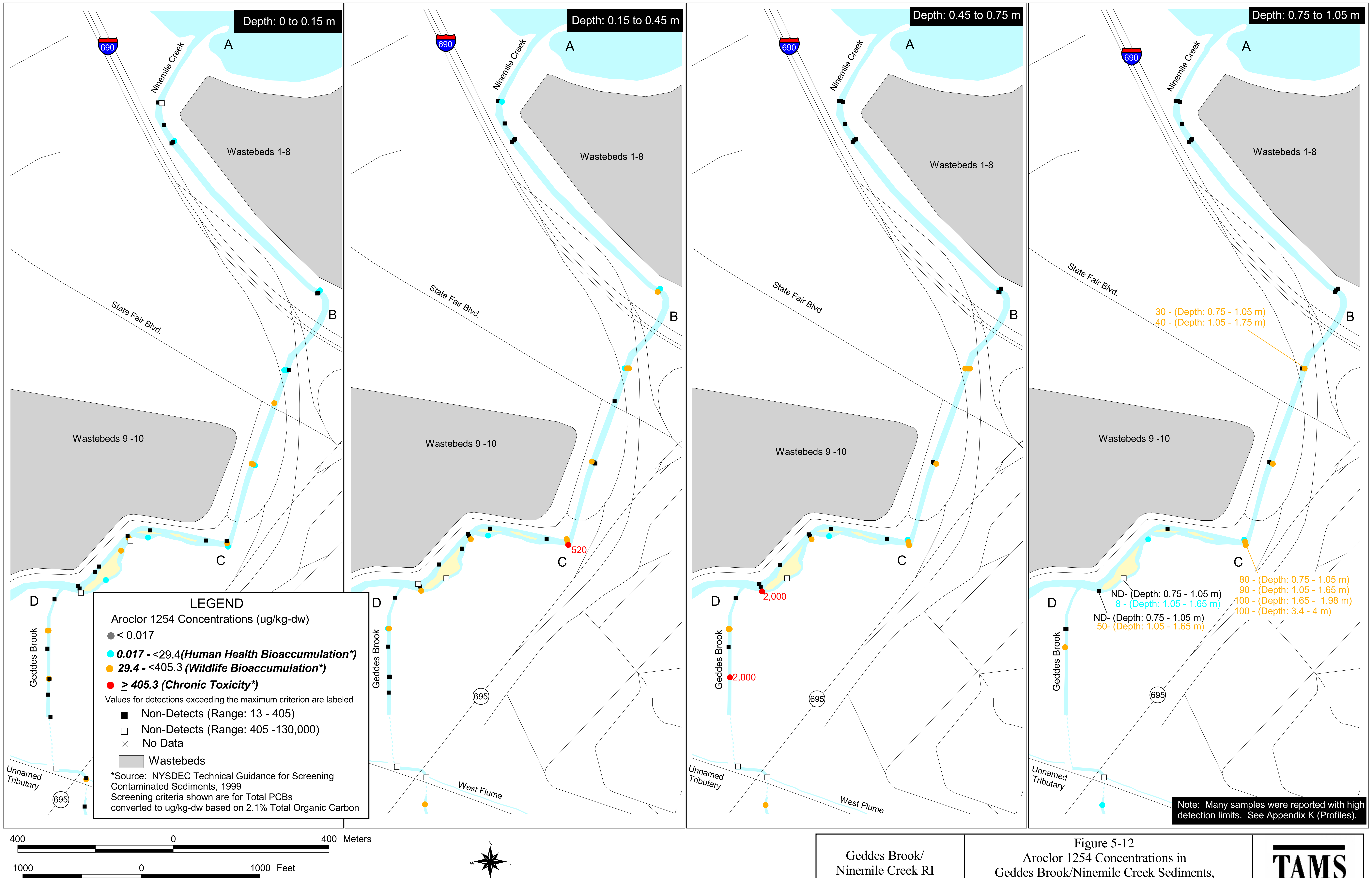
Geddes Brook/
Ninemile Creek RI

Figure 5-11a
Total PAH Concentrations in
Geddes Brook/Ninemile Creek Sediments,
0 to 1.05 m Depth Intervals

TAMS



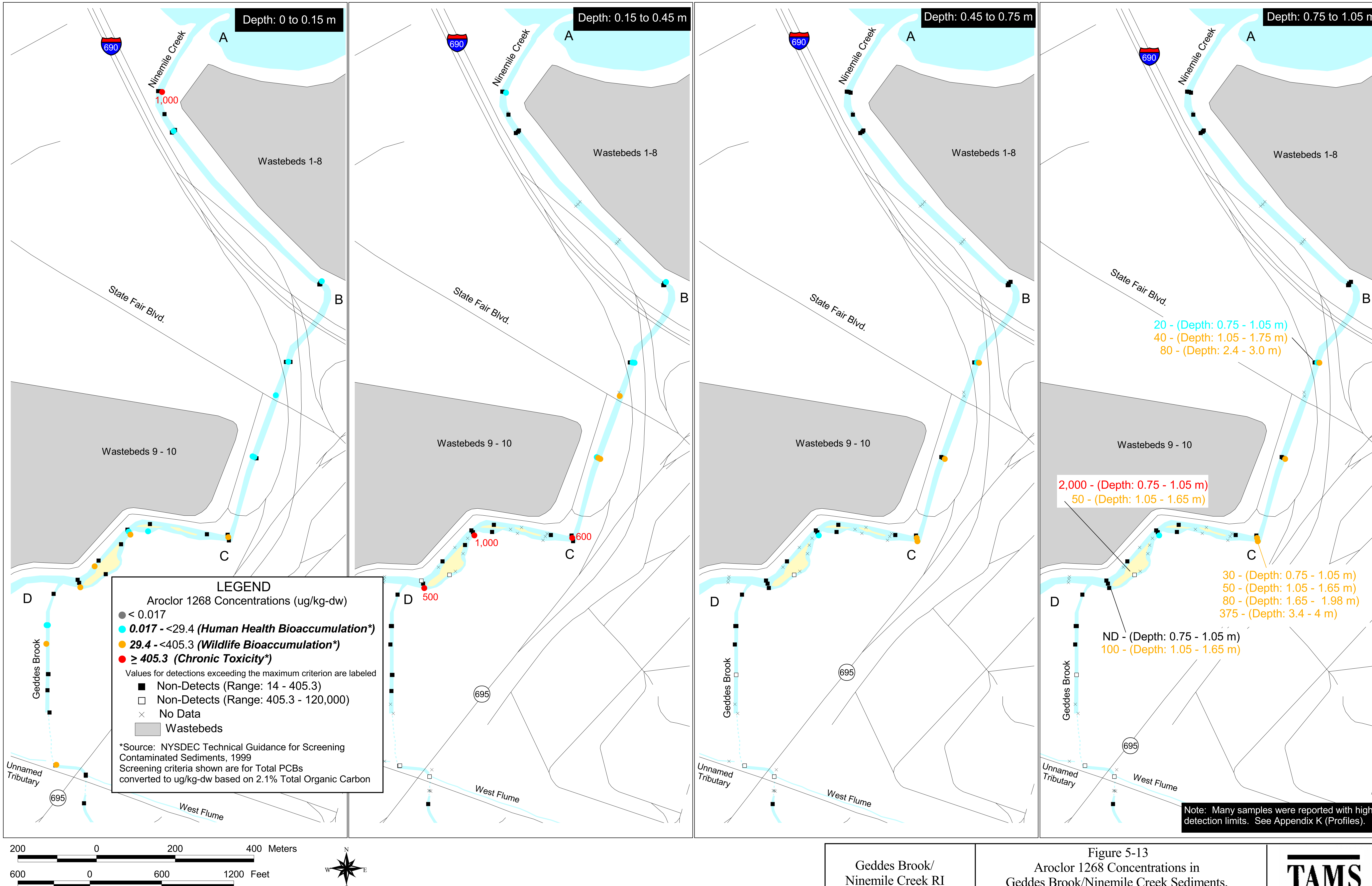
Geddes Brook/ Ninemile Creek RI	Figure 5-11b Total PAH Concentrations in Geddes Brook/Ninemile Creek Sediments, 1.05 to 5 m Depth Intervals	TAMS



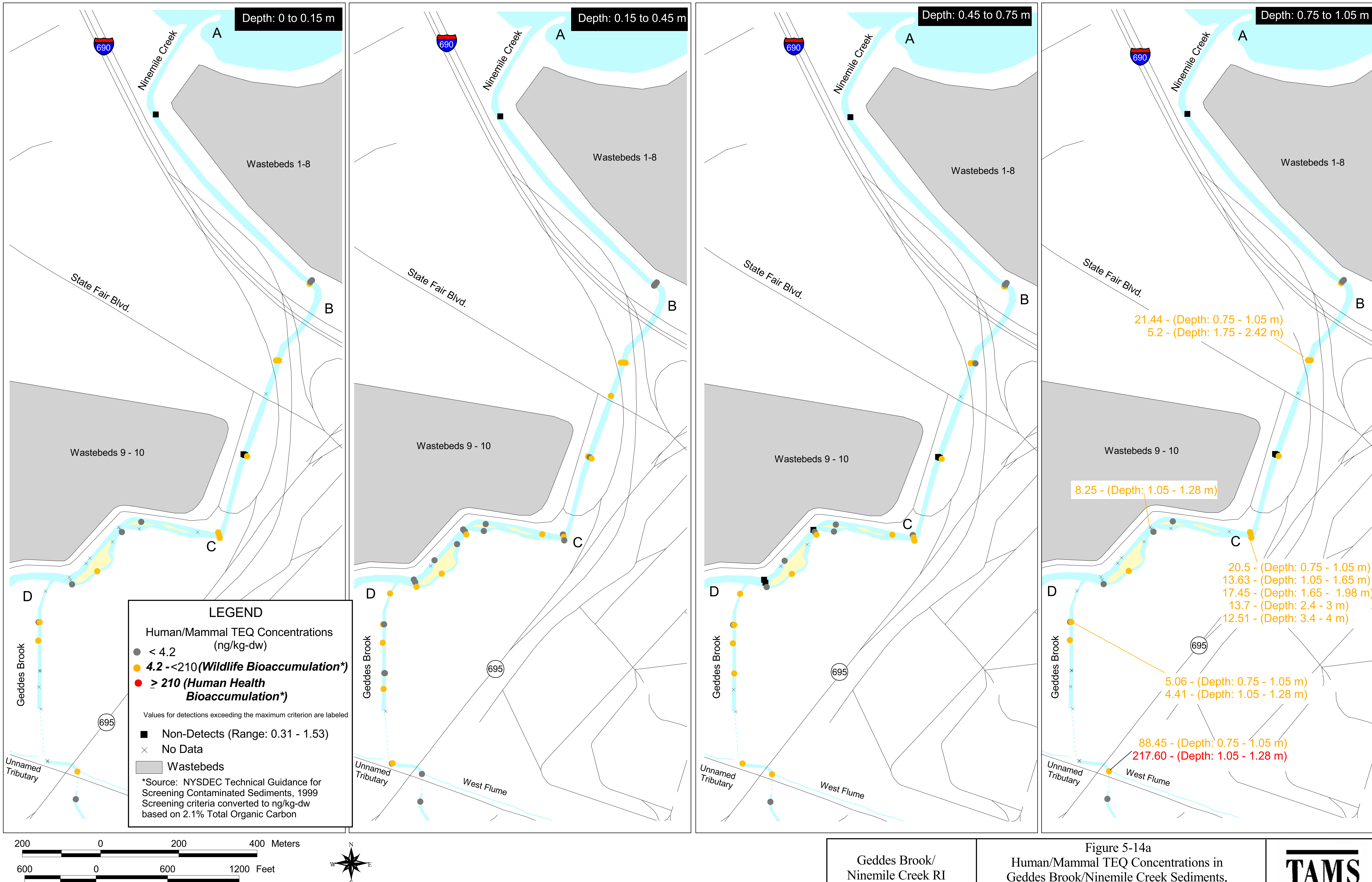
Geddes Brook/ Ninemile Creek RI

Figure 5-12
Aroclor 1254 Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals

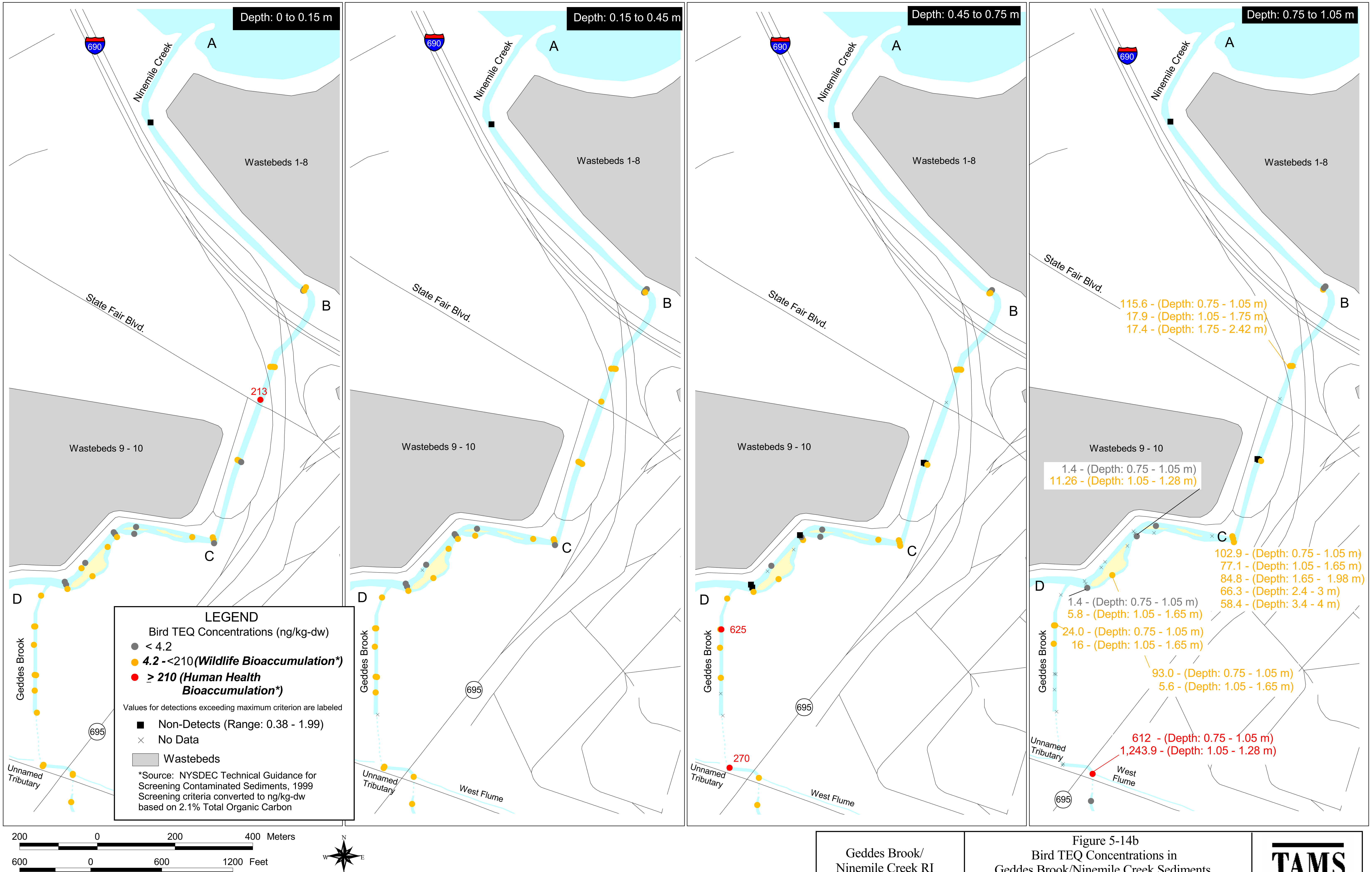
TAMS



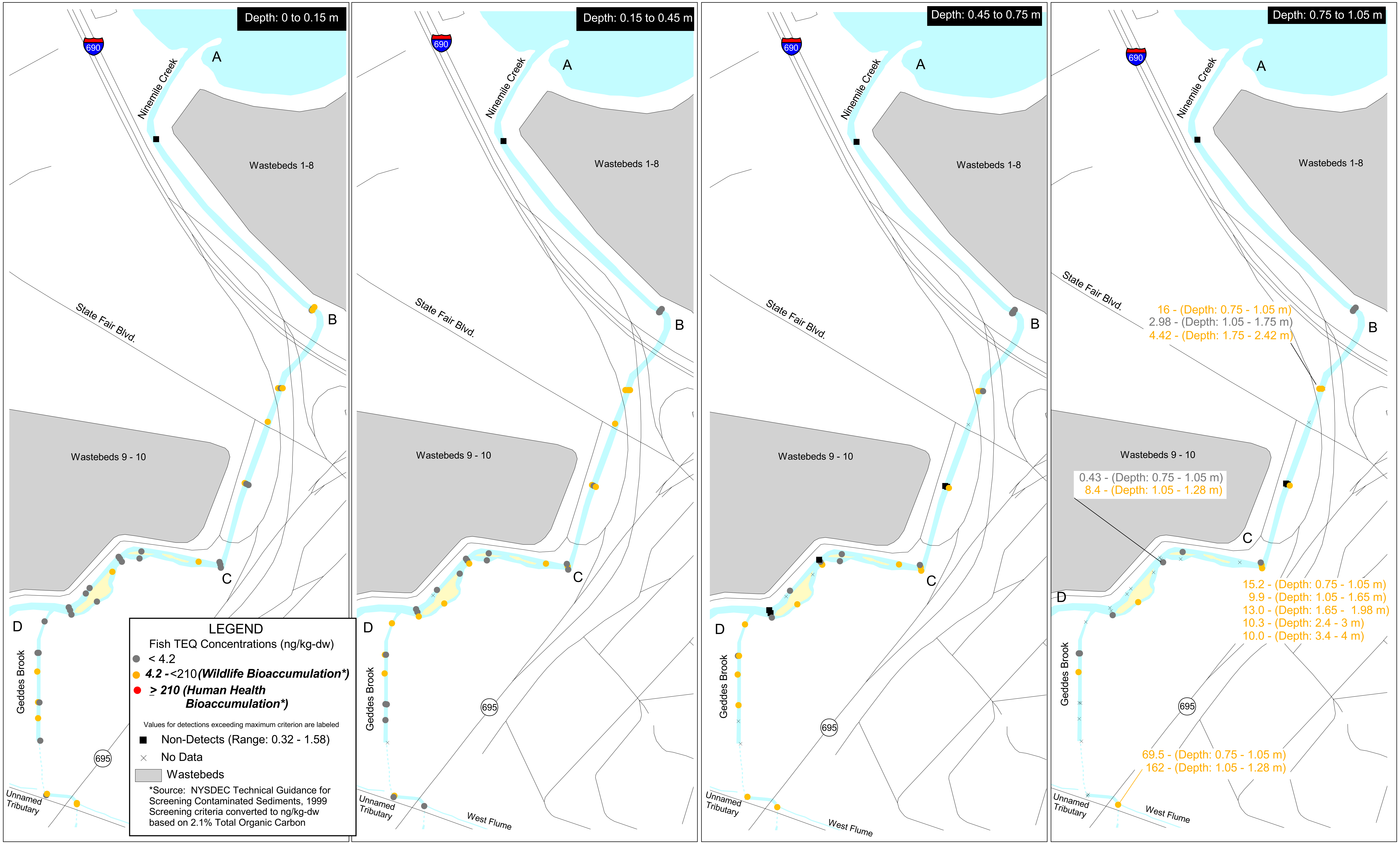
Geddes Brook/ Ninemile Creek RI	Figure 5-13 Aroclor 1268 Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 5-14a Human/Mammal TEQ Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



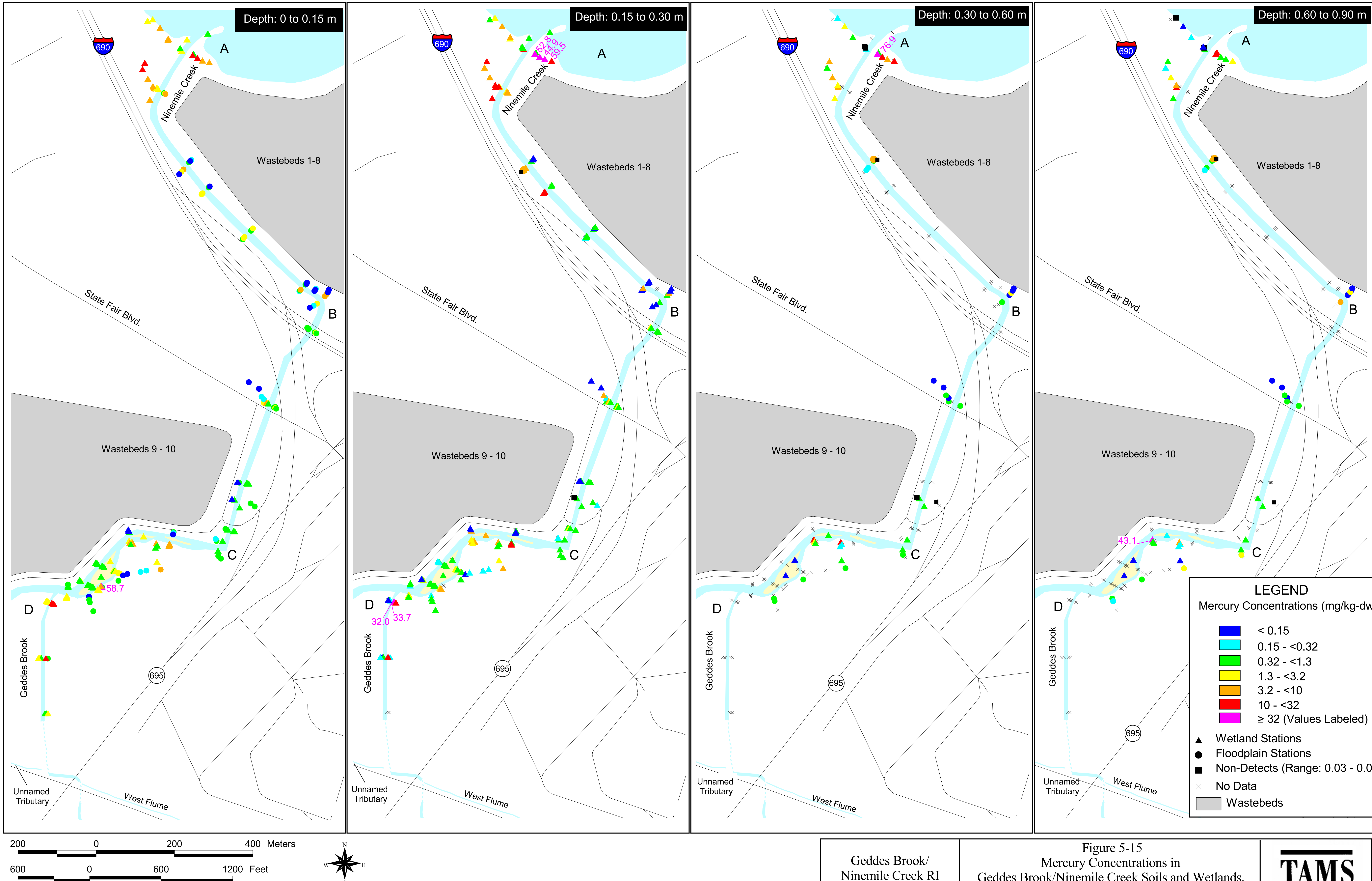
Geddes Brook/ Ninemile Creek RI	Figure 5-14b Bird TEQ Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



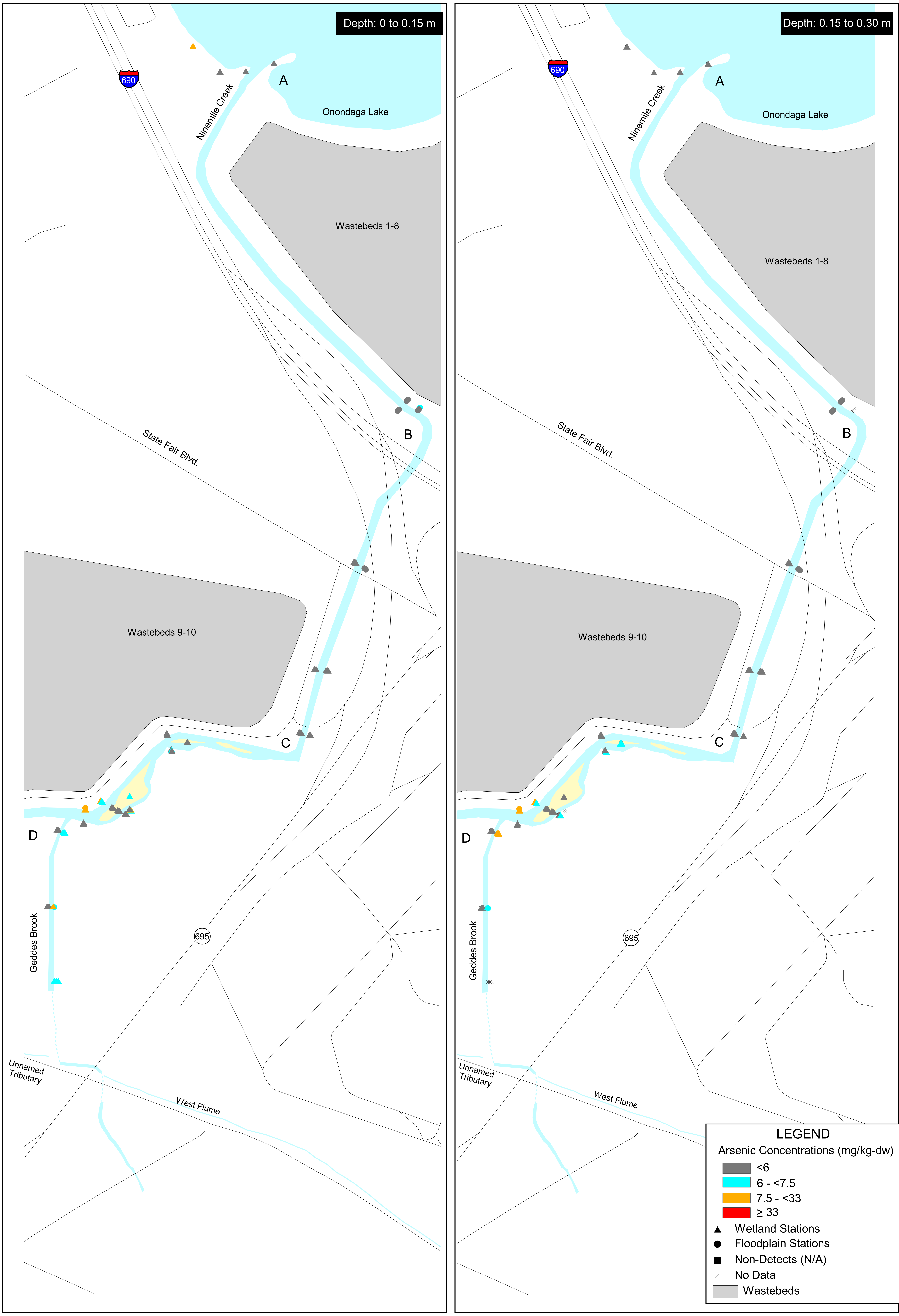
200 0 200 400 Meters

600 0 600 1200 Feet

Geddes Brook/ Ninemile Creek RI	Figure 5-14c Fish TEQ Concentrations in Geddes Brook/Ninemile Creek Sediments, 0 to 1.05 m Depth Intervals	TAMS



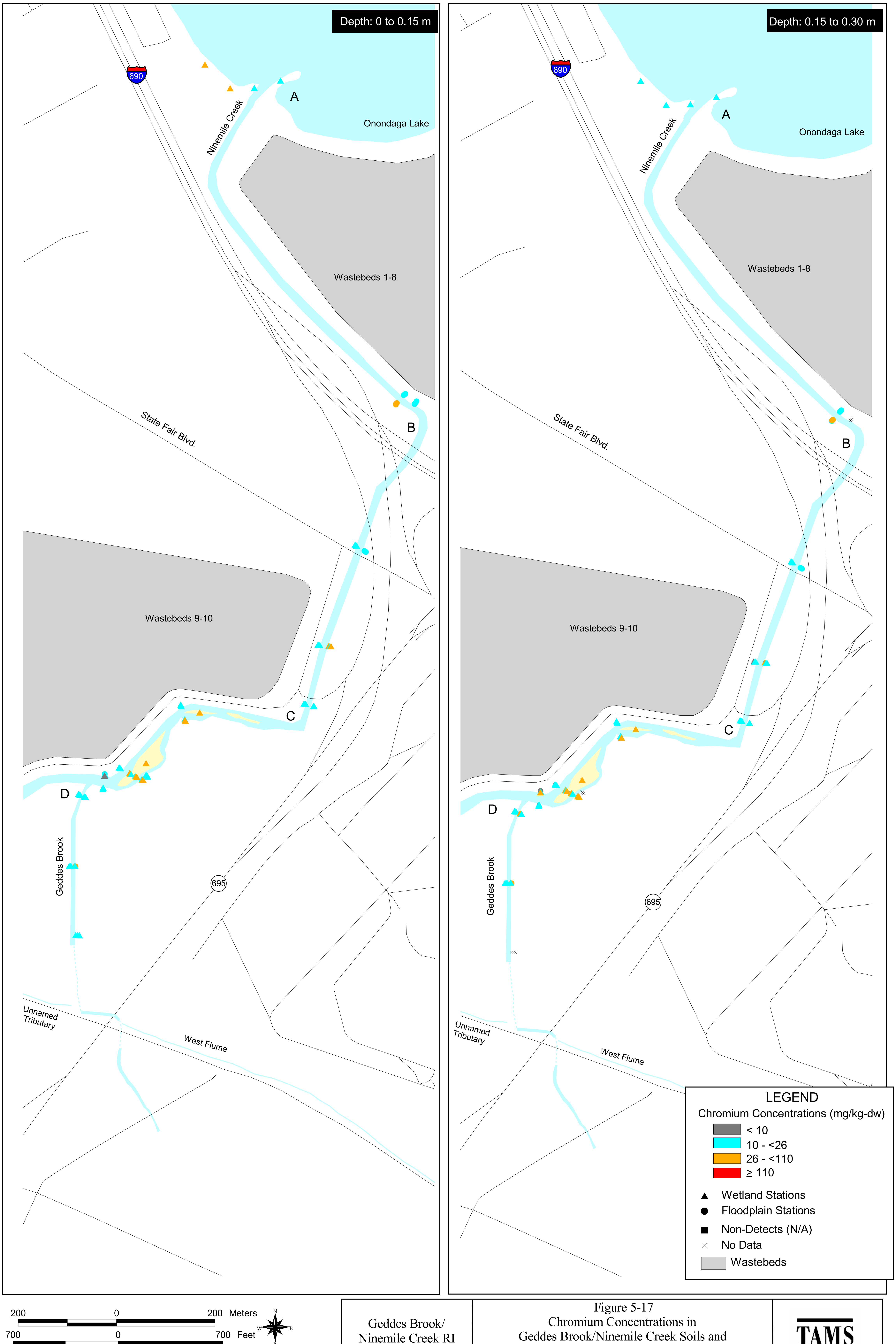
Geddes Brook/ Ninemile Creek RI	Figure 5-15 Mercury Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.90 m Depth Intervals	TAMS



Geddes Brook/
Ninemile Creek RI

Figure 5-16
Arsenic Concentrations in
Geddes Brook/Ninemile Creek Soils and
Wetlands, 0 to 0.30 m Depth Intervals

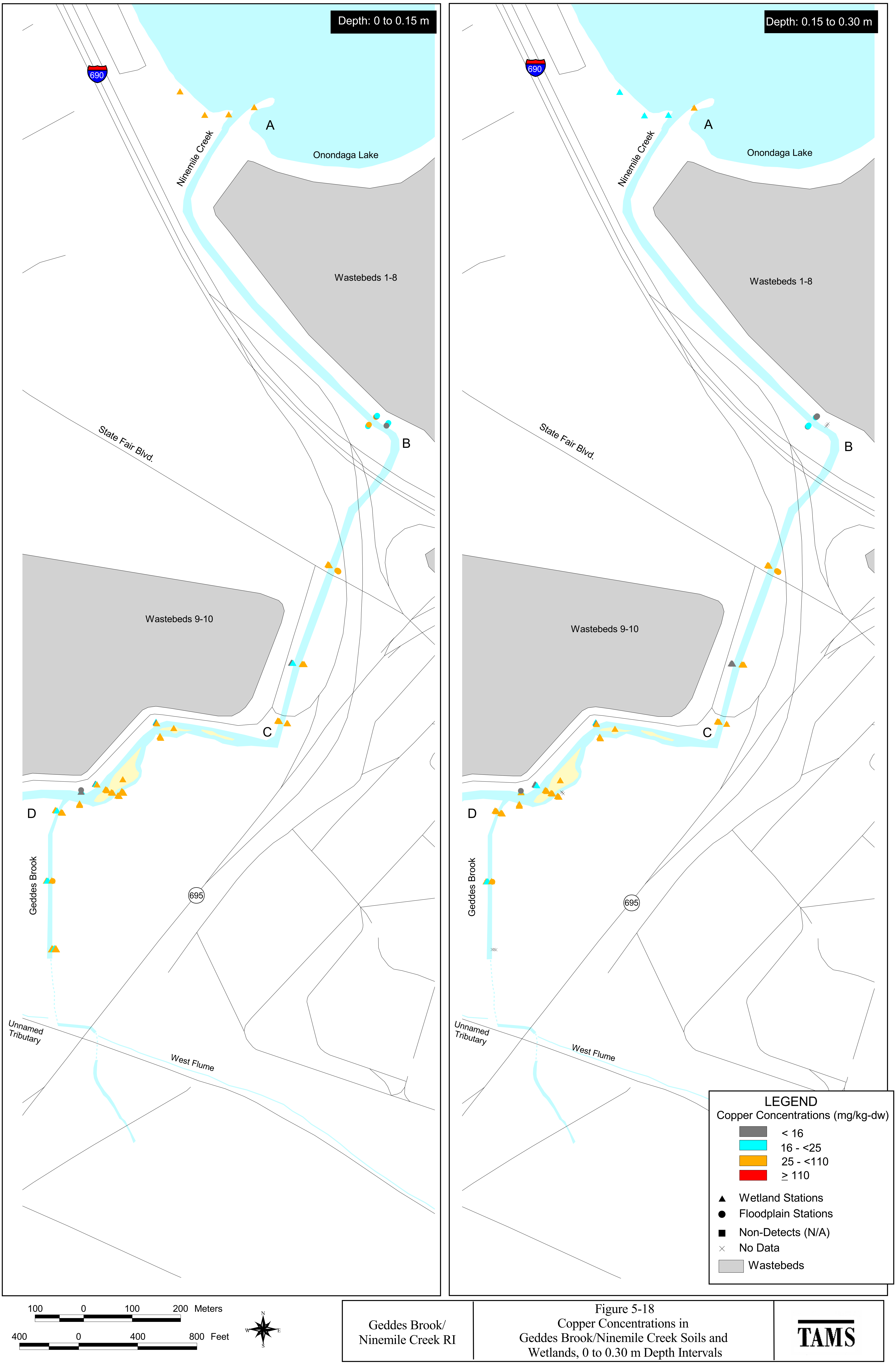
TAMS



Geddes Brook/
Ninemile Creek RI

Figure 5-17
Chromium Concentrations in
Geddes Brook/Ninemile Creek Soils and
Wetlands, 0 to 0.30 m Depth Intervals

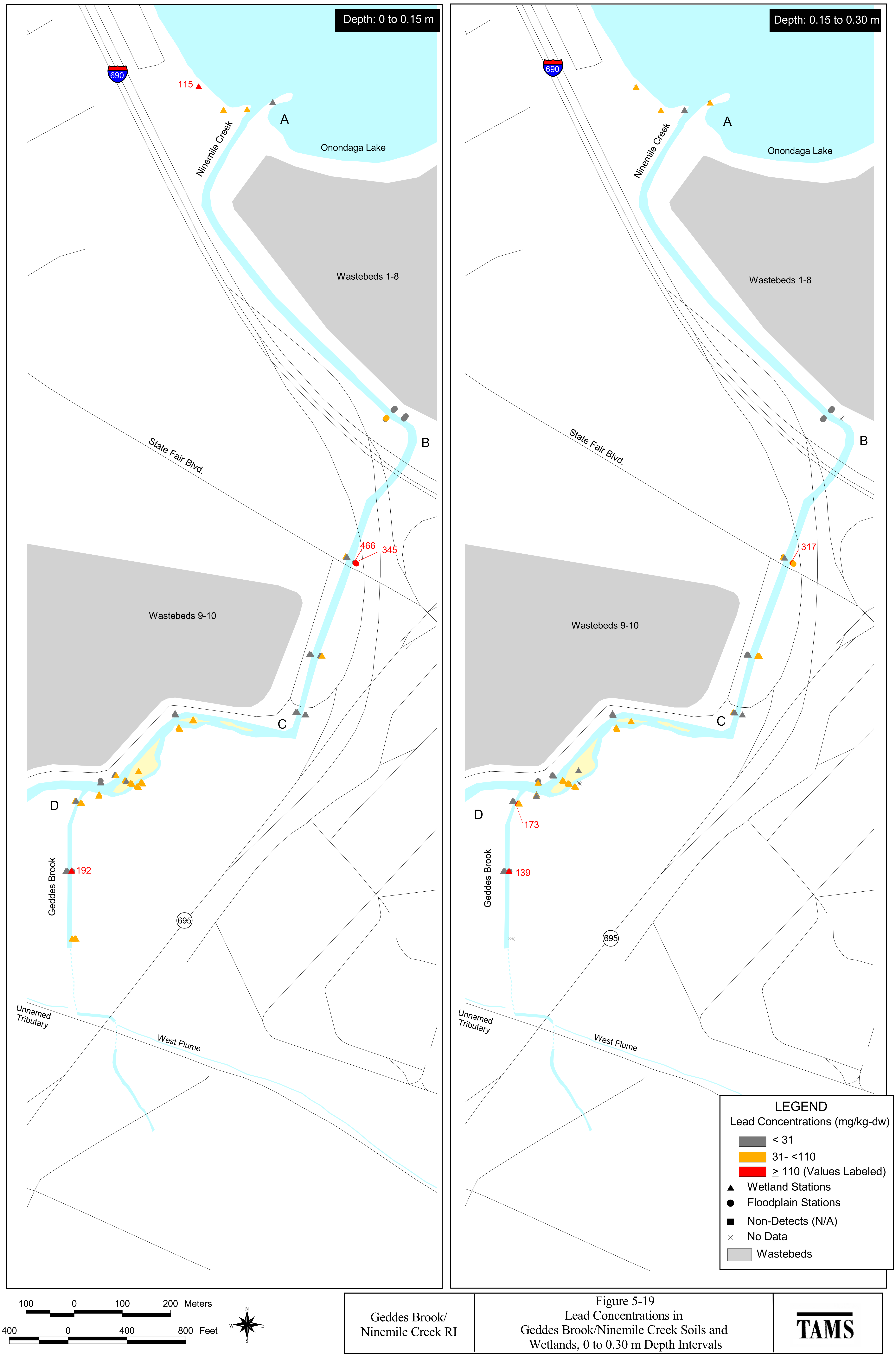
TAMS



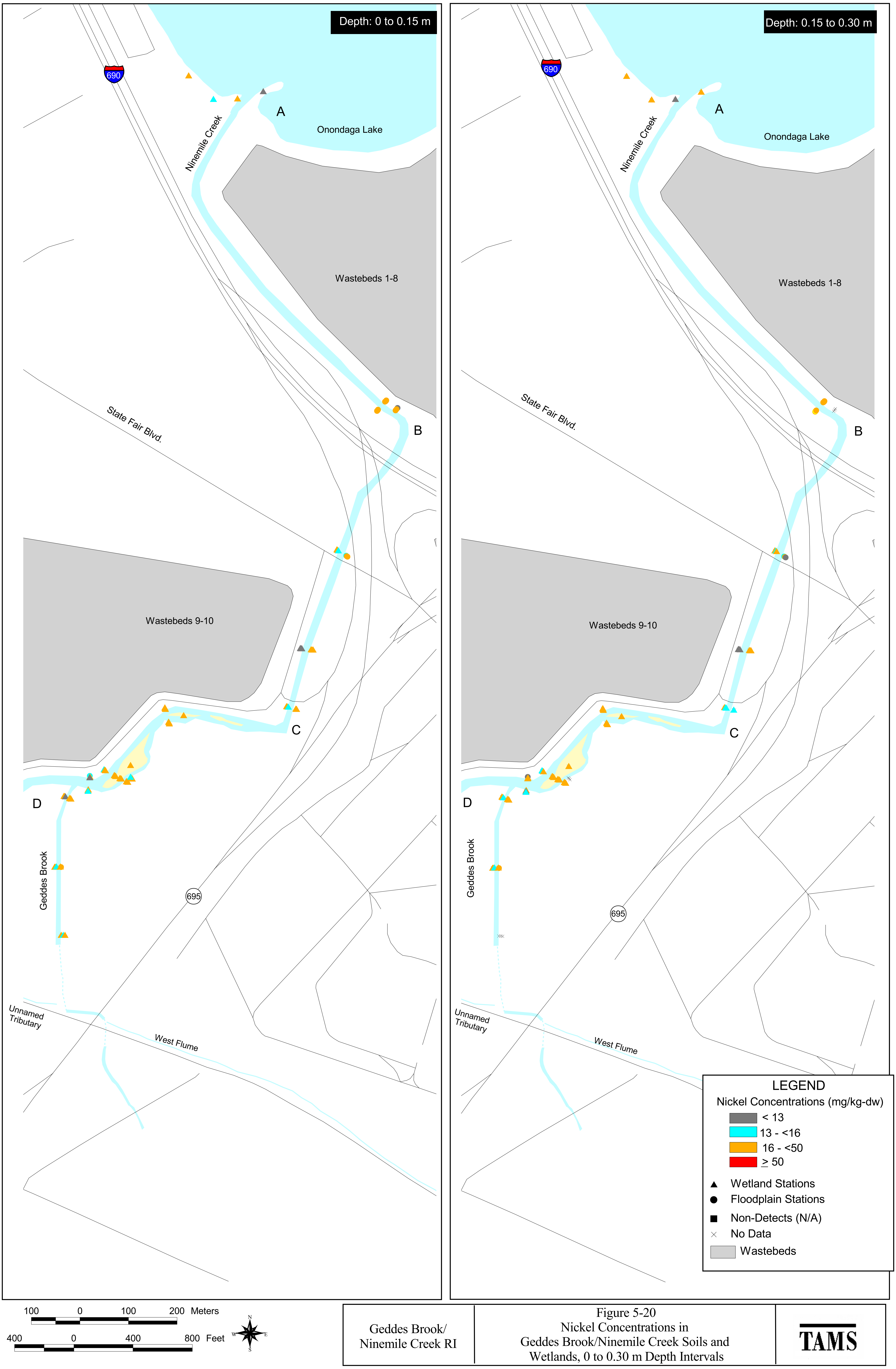
Geddes Brook/
Ninemile Creek RI

Figure 5-18
Copper Concentrations in
Geddes Brook/Ninemile Creek Soils and
Wetlands, 0 to 0.30 m Depth Intervals

TAMS



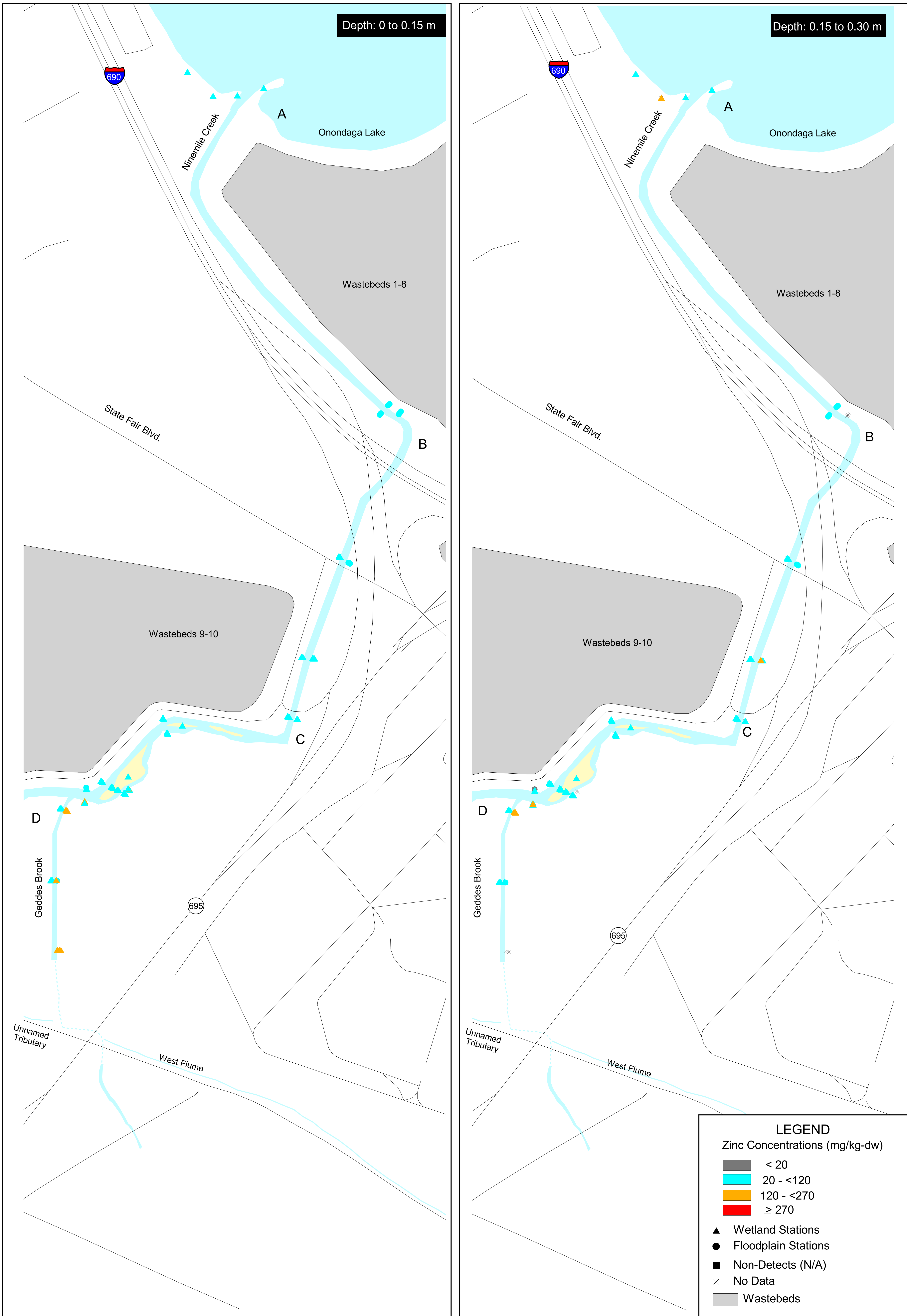
Geddes Brook/ Ninemile Creek RI	Figure 5-19 Lead Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.30 m Depth Intervals	TAMS

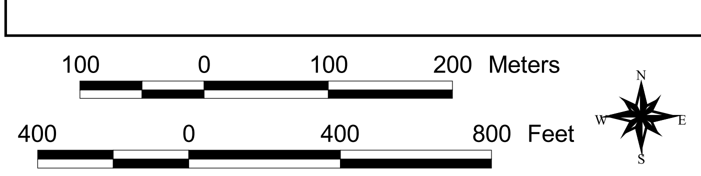


Geddes Brook/ Ninemile Creek RI

Figure 5-20
Nickel Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.30 m Depth Intervals

TAMS

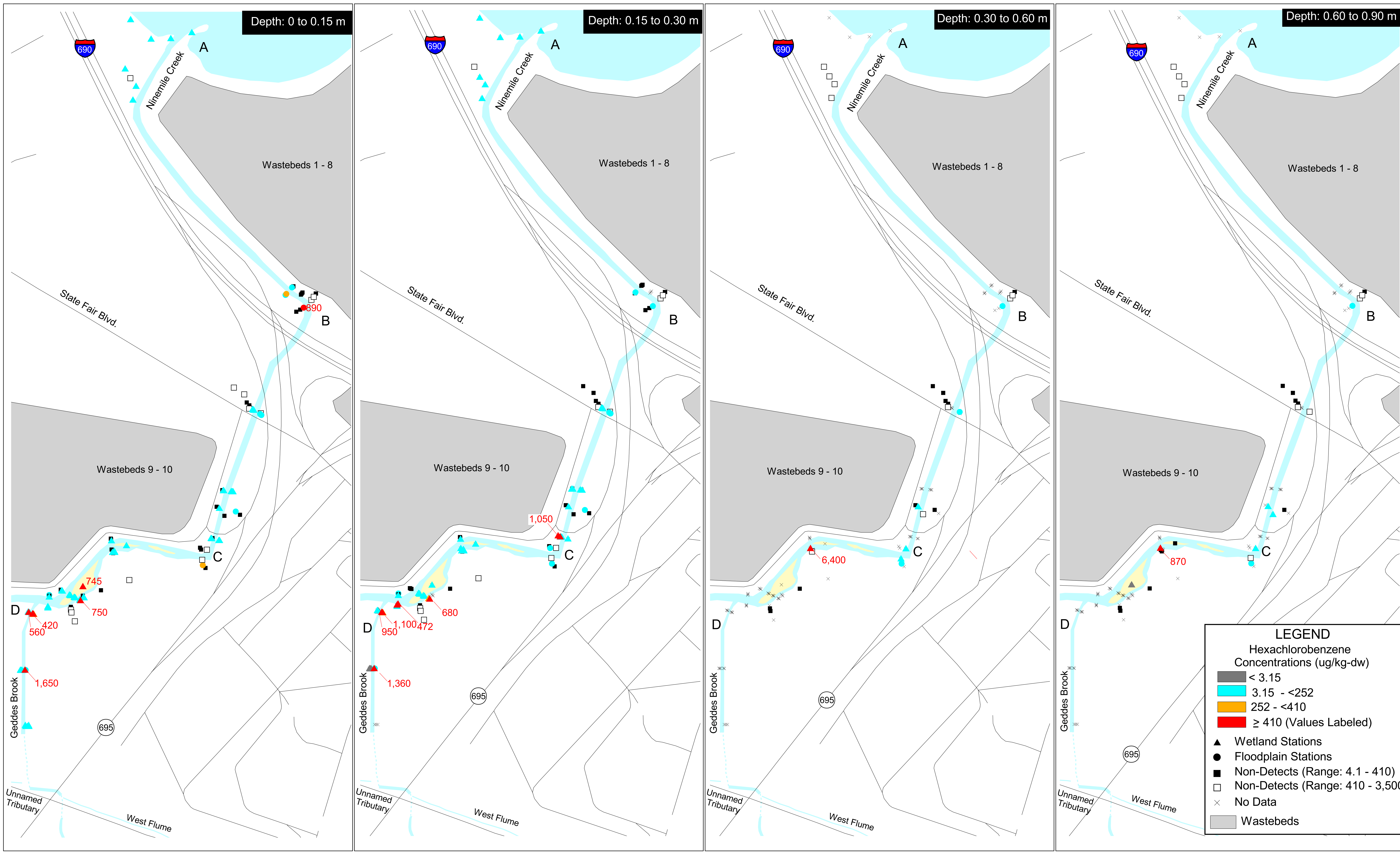


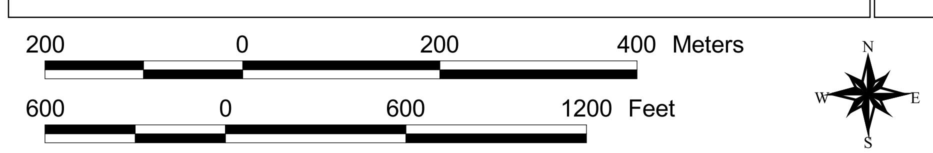


Geddes Brook/
Ninemile Creek RI

Figure 5-21
Zinc Concentrations in
Geddes Brook/Ninemile Creek Soils and
Wetlands, 0 to 0.30 m Depth Intervals

TAMS

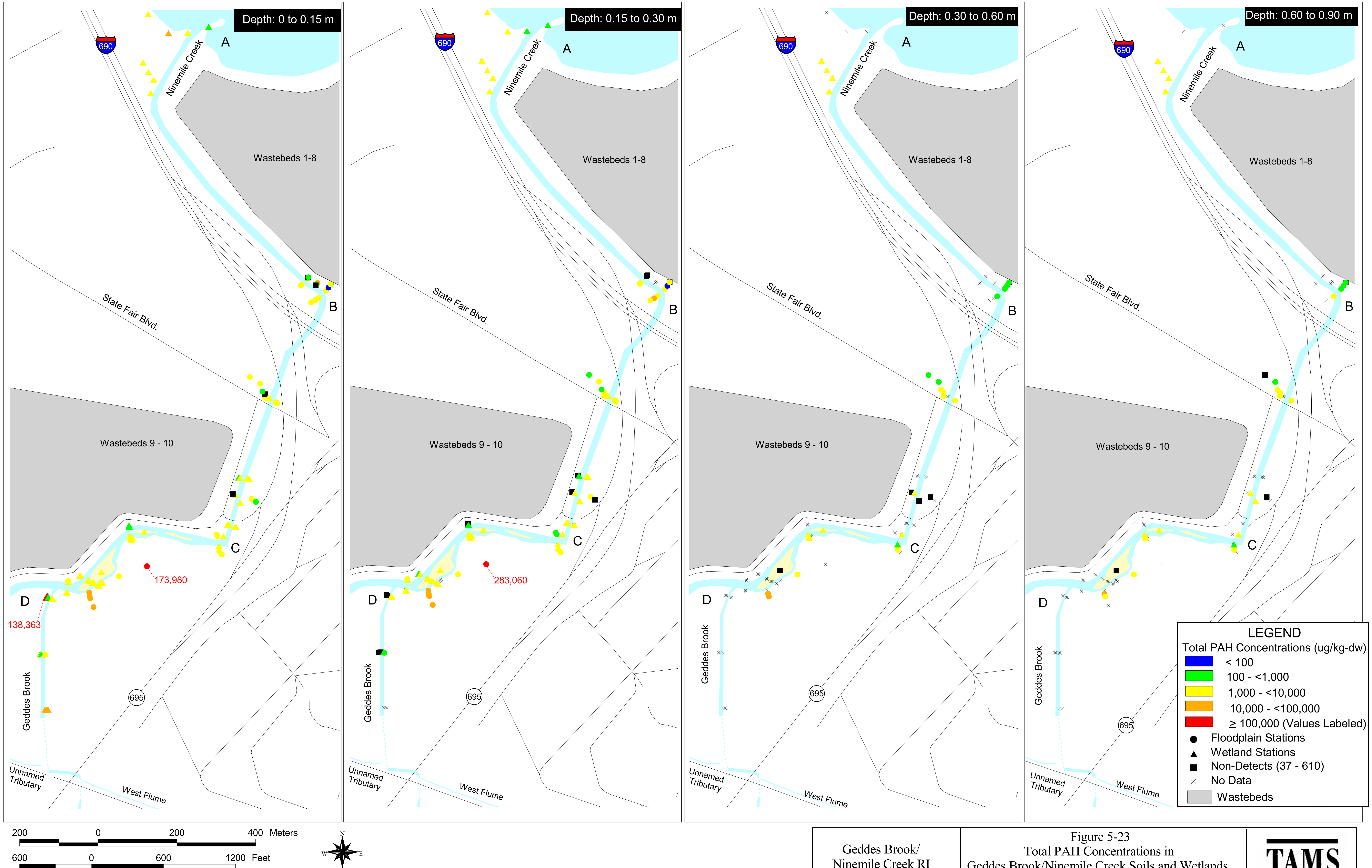




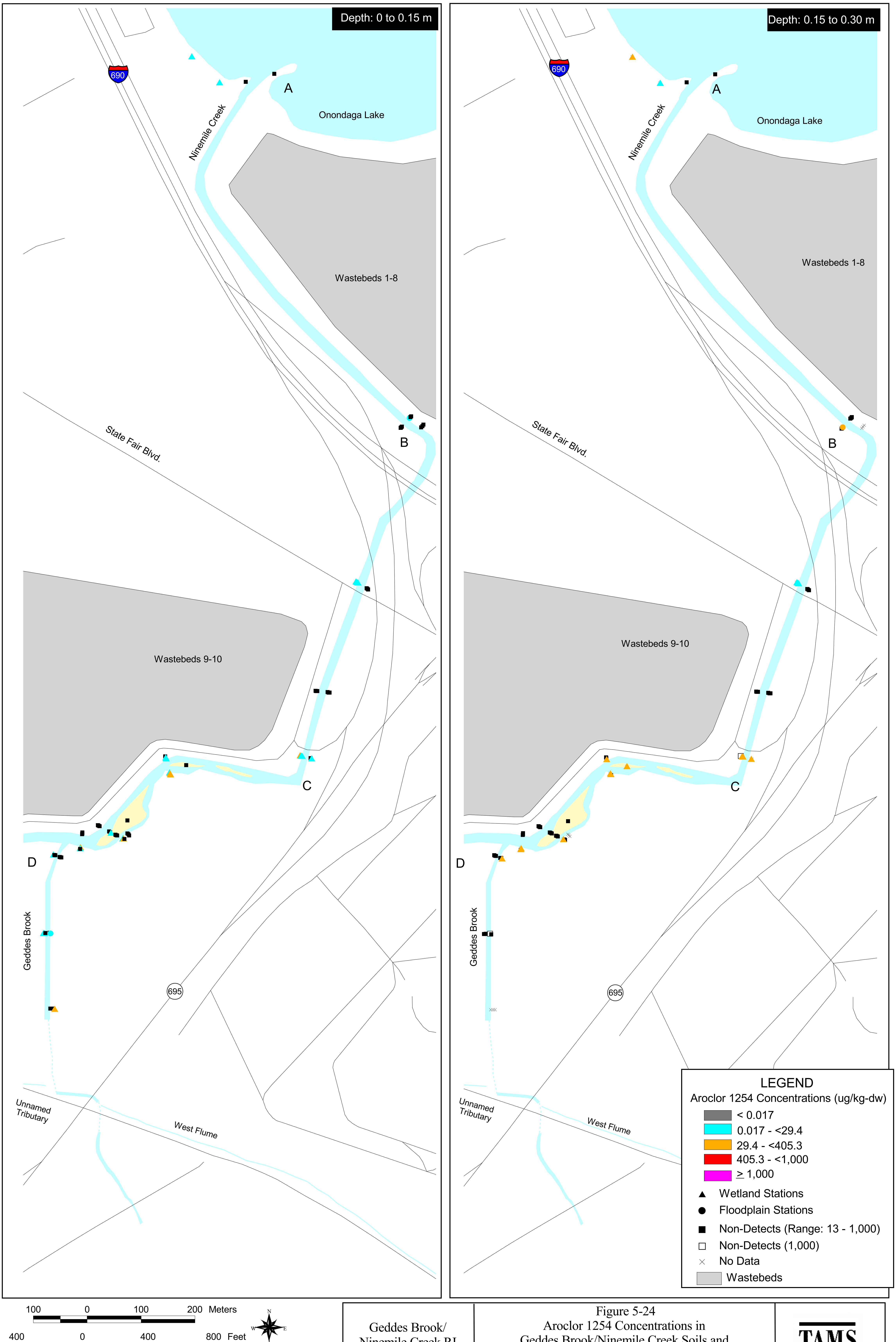
Geddes Brook/
Ninemile Creek RI

Figure 5-22
Hexachlorobenzene Concentrations in
Geddes Brook/Ninemile Creek Soils and Wetlands,
0 to 0.90 m Depth Intervals

TAMS



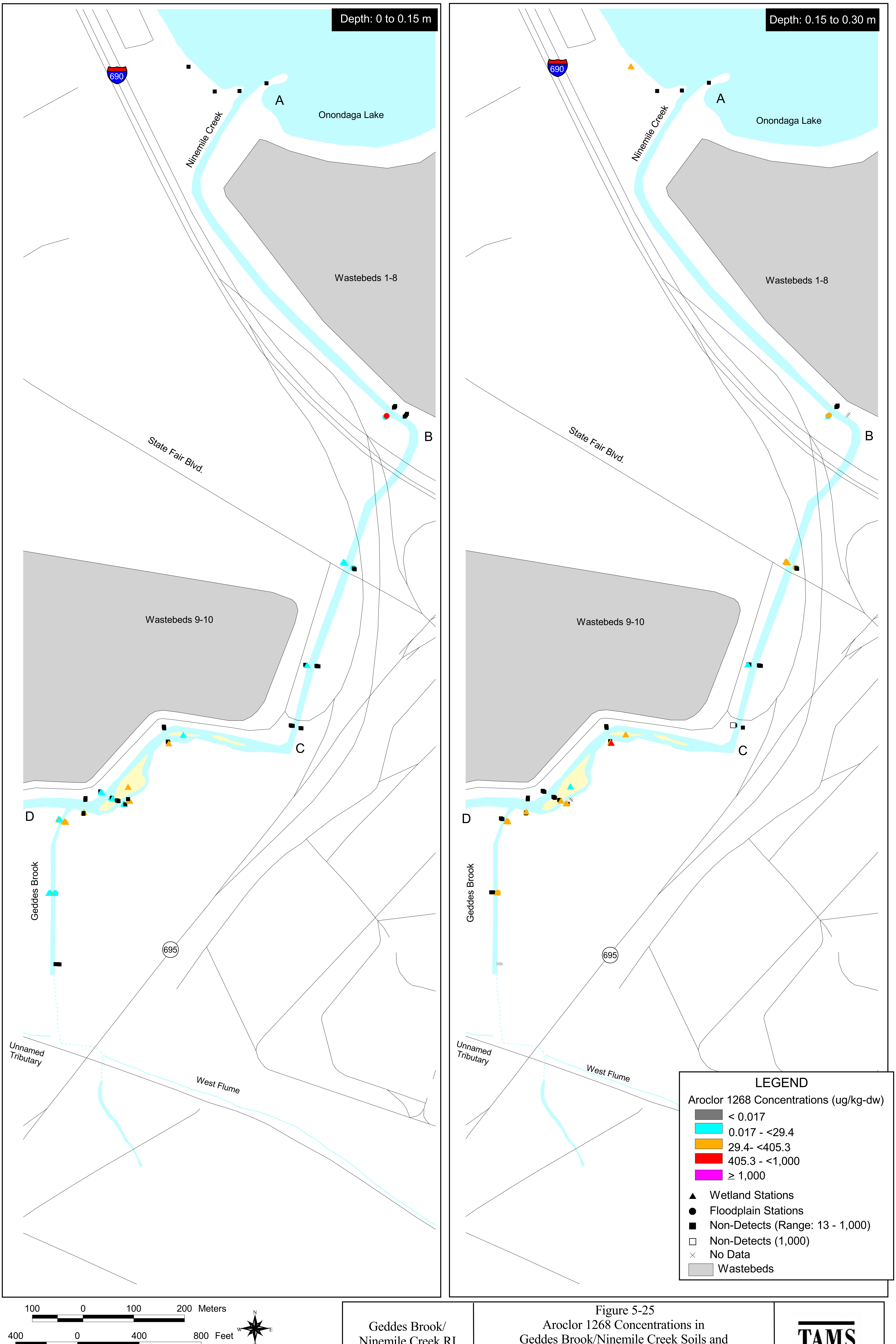
Geddes Brook/ Ninemile Creek RI	Figure 5-23 Total PAH Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.90 m Depth Intervals	TAMS



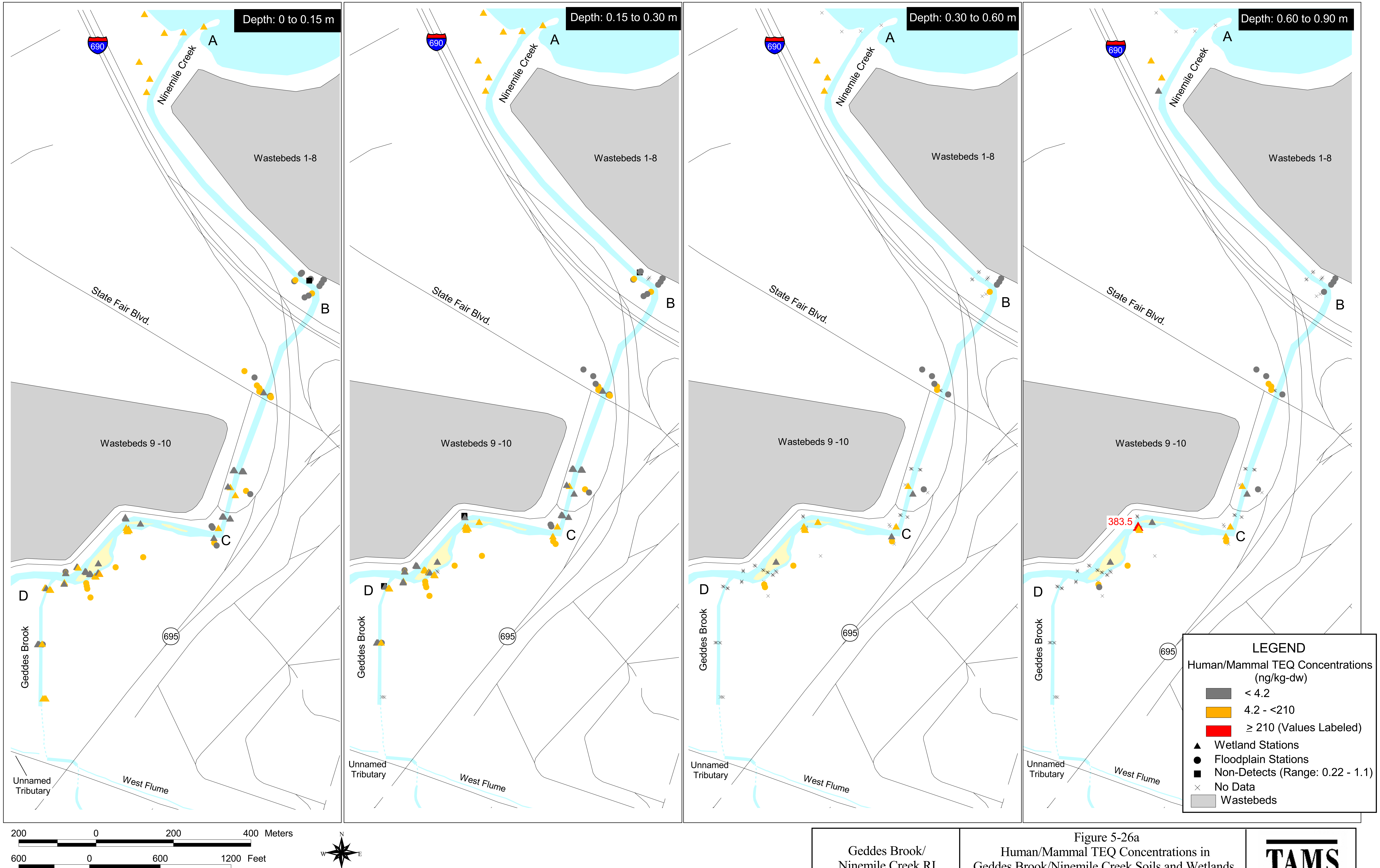
Geddes Brook/ Ninemile Creek RI

Figure 5-24
Aroclor 1254 Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.30 m Depth Intervals

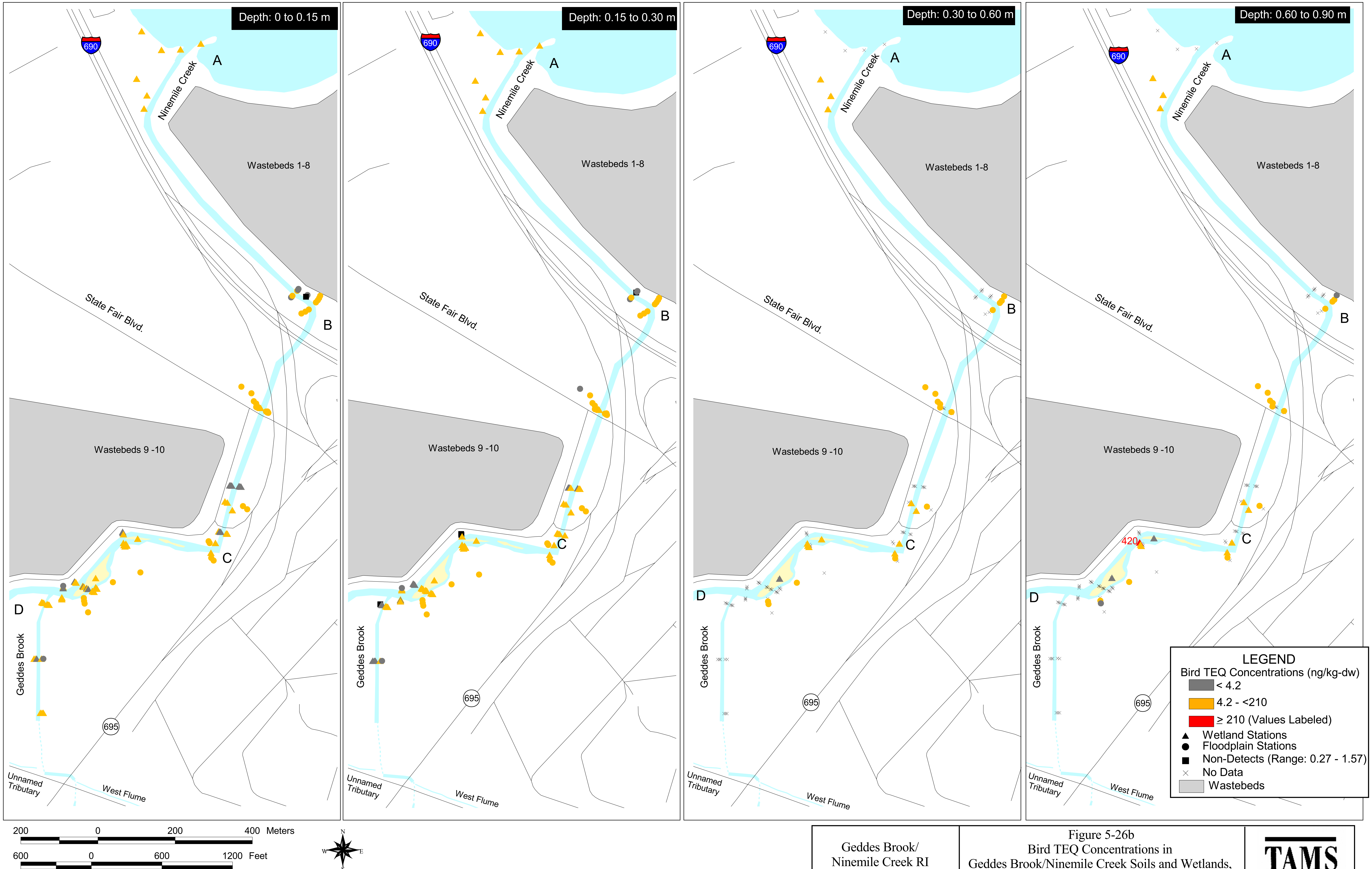
TAMS



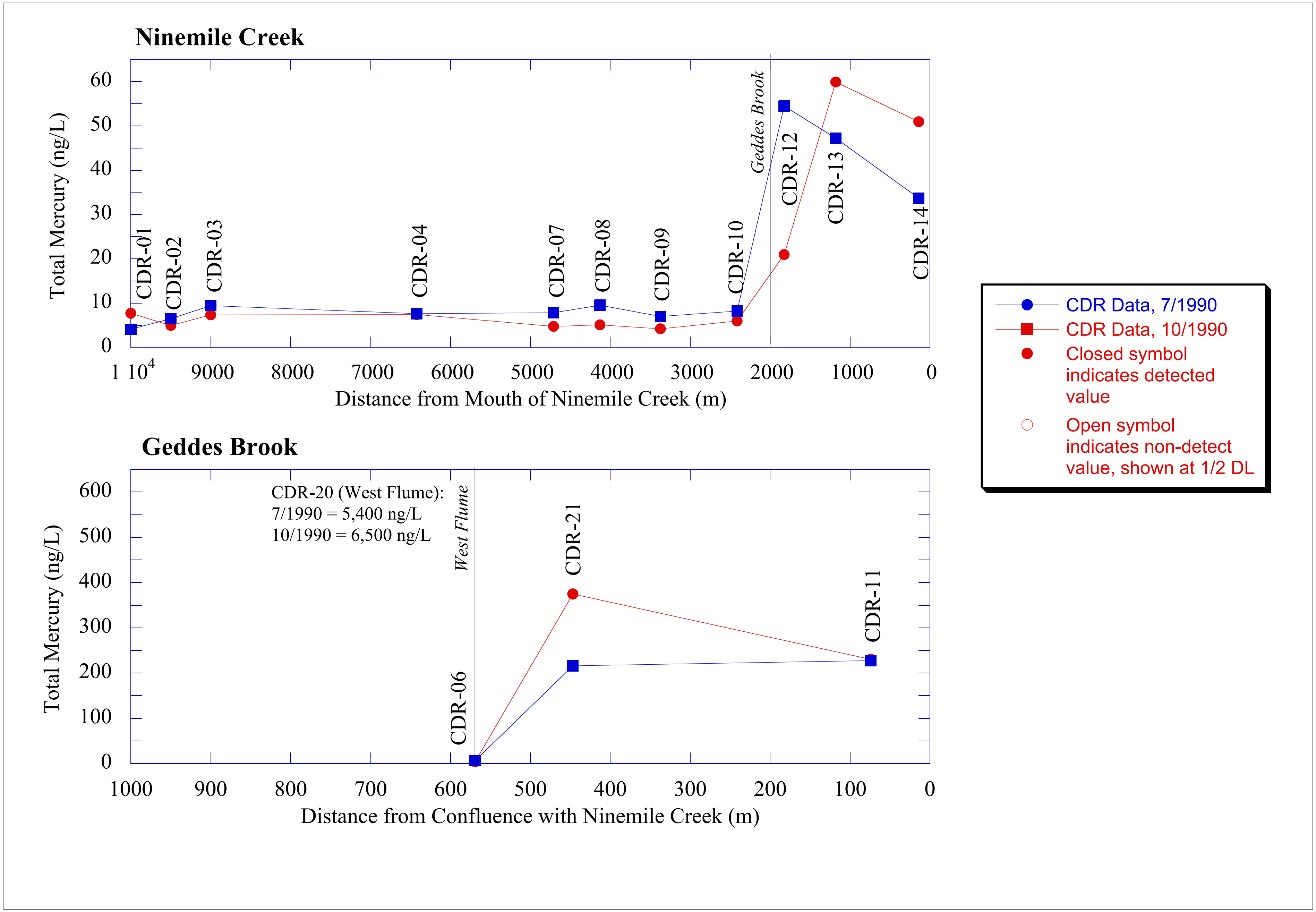
Geddes Brook/ Ninemile Creek RI	Figure 5-25 Aroclor 1268 Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.30 m Depth Intervals	TAMS



Geddes Brook/ Ninemile Creek RI	Figure 5-26a Human/Mammal TEQ Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.90 m Depth Intervals	TAMS

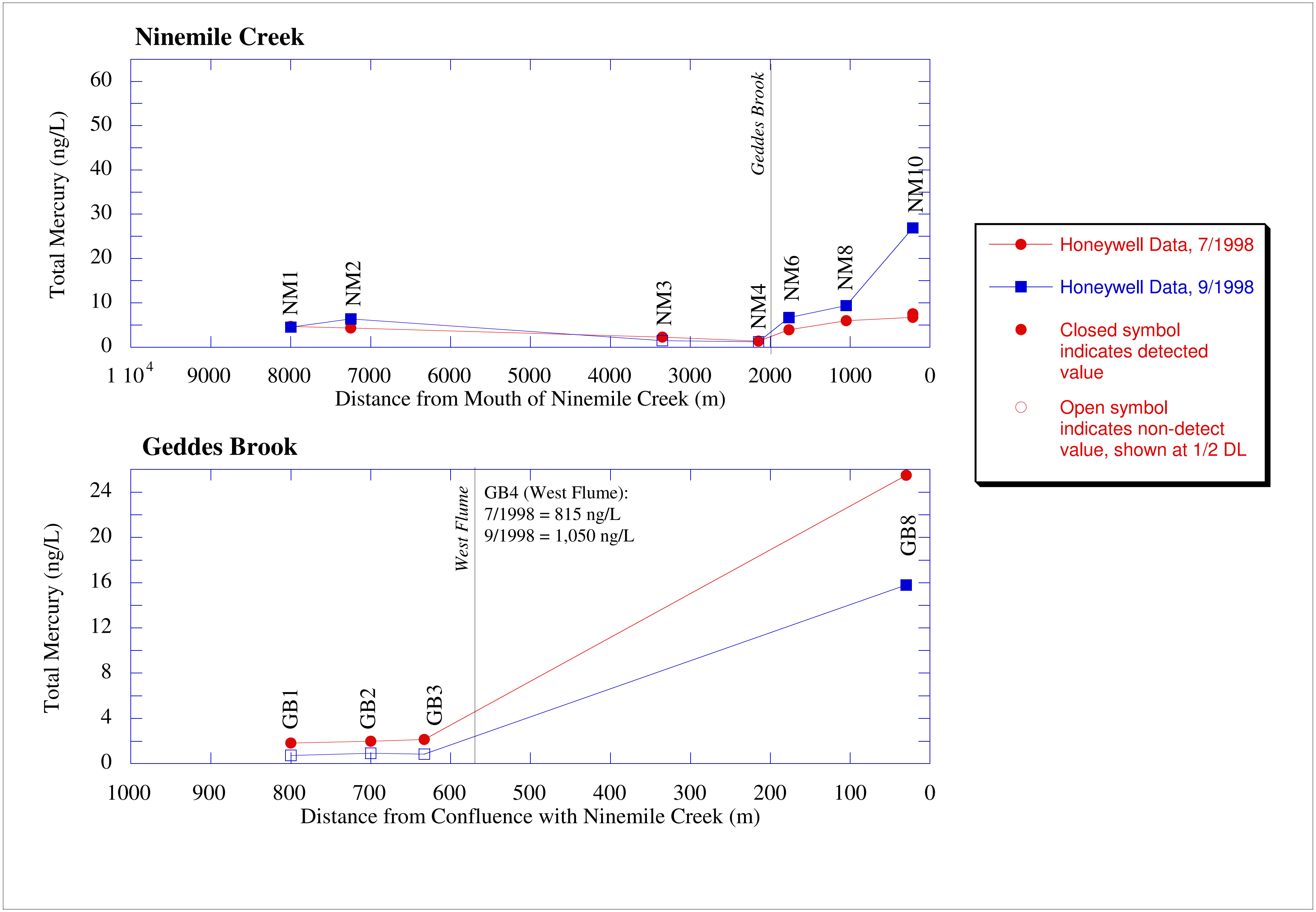


Geddes Brook/ Ninemile Creek RI	Figure 5-26b Bird TEQ Concentrations in Geddes Brook/Ninemile Creek Soils and Wetlands, 0 to 0.90 m Depth Intervals	TAMS



TAMS

Figure 5-27a
Total Mercury Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1990



TAMS

Figure 5-27b
Total Mercury Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998

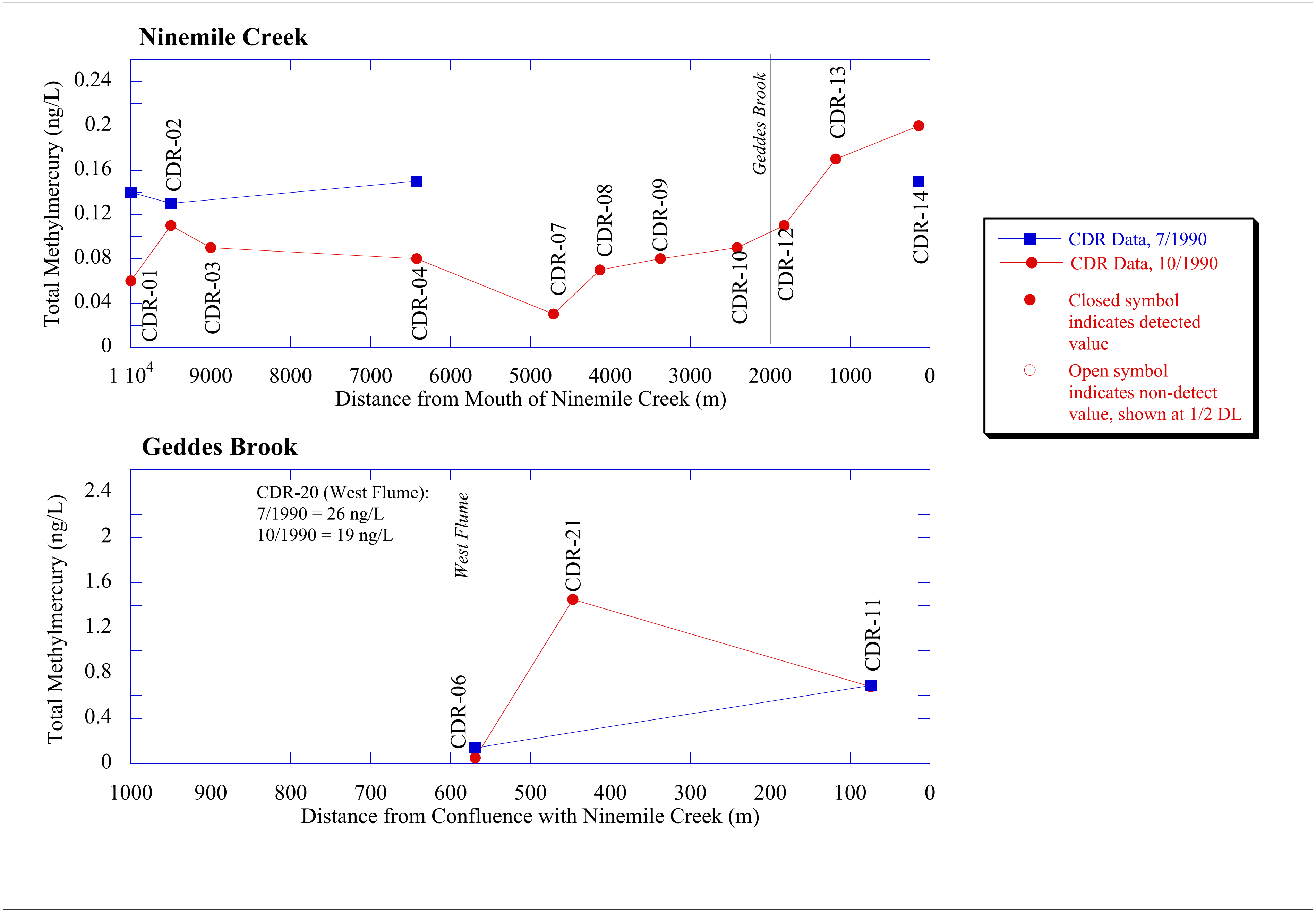
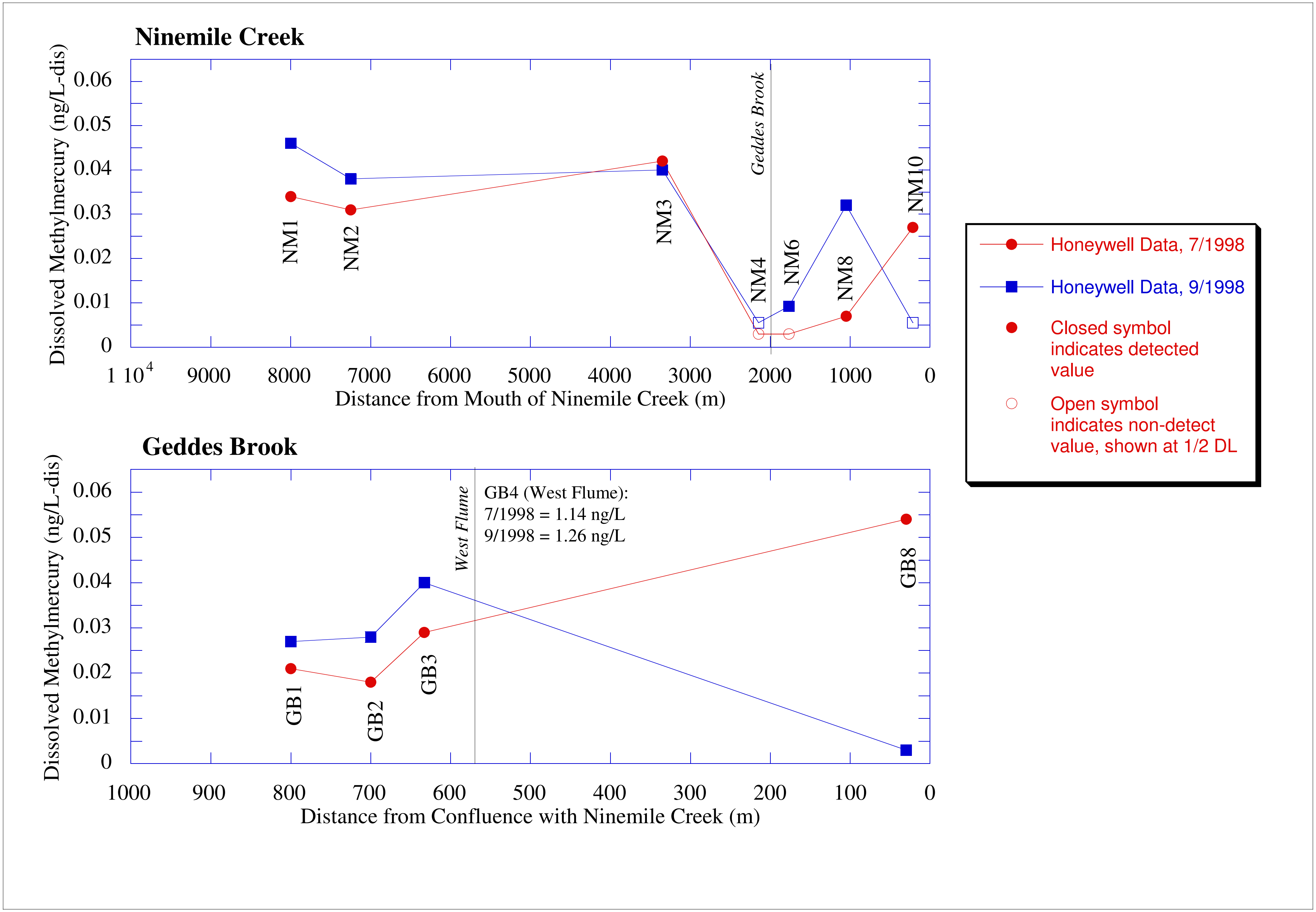


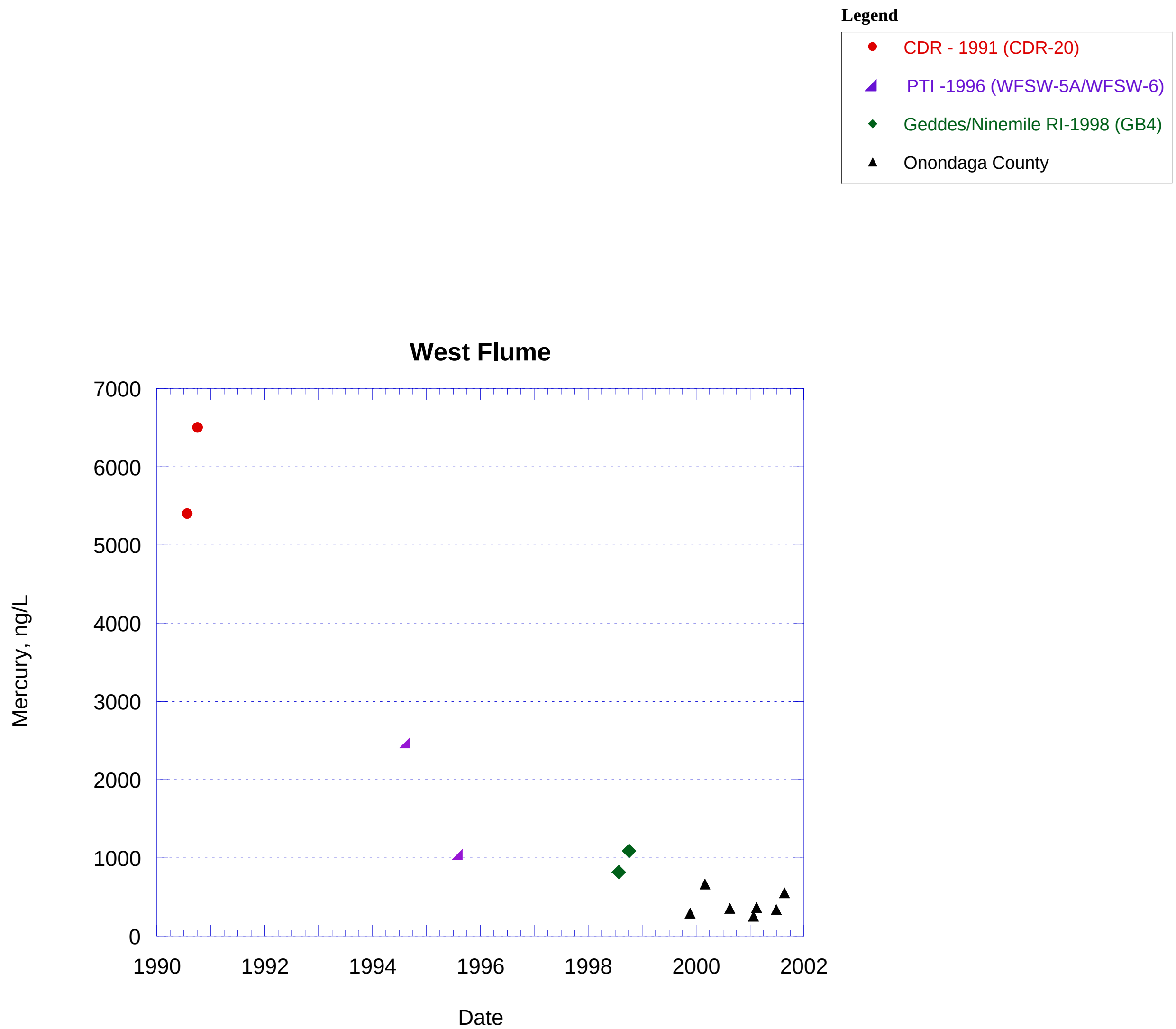
Figure 5-28a
Total Methylmercury Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1990

TAMS



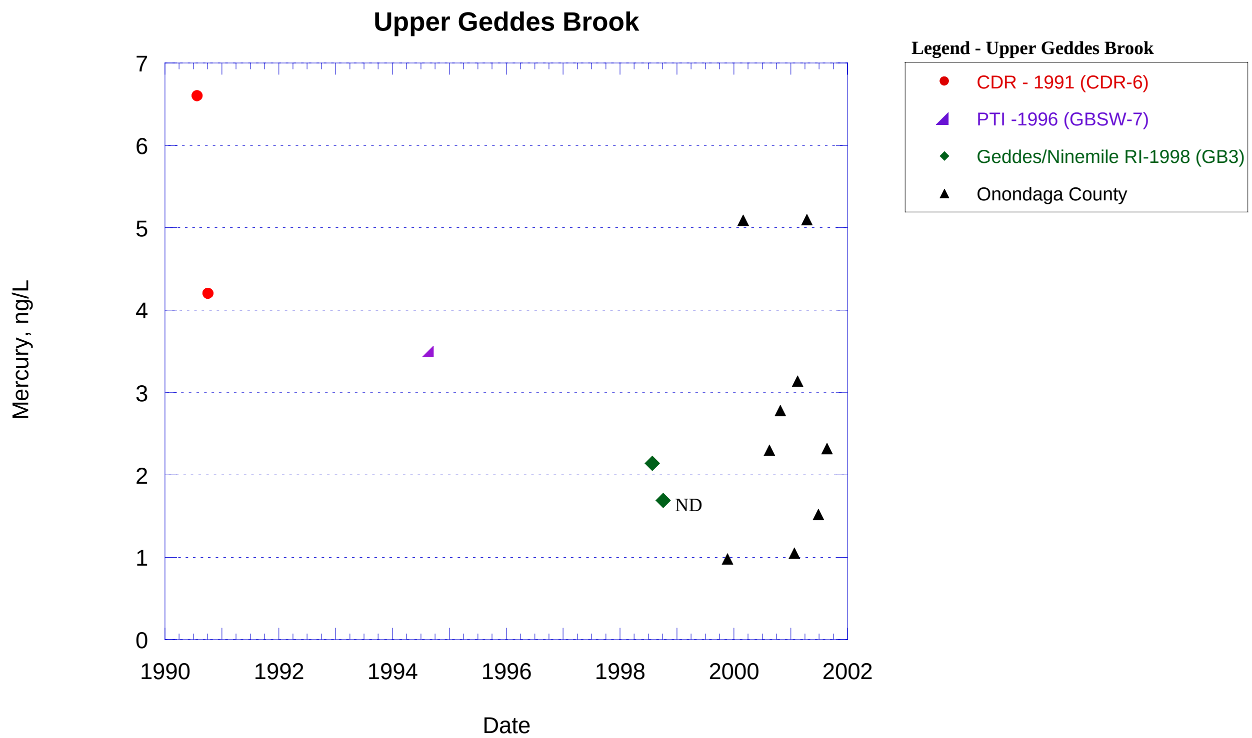
TAMS

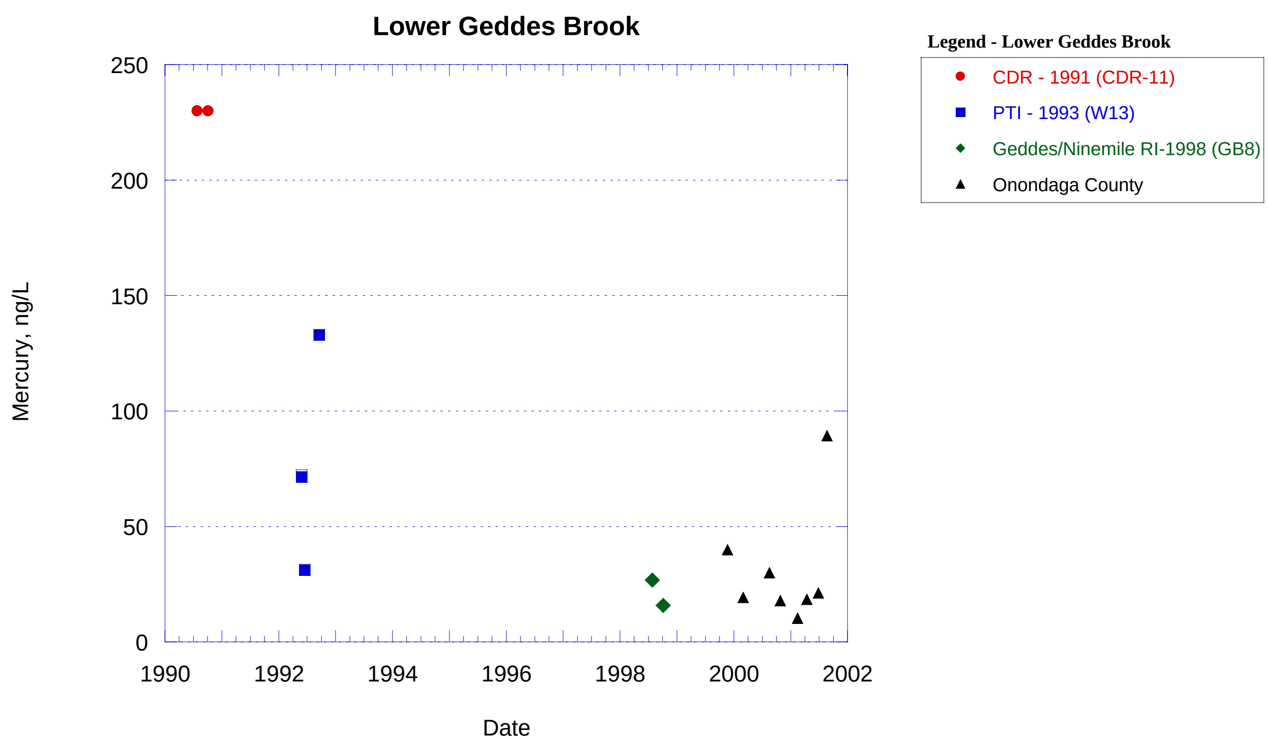
Figure 5-28b
Dissolved Methylmercury Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



TAMS

Figure 5-29
Total Mercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at West Flume

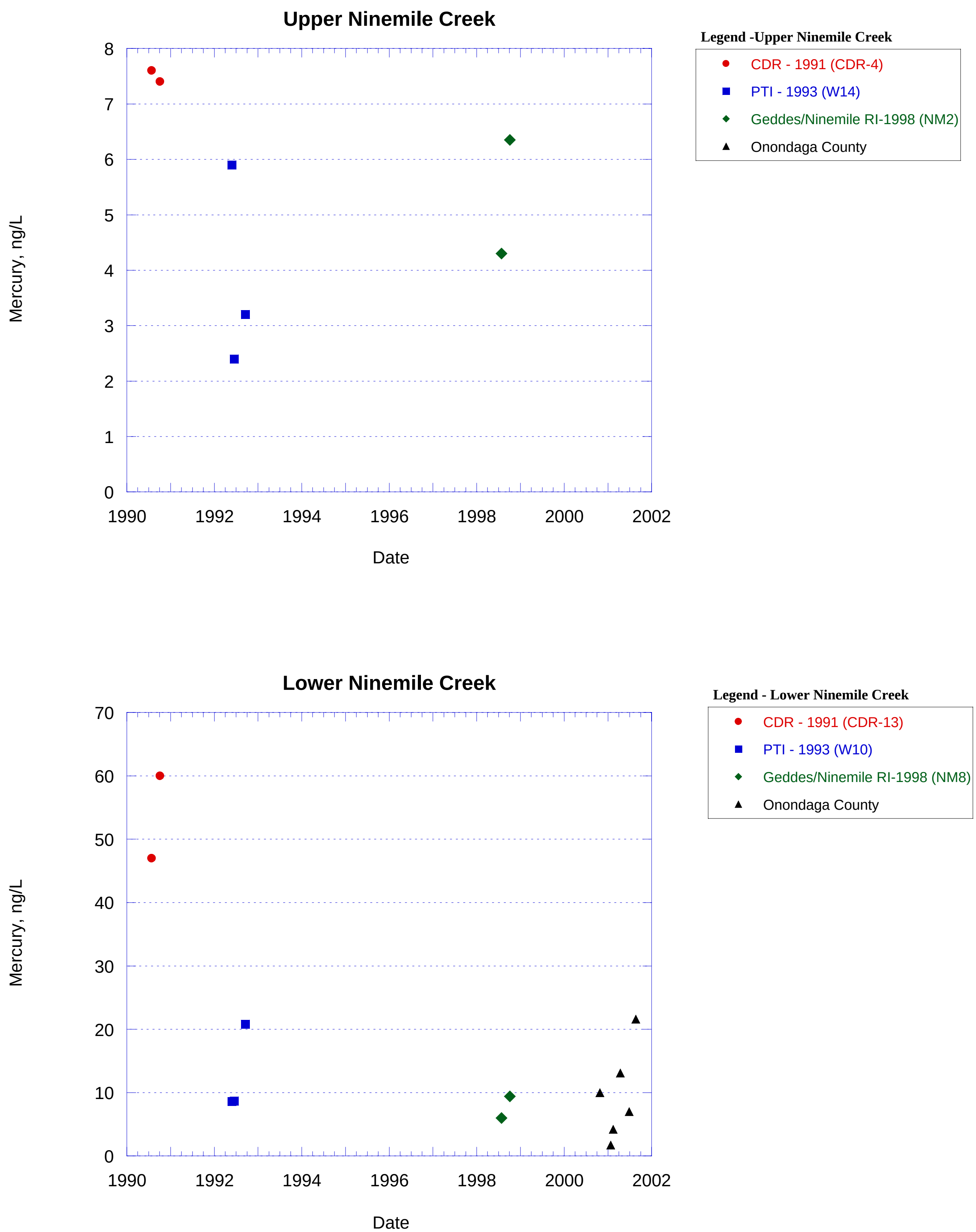




Note: ND indicates the sample was not detected and the detection limit is shown.

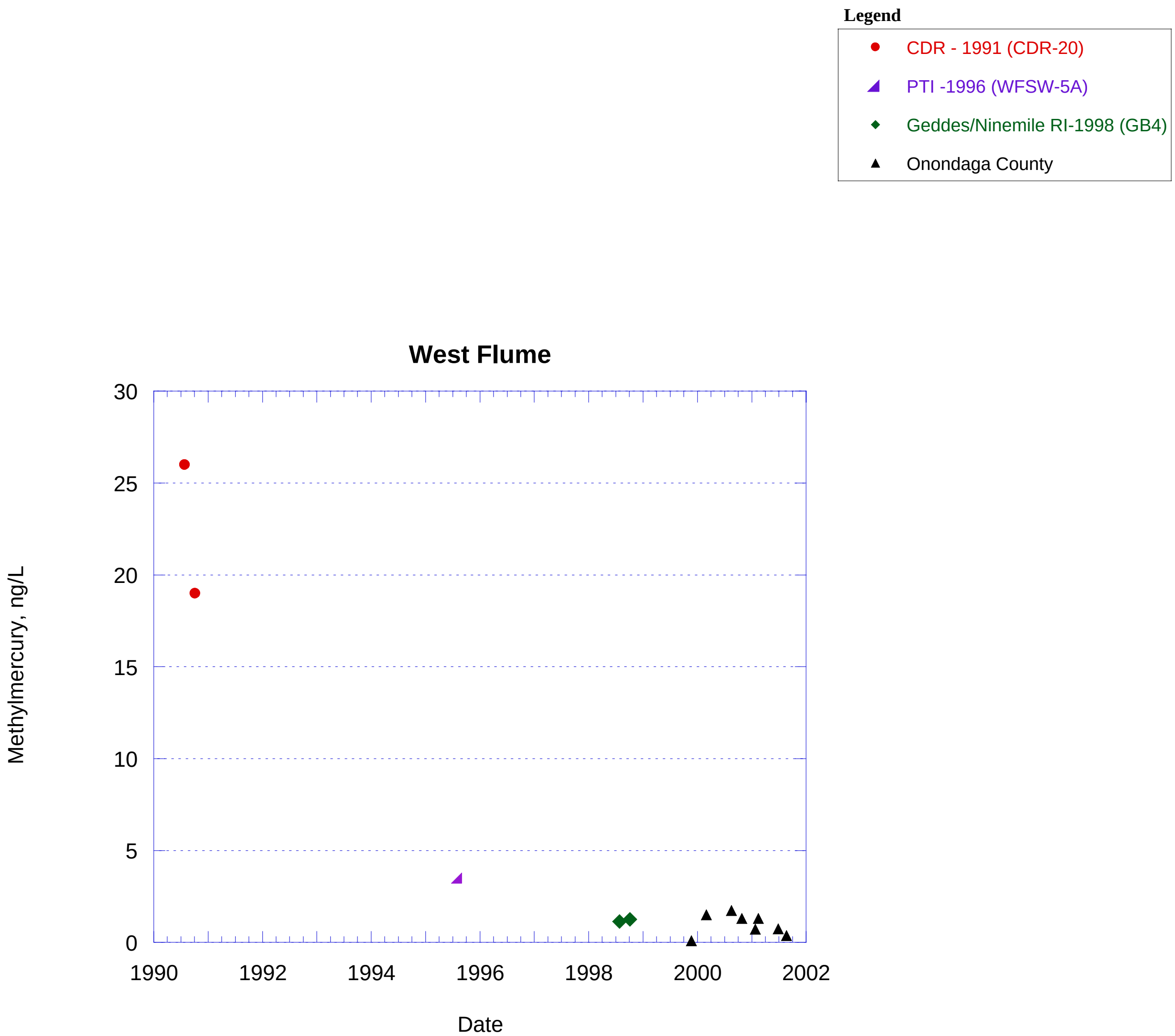
TAMS

Figure 5-30
Total Mercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at Geddes Brook



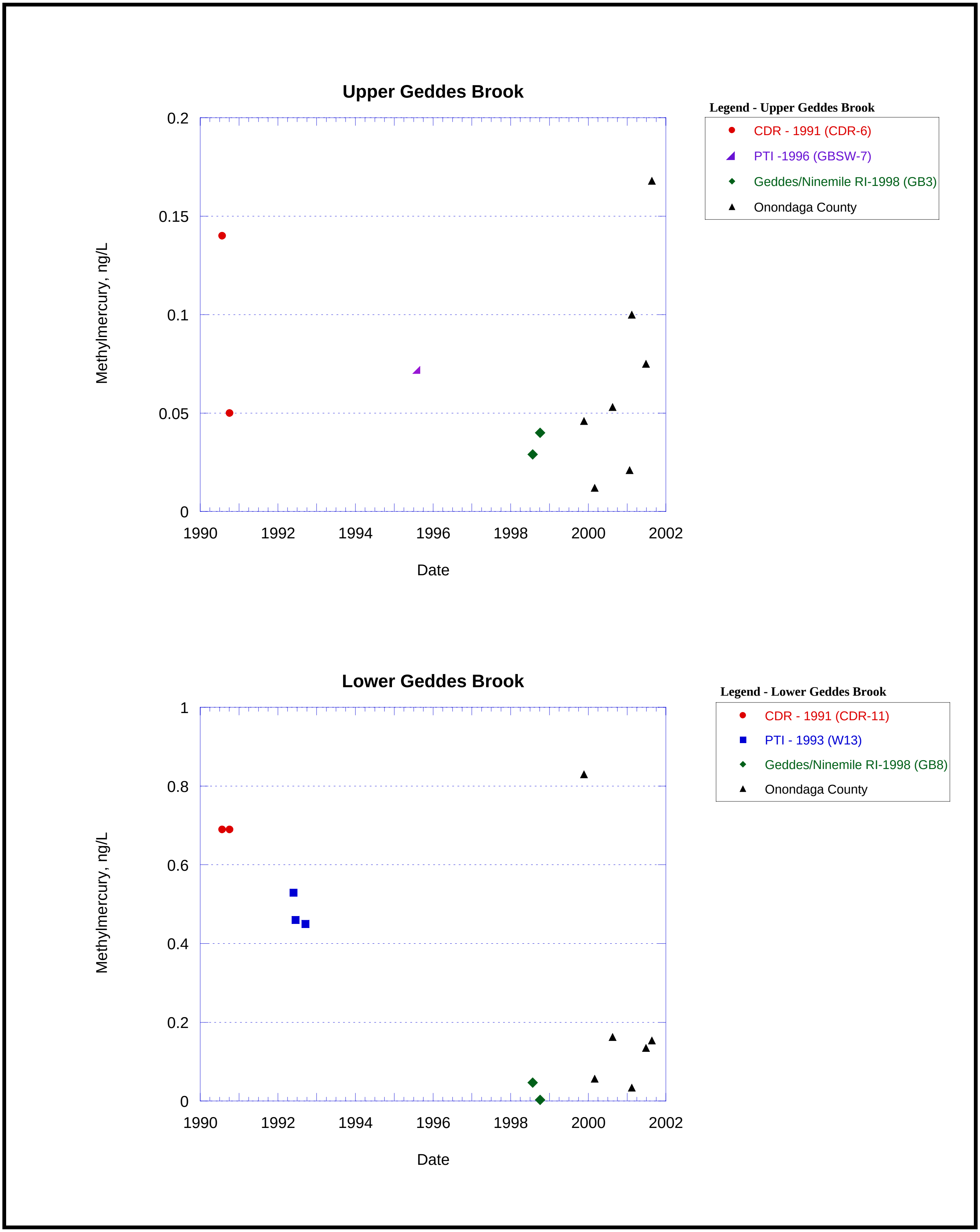
TAMS

Figure 5-31
Total Mercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at Ninemile Creek



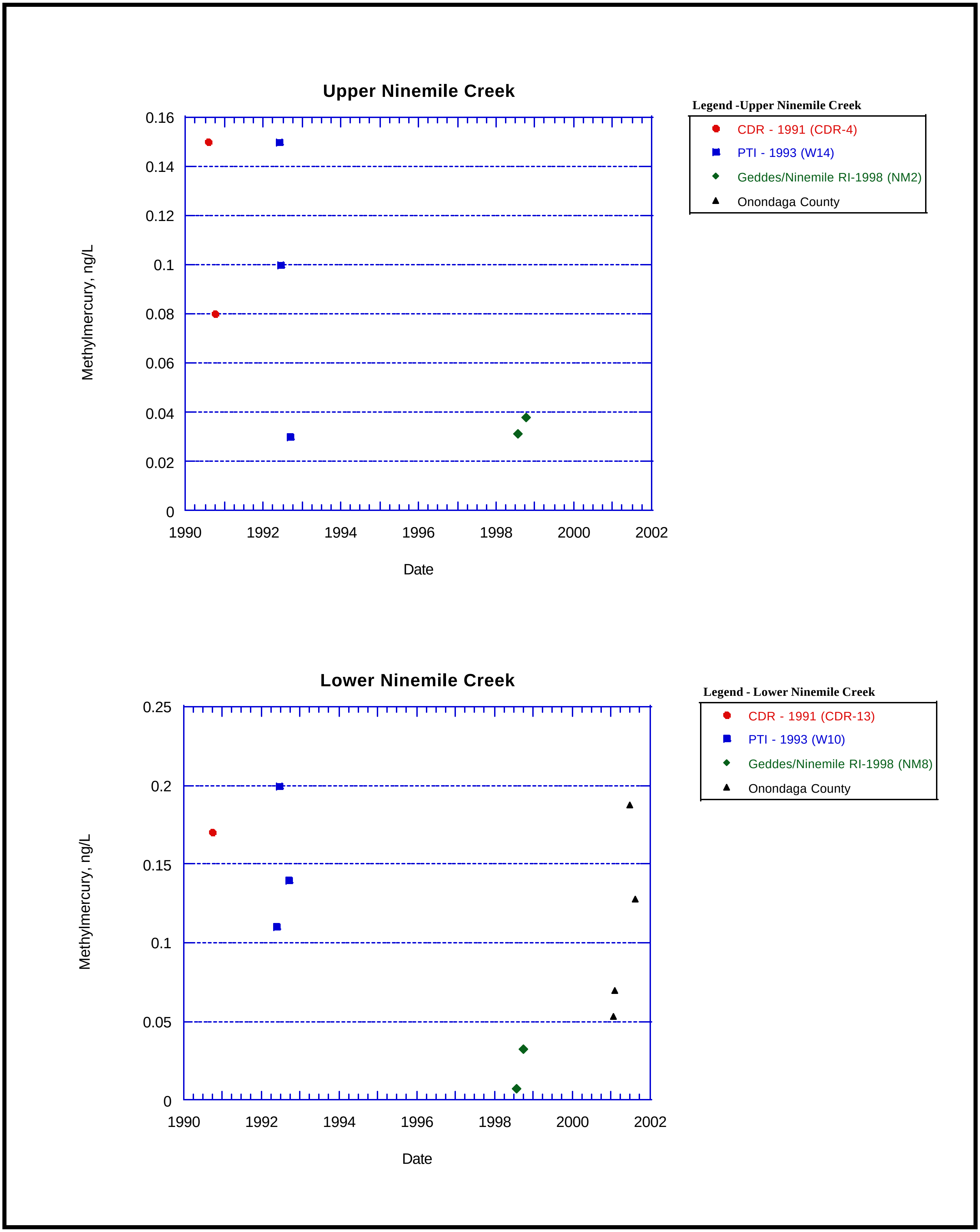
TAMS

Figure 5-32
Methylmercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at West Flume



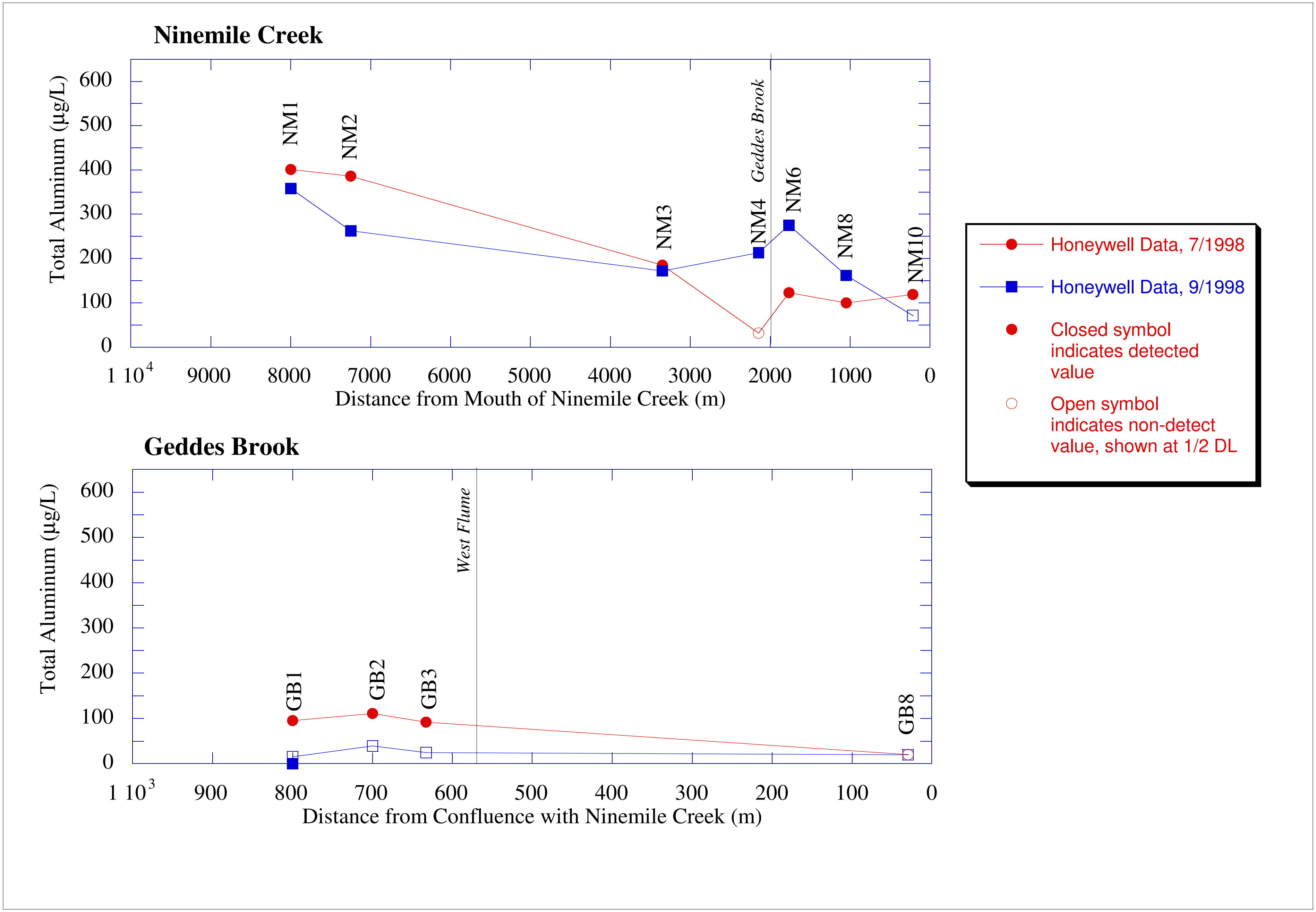
TAMS

Figure 5-33
Methylmercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at Geddes Brook



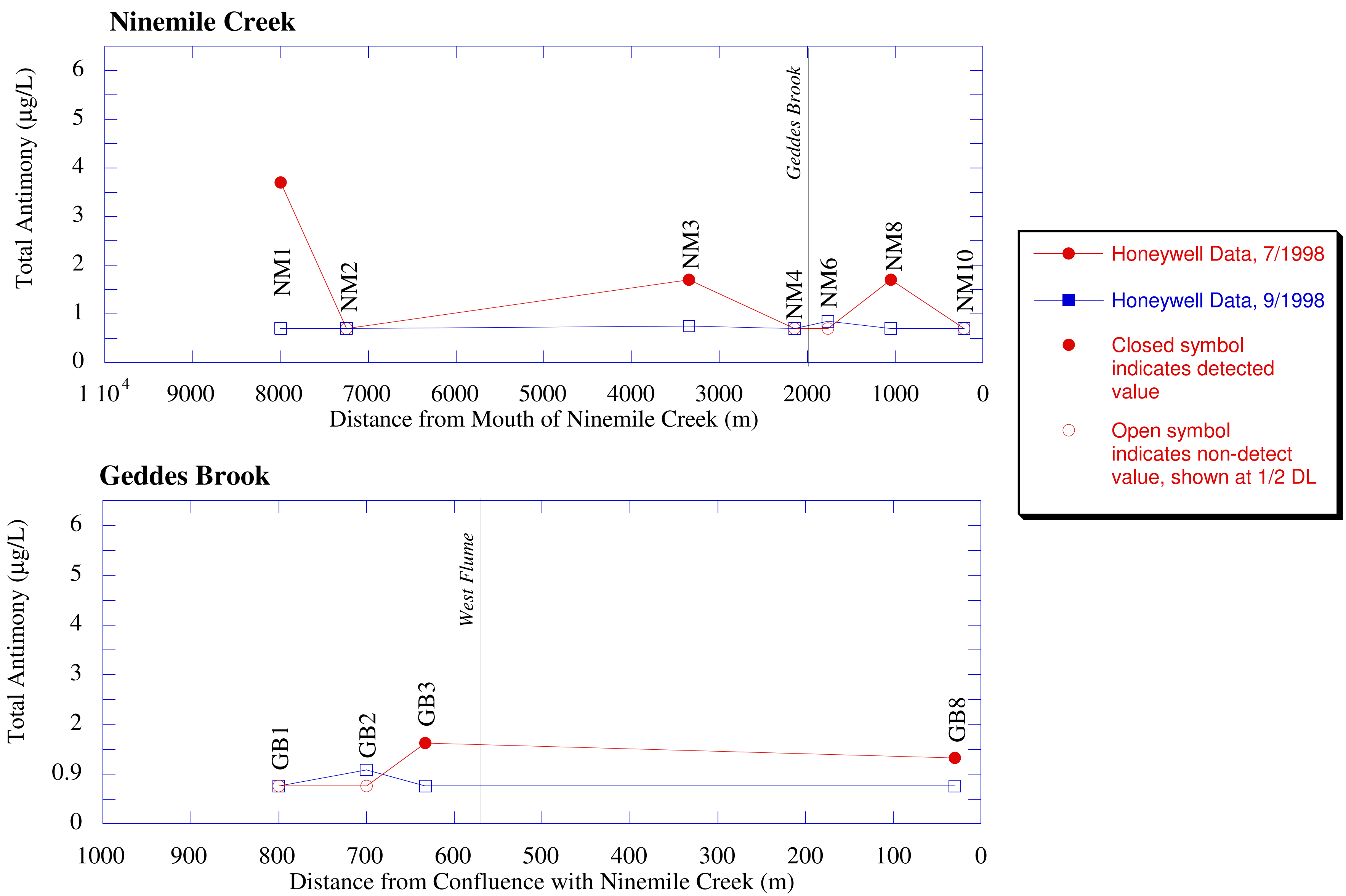
TAMS

Figure 5-34
Methylmercury Concentrations in Surface Water Under Low Flow Conditions for 1990 to 2001 at Ninemile Creek



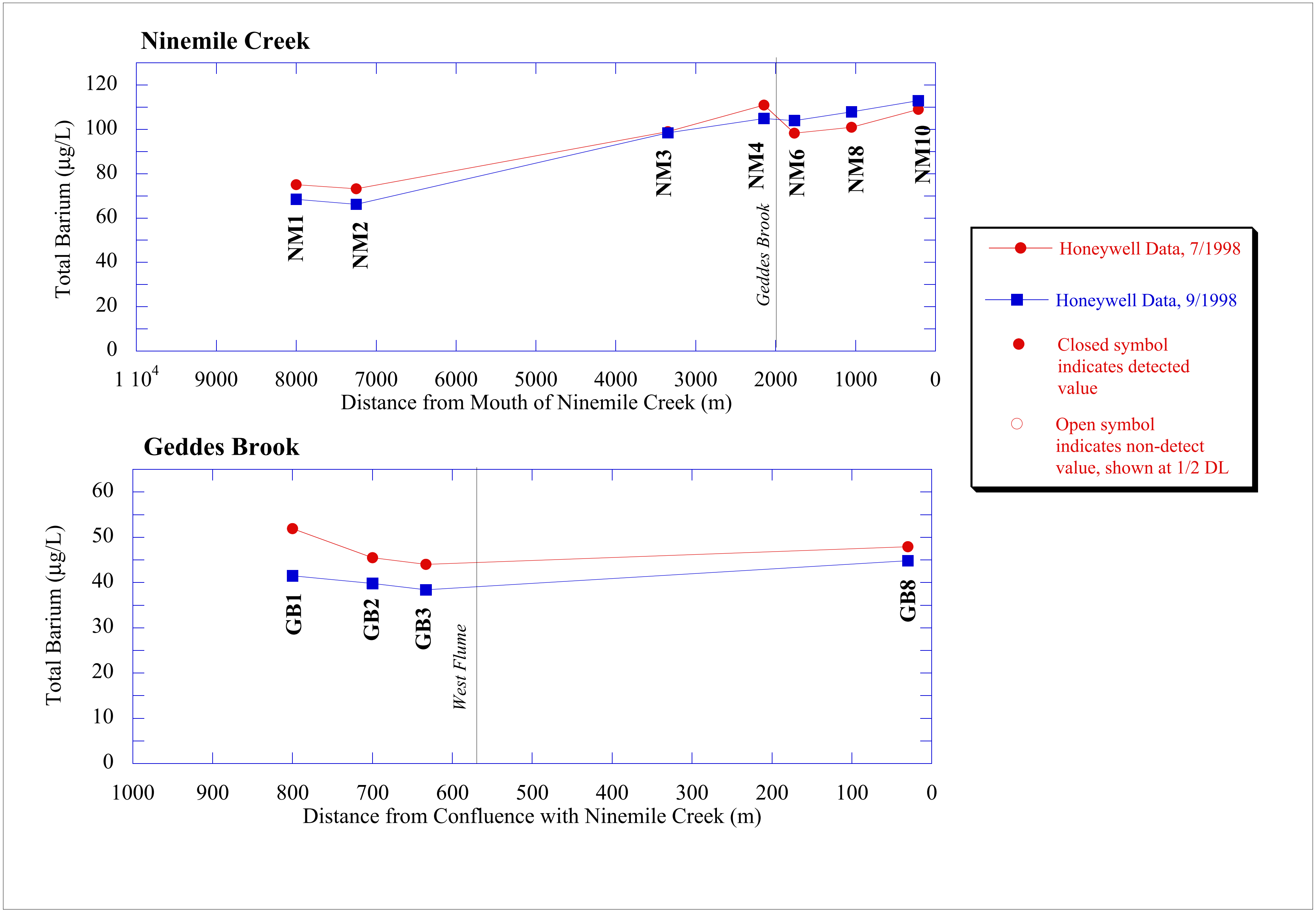
TAMS

Figure 5-35
Total Aluminum Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



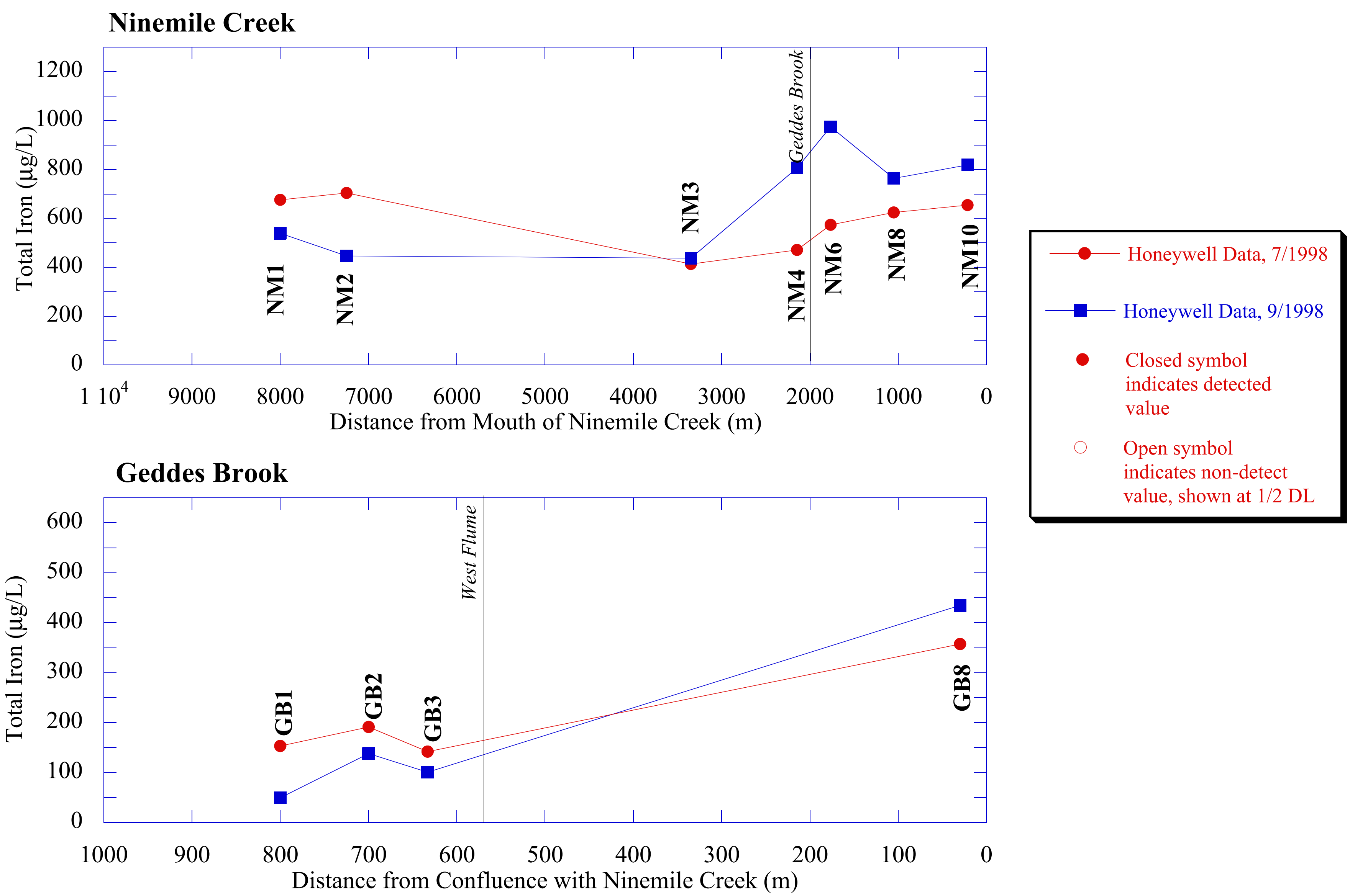
TAMS

Figure 5-36
Total Antimony Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



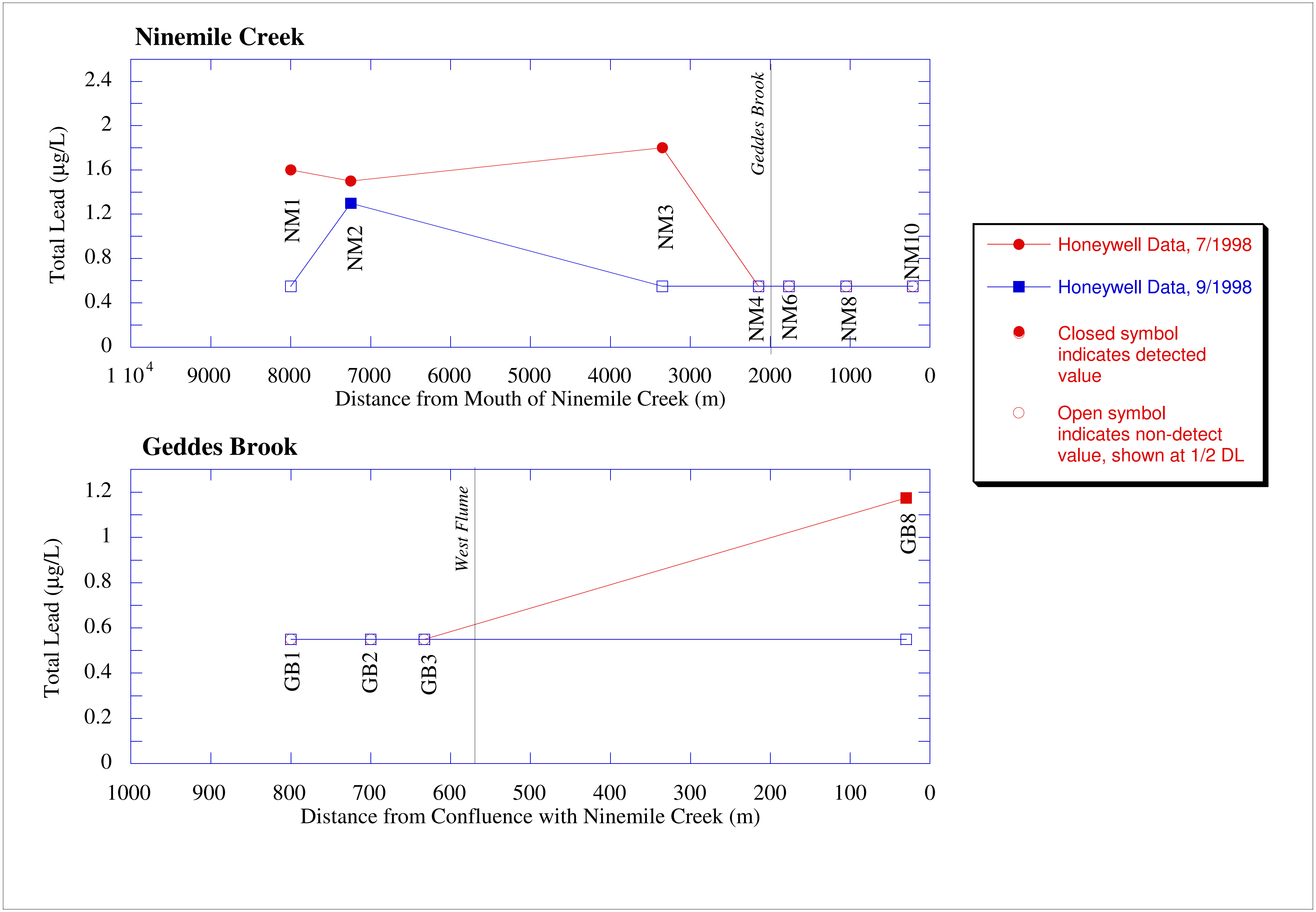
TAMS

Figure 5-37
Total Barium Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



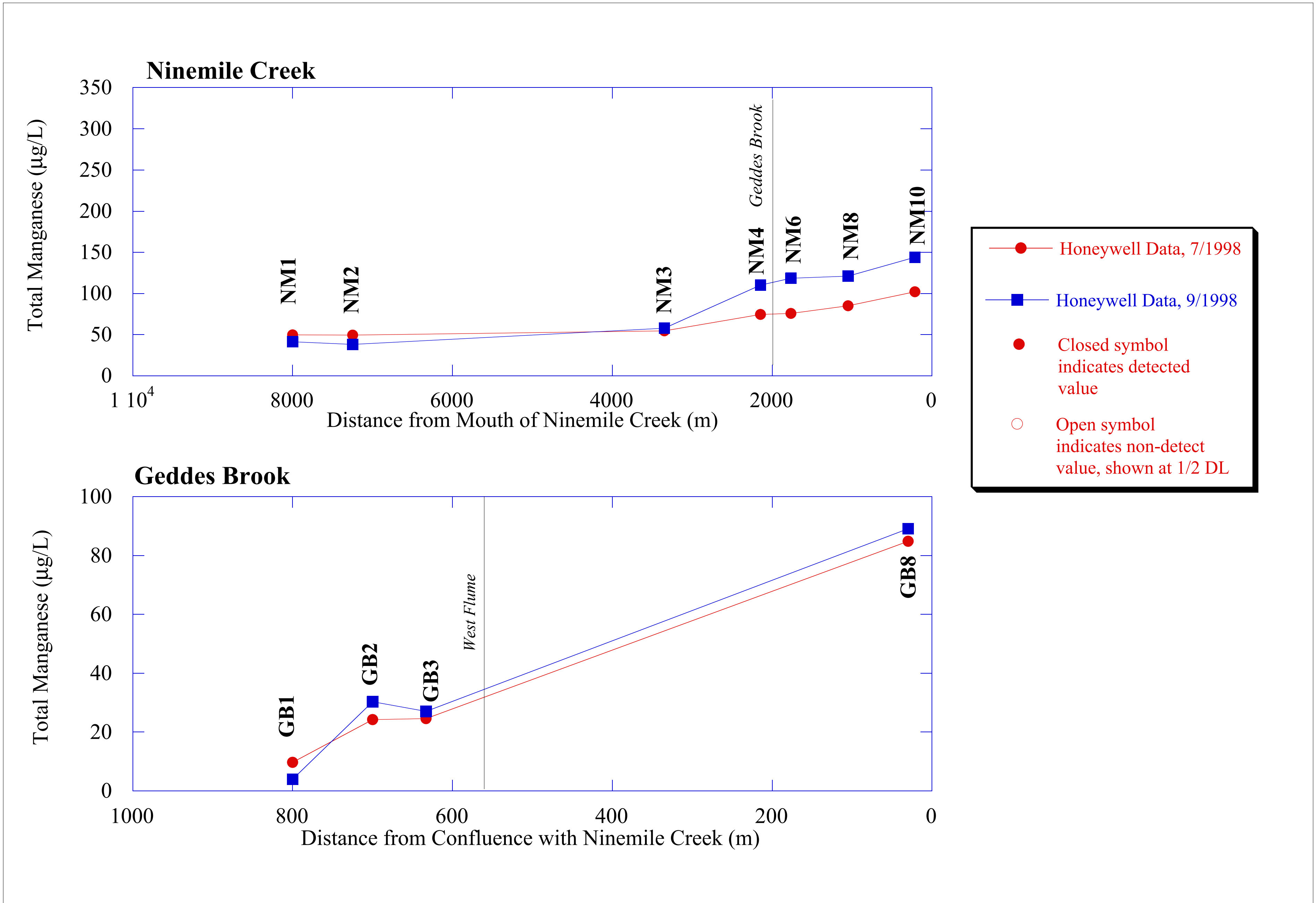
TAMS

Figure 5-38
Total Iron Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



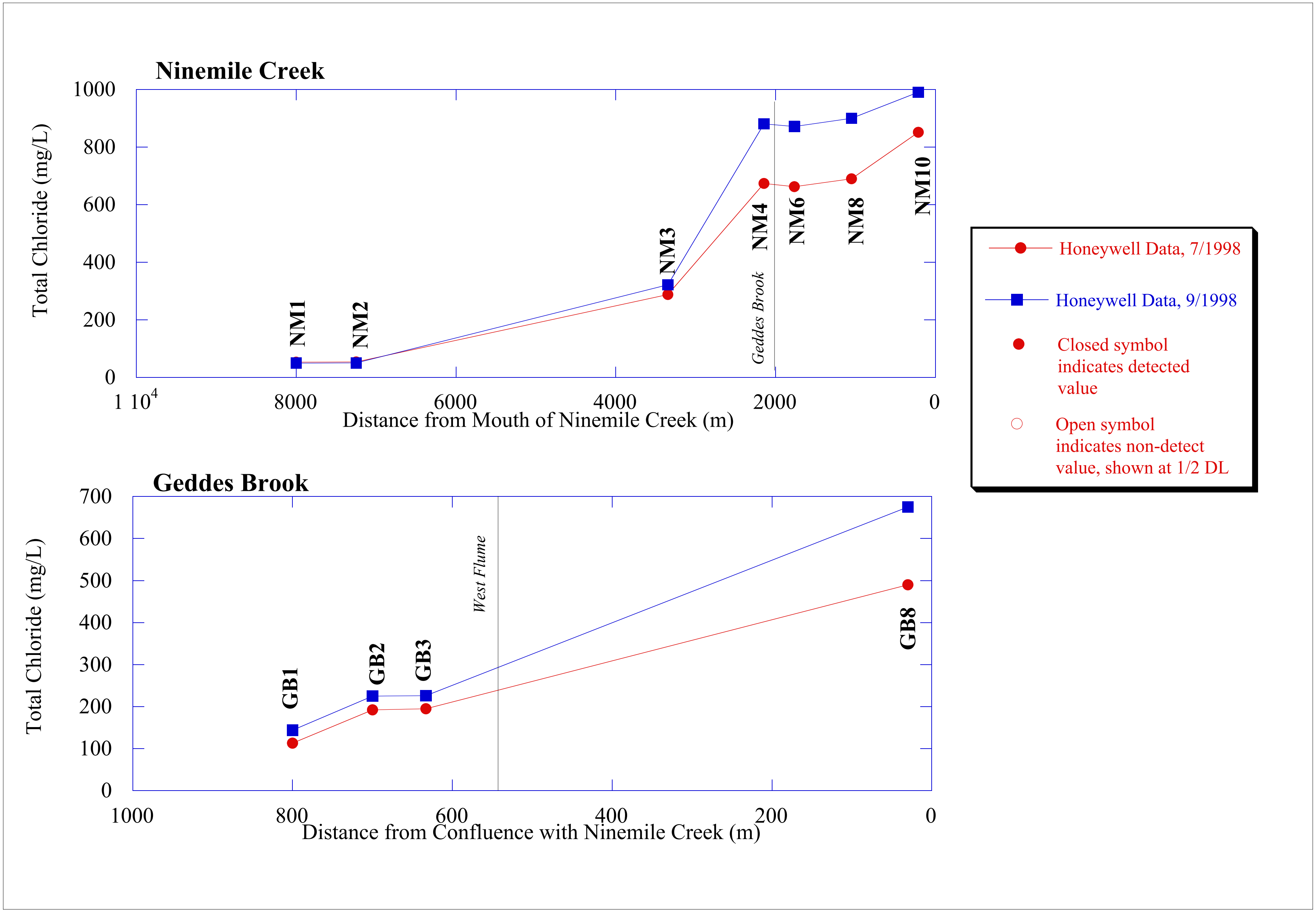
TAMS

Figure 5-39
Total Lead Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



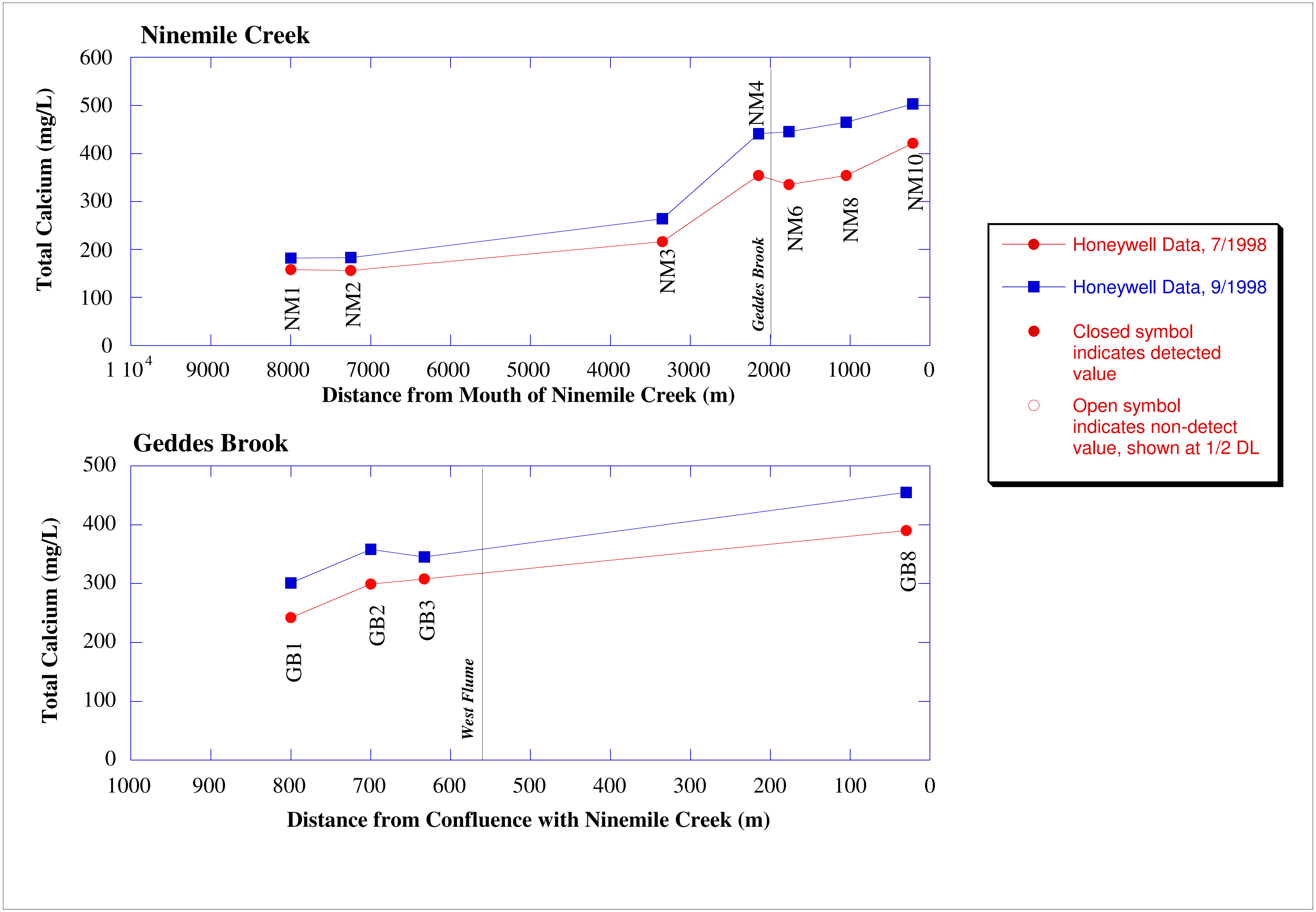
TAMS

Figure 5-40
Total Manganese Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



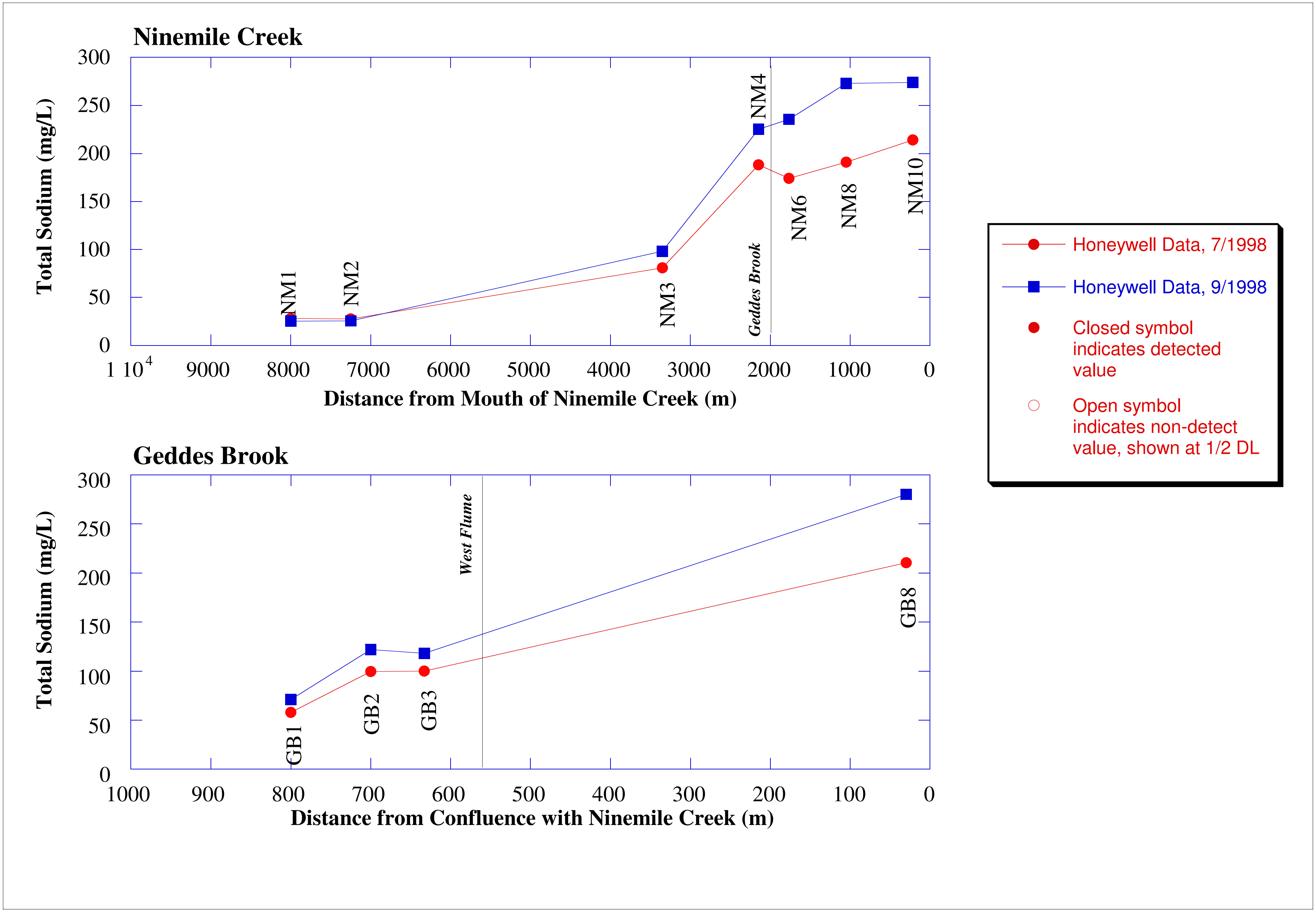
TAMS

Figure 5-41
Total Chloride Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



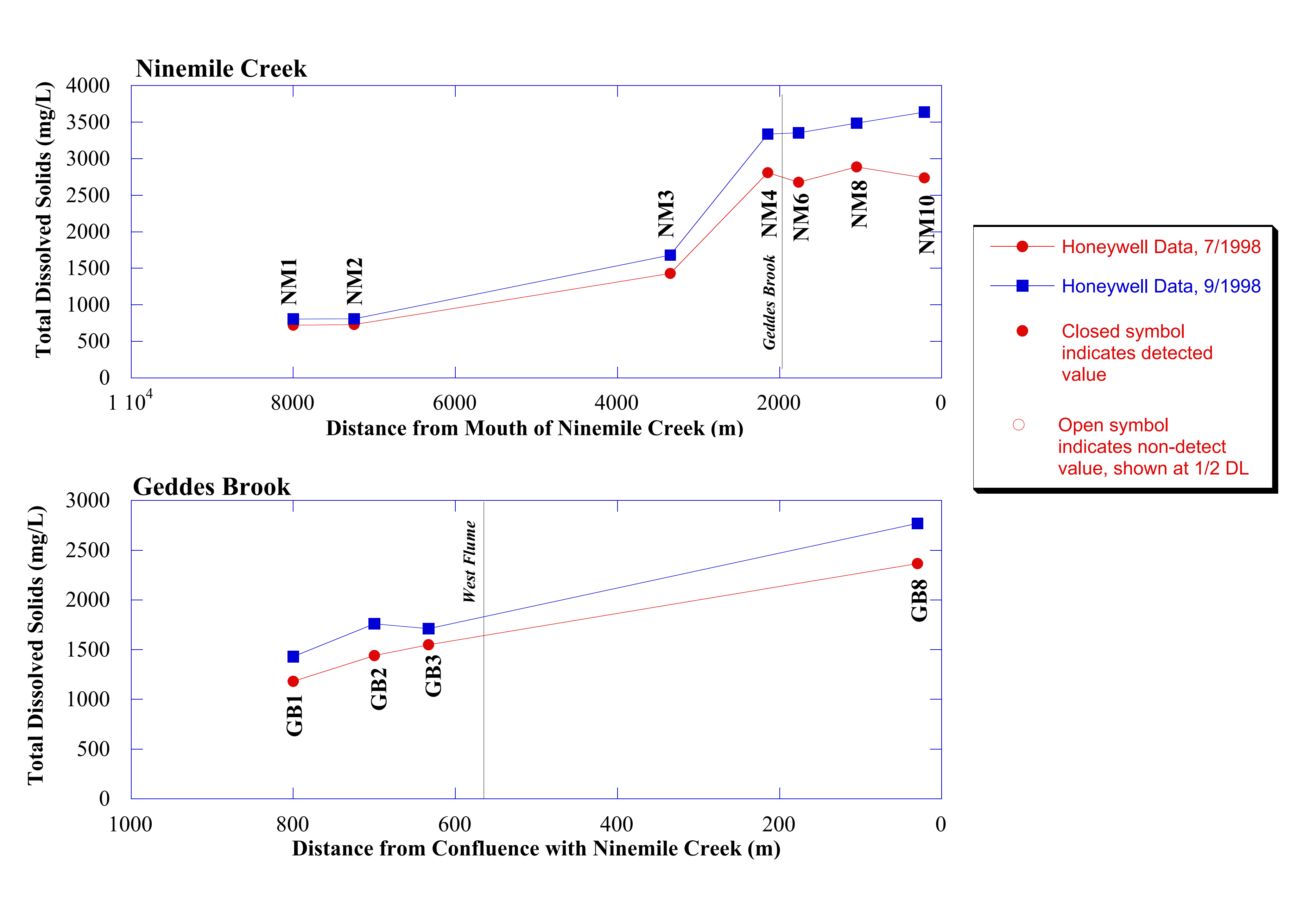
TAMS

Figure 5-42
Total Calcium Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



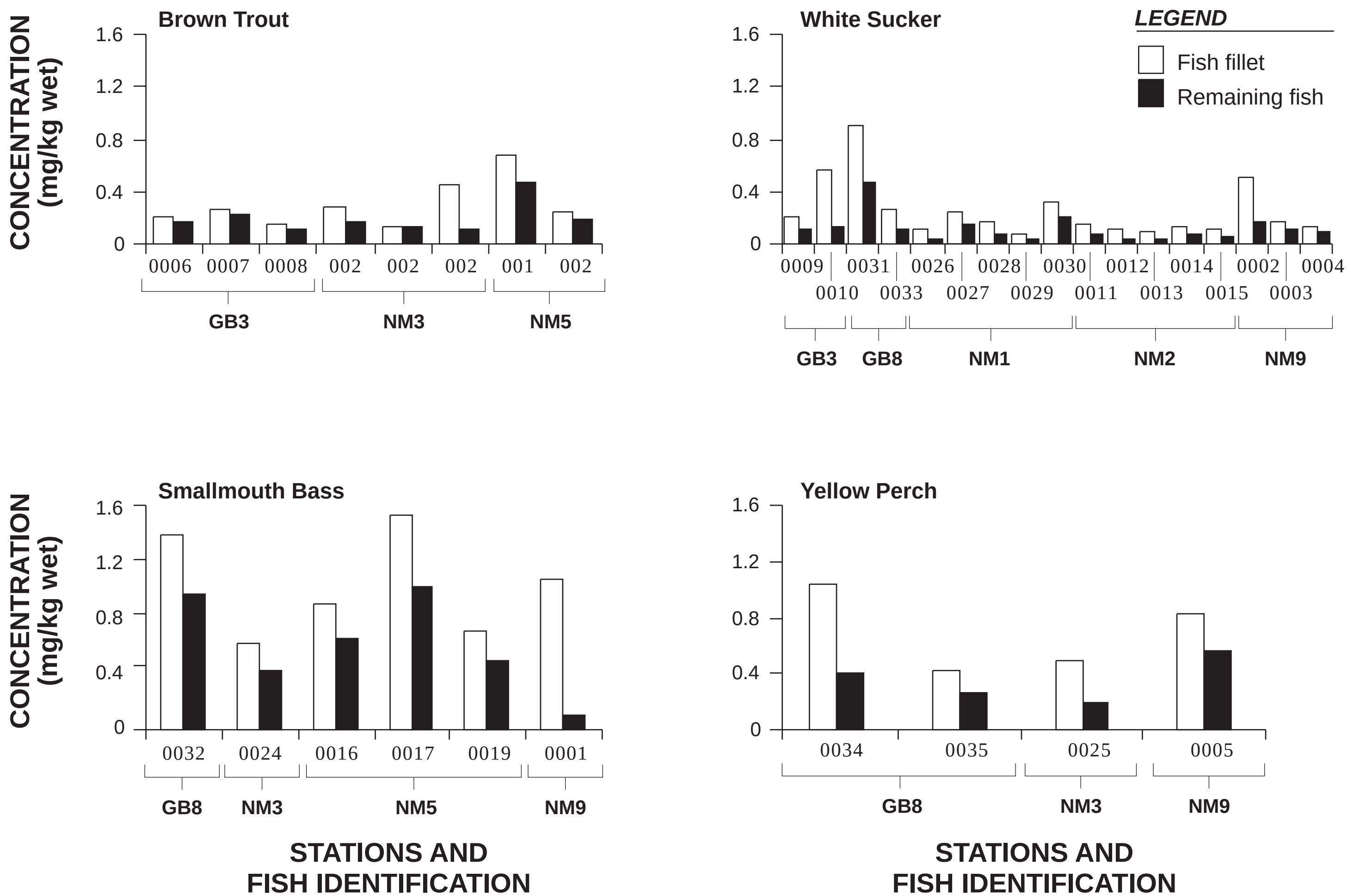
TAMS

Figure 5-43
Total Sodium Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



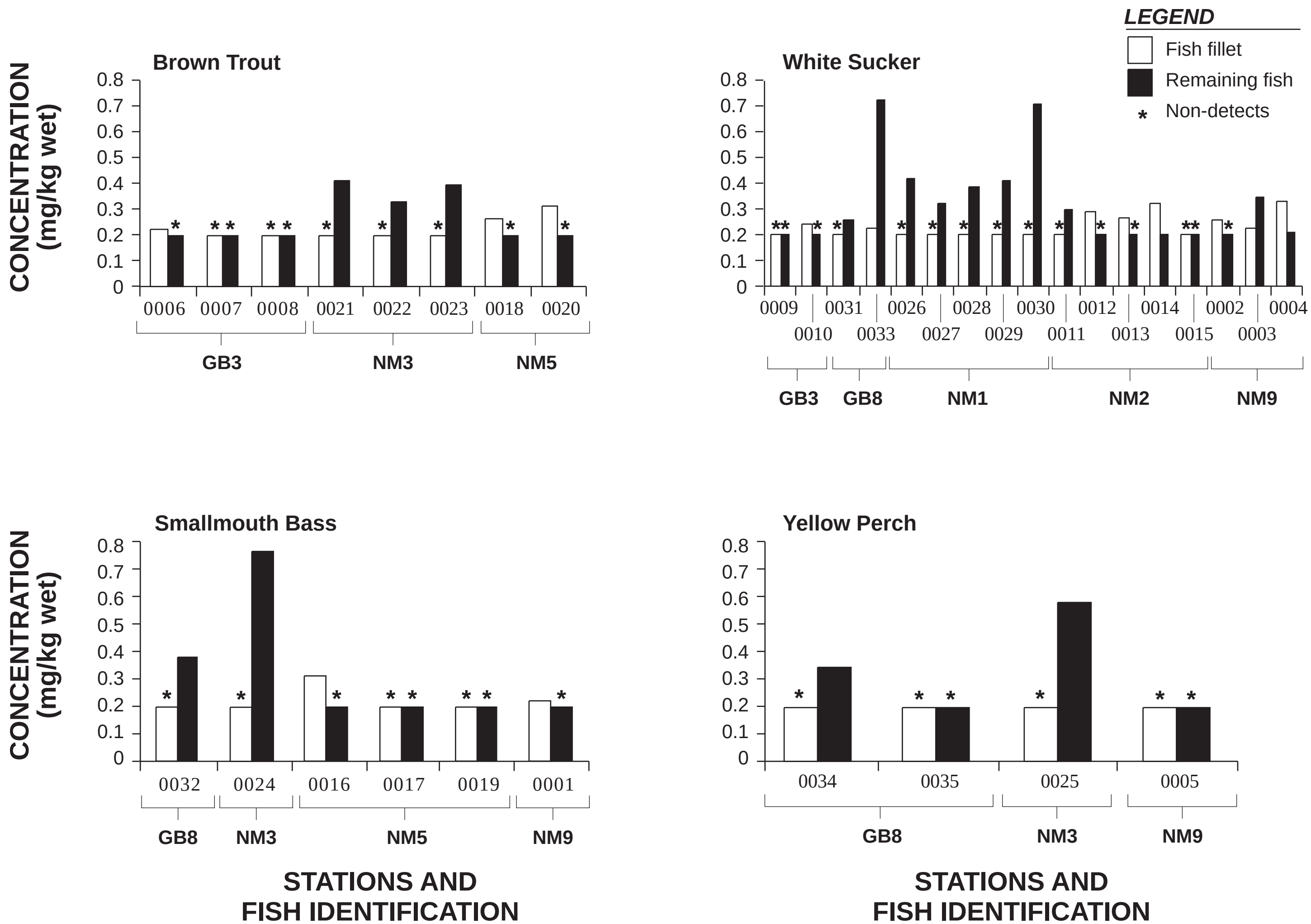
TAMS

Figure 5-44
Total Dissolved Solids Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1998



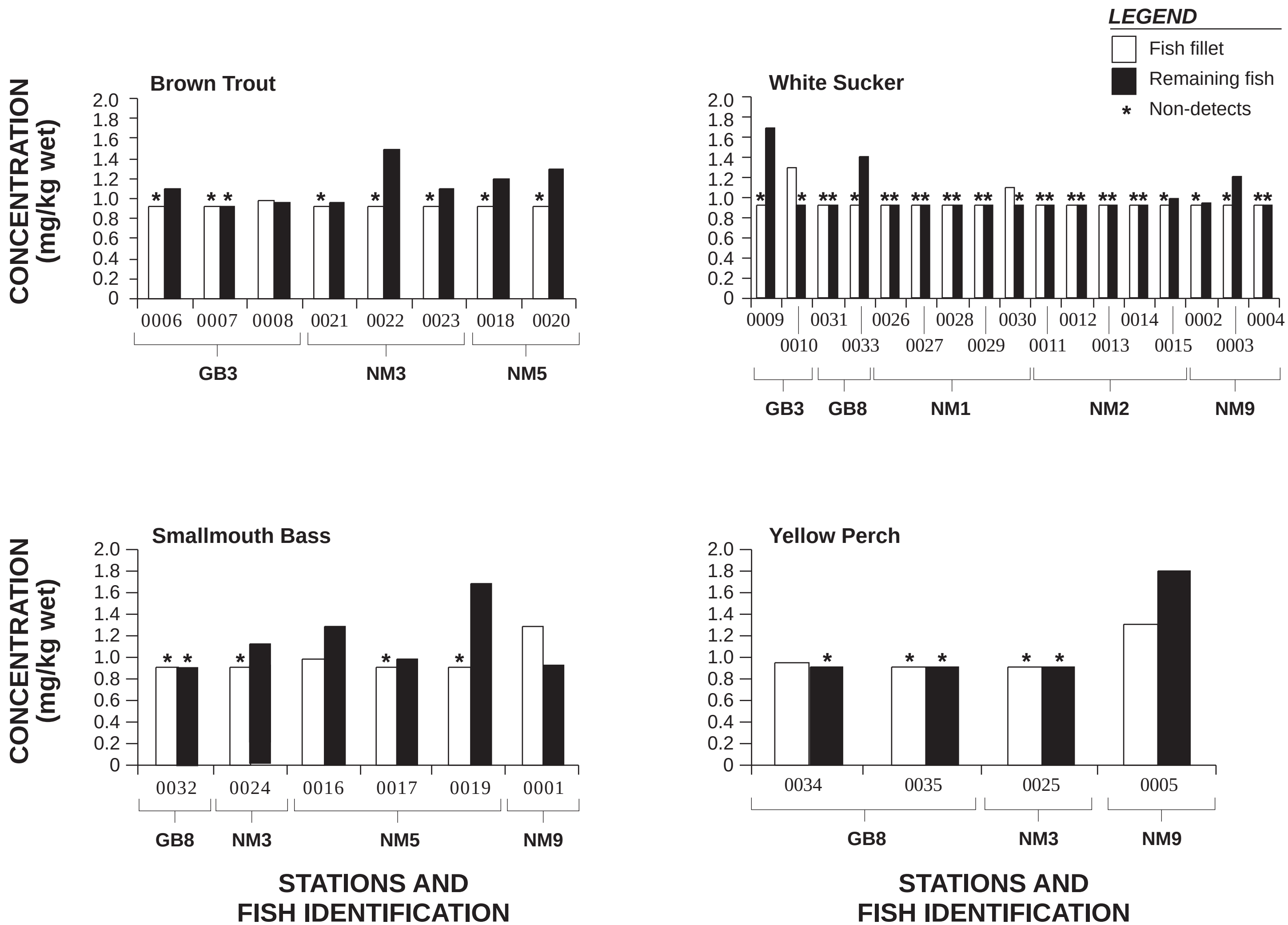
Source: Modified from Exponent, 2001c

Figure 5-45. Total Mercury Concentrations in Fish Collected by Honeywell in 1998



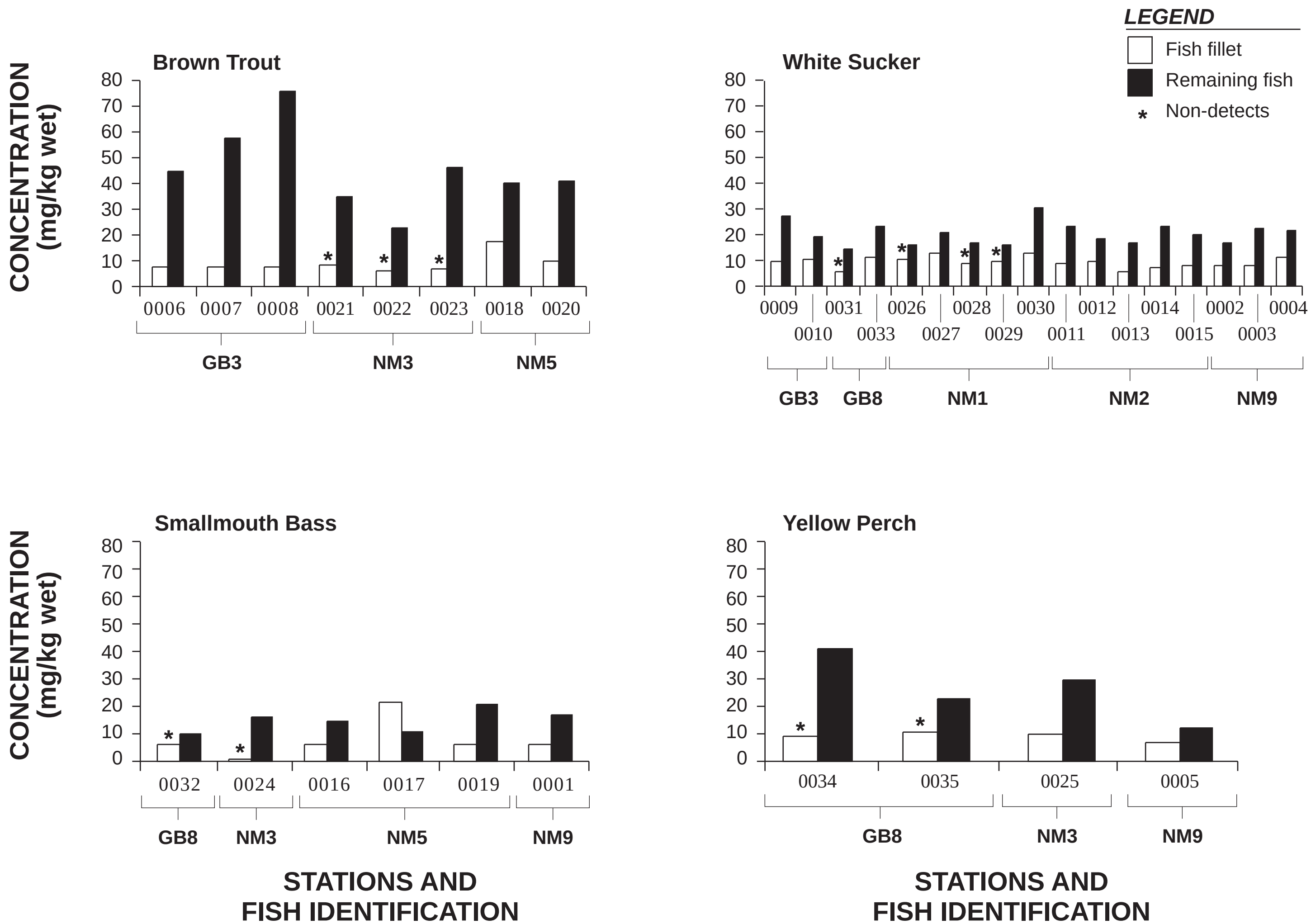
Source: Exponent, 2001c

Figure 5-46. Chromium Concentrations in Fish Collected by Honeywell in 1998



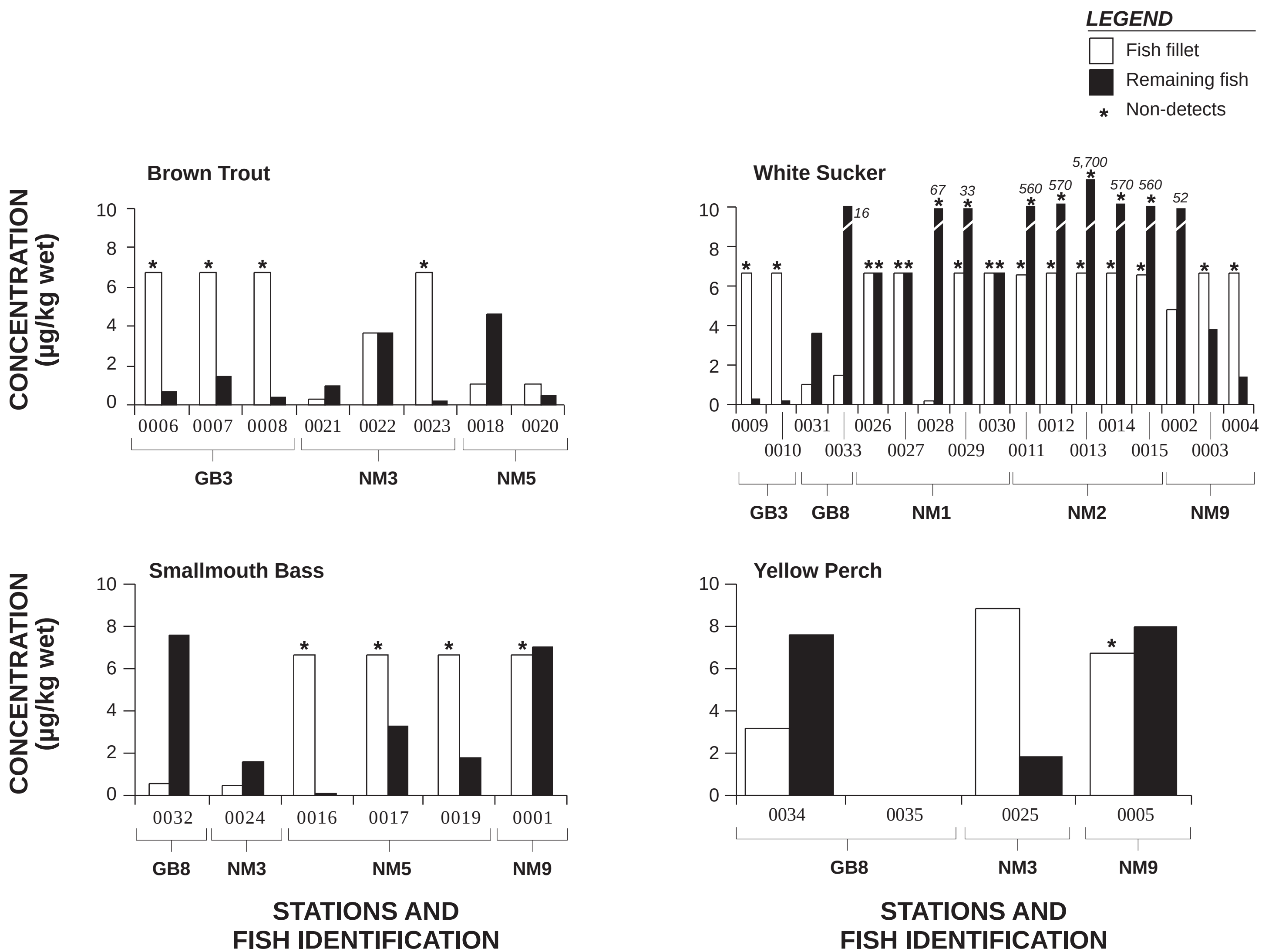
Source: Modified from Exponent, 2001c

Figure 5-47. Selenium Concentrations in Fish Collected by Honeywell in 1998



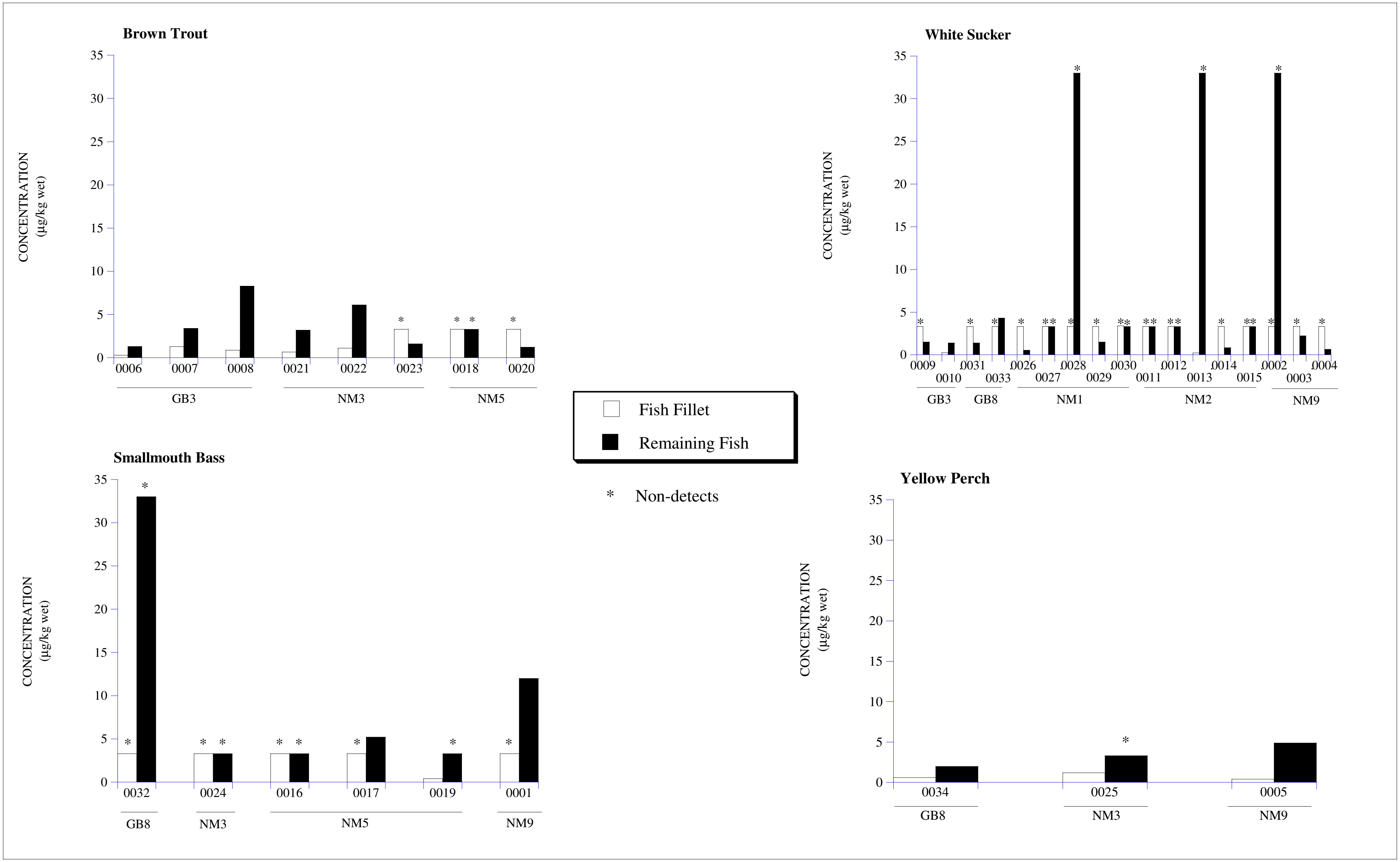
Source: Exponent, 2001c

Figure 5-48. Zinc Concentrations in Fish Collected by Honeywell in 1998



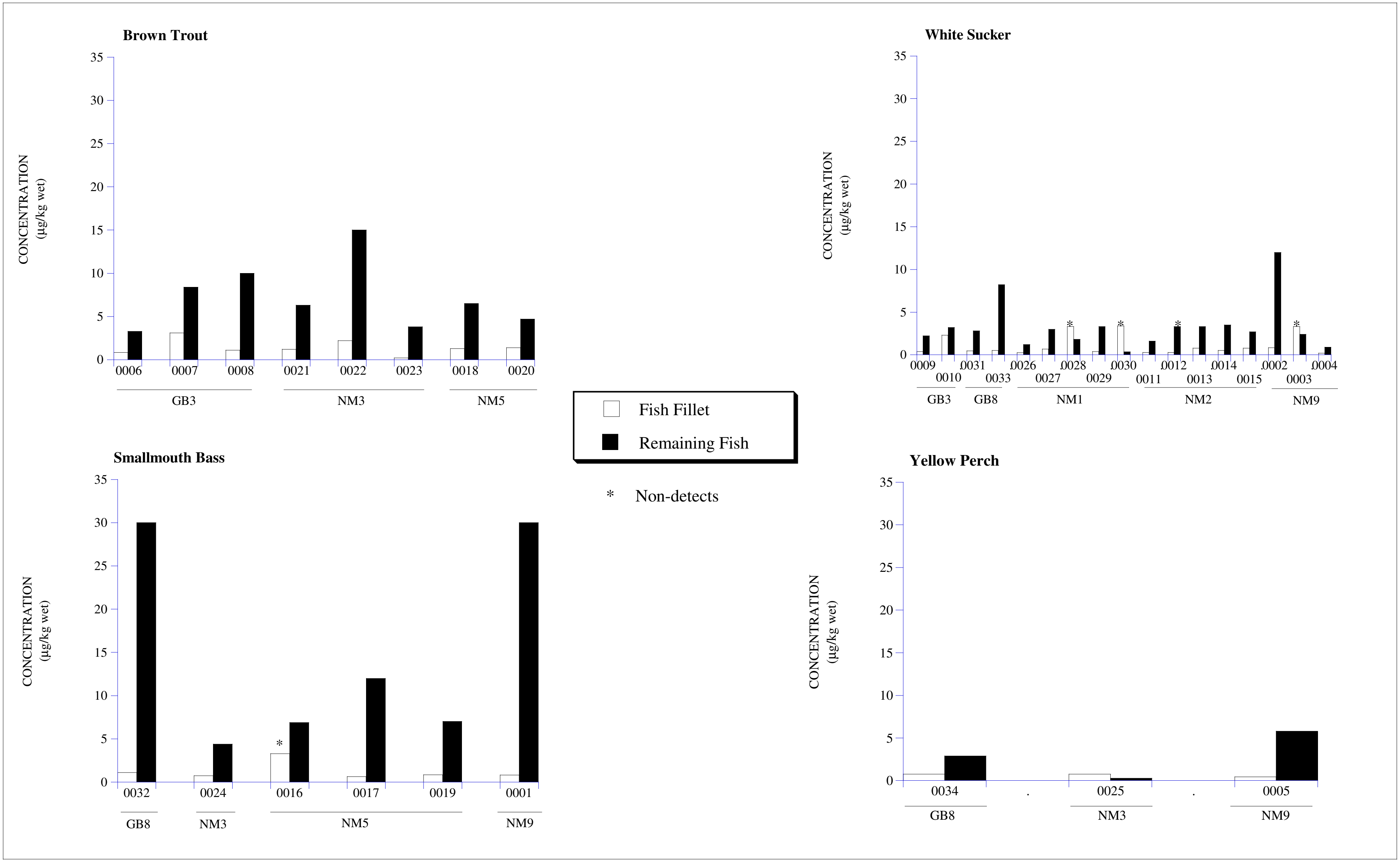
Source: Modified from Exponent, 2001c

Figure 5-49. Hexachlorobenzene Concentrations in Fish Collected by Honeywell in 1998



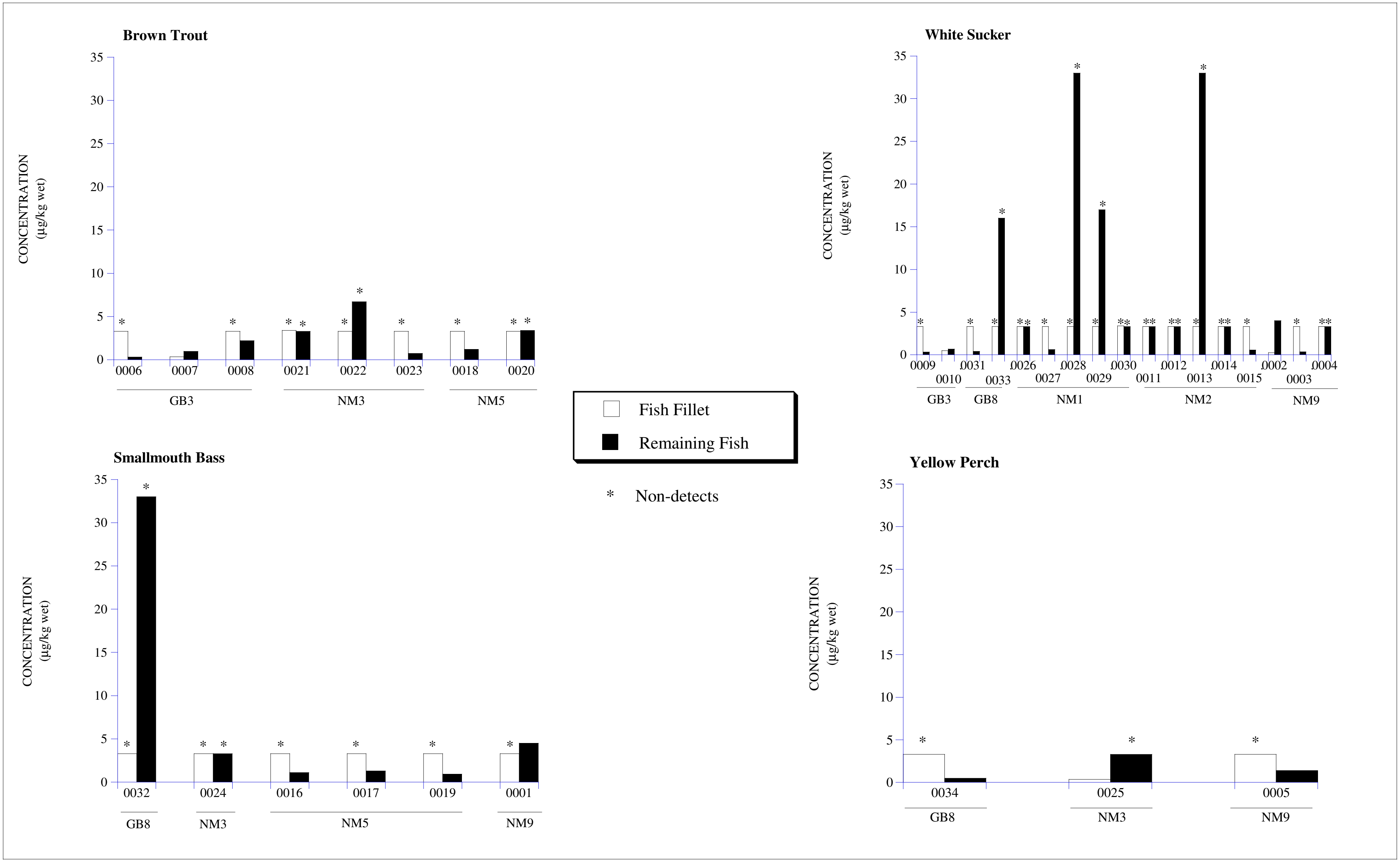
TAMS

Figure 5-50
4,4'-DDD Concentrations in Fish Collected by Honeywell in 1998



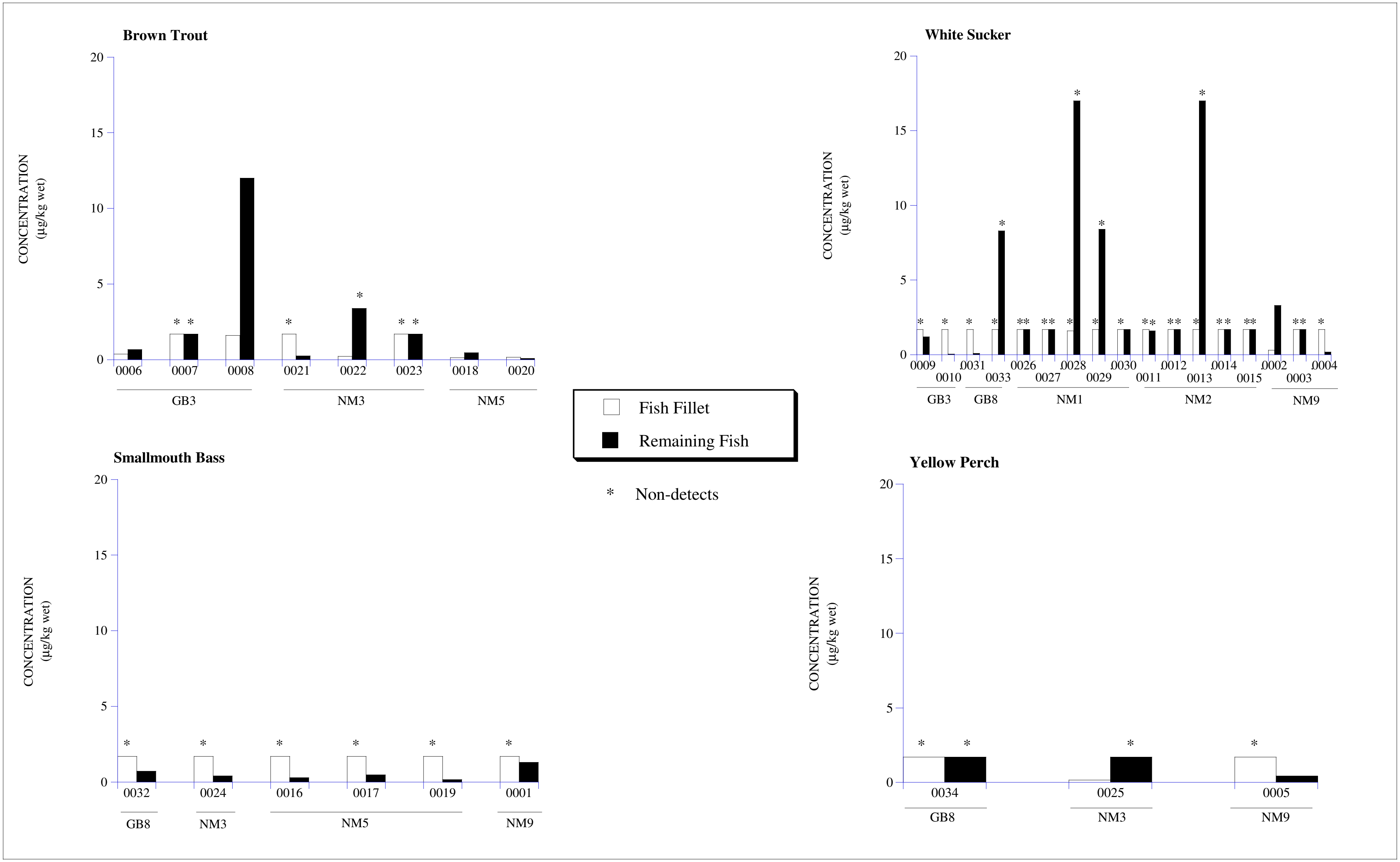
TAMS

Figure 5-51
4,4'-DDE Concentrations in Fish Collected by Honeywell in 1998



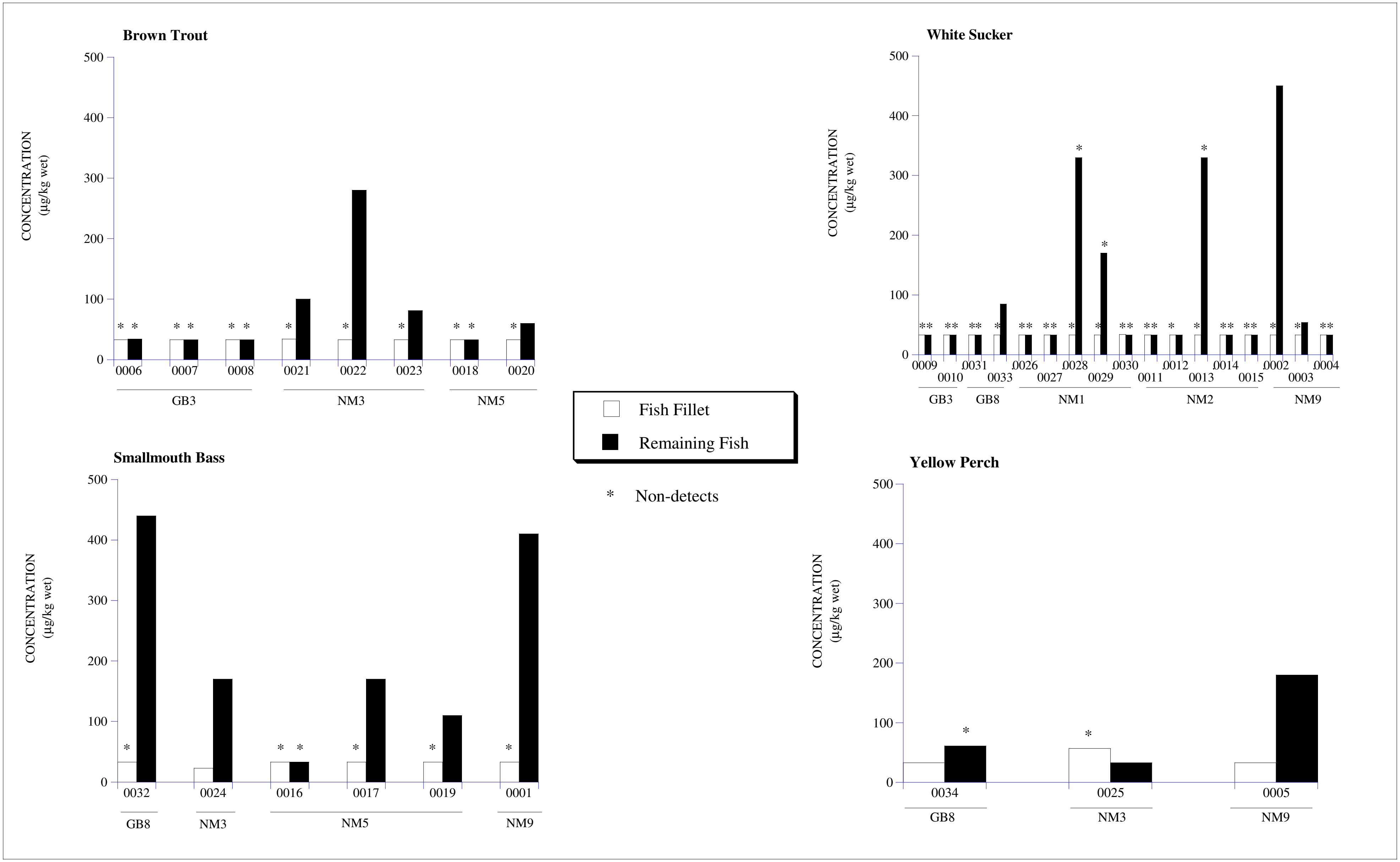
TAMS

Figure 5-52
4,4'-DDT Concentrations in Fish Collected by Honeywell in 1998



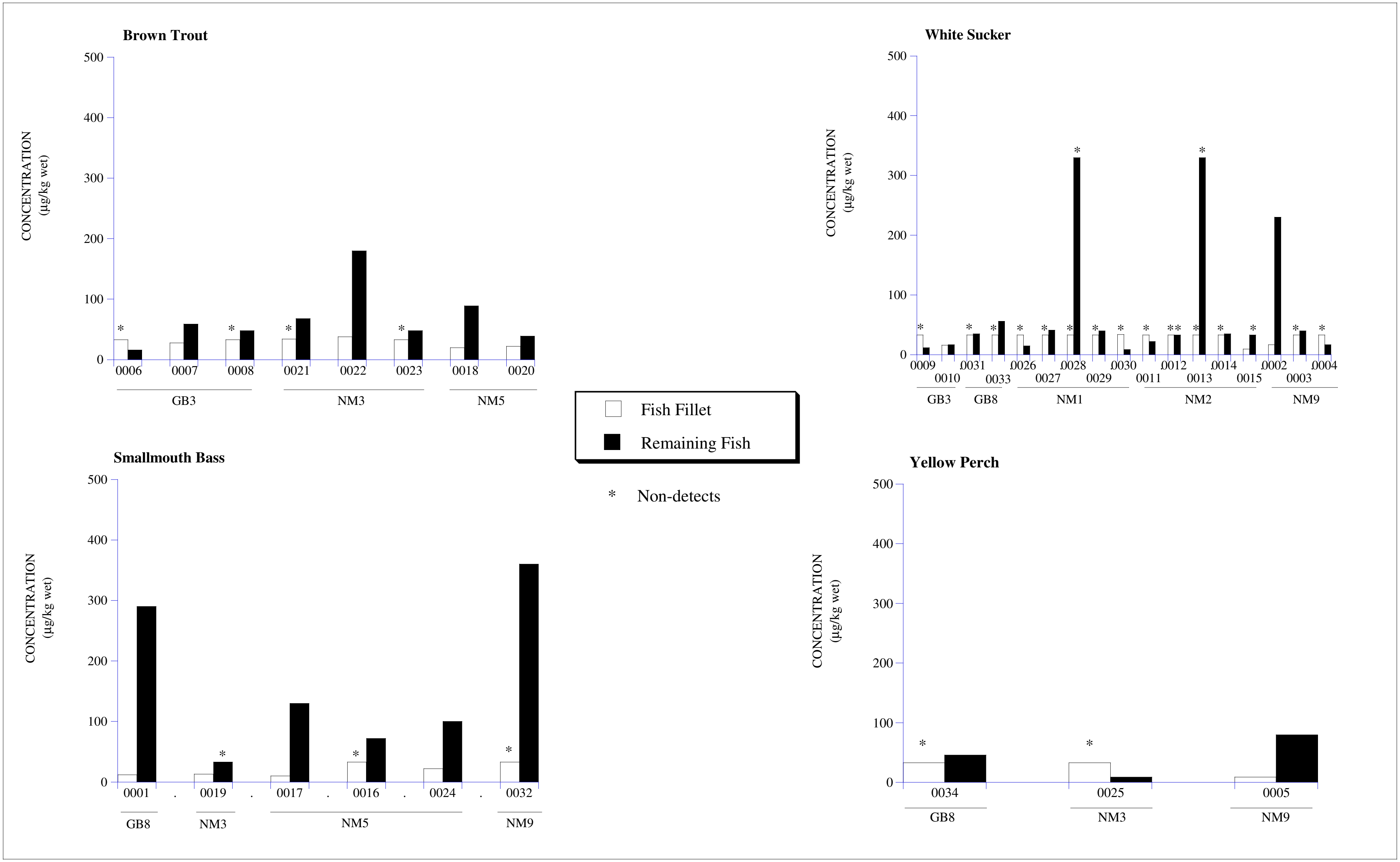
TAMS

Figure 5-53
Heptachlor Epoxide Concentrations in Fish Collected by Honeywell in 1998



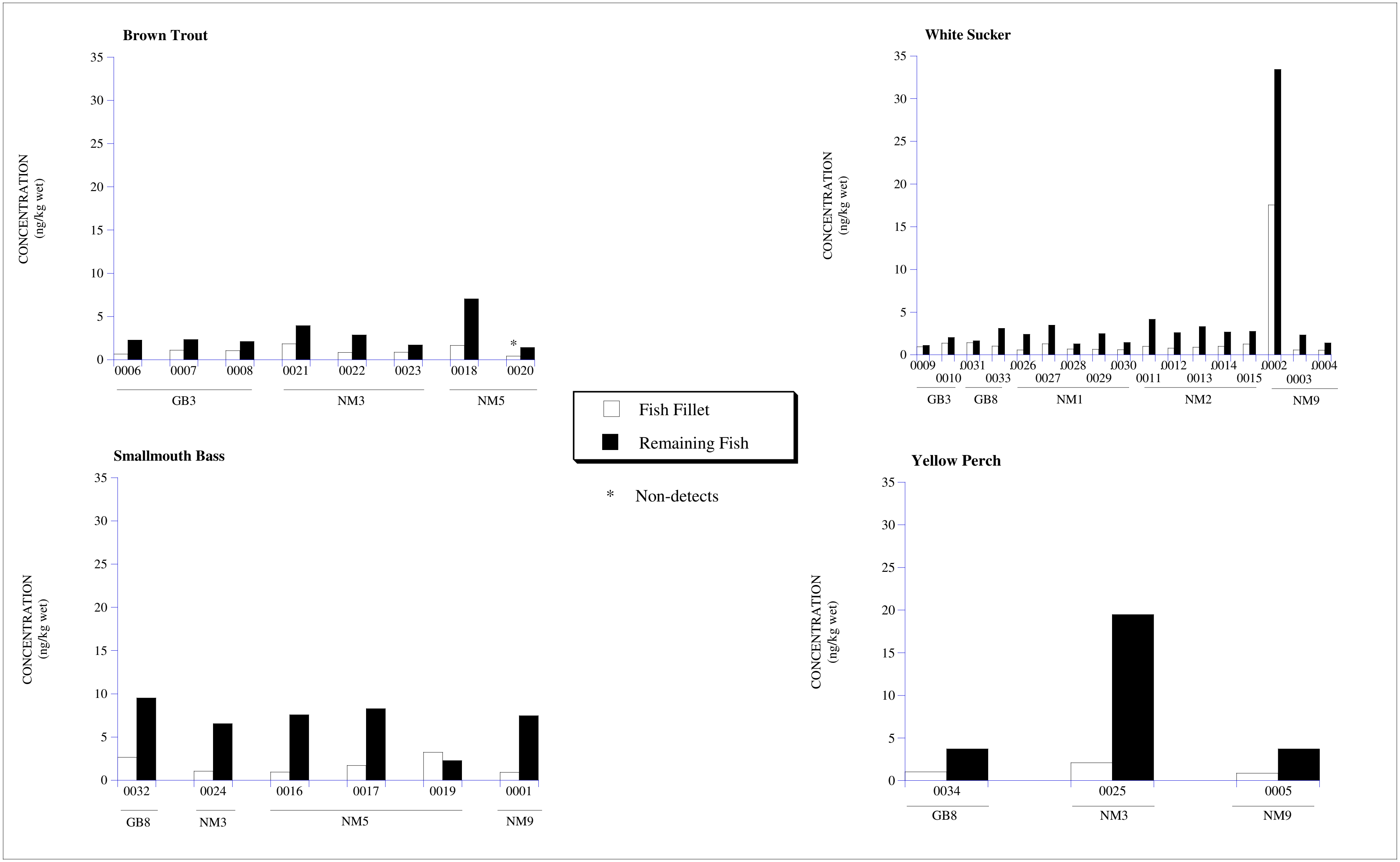
TAMS

Figure 5-54
Aroclor 1248 Concentrations in Fish Collected by Honeywell in 1998



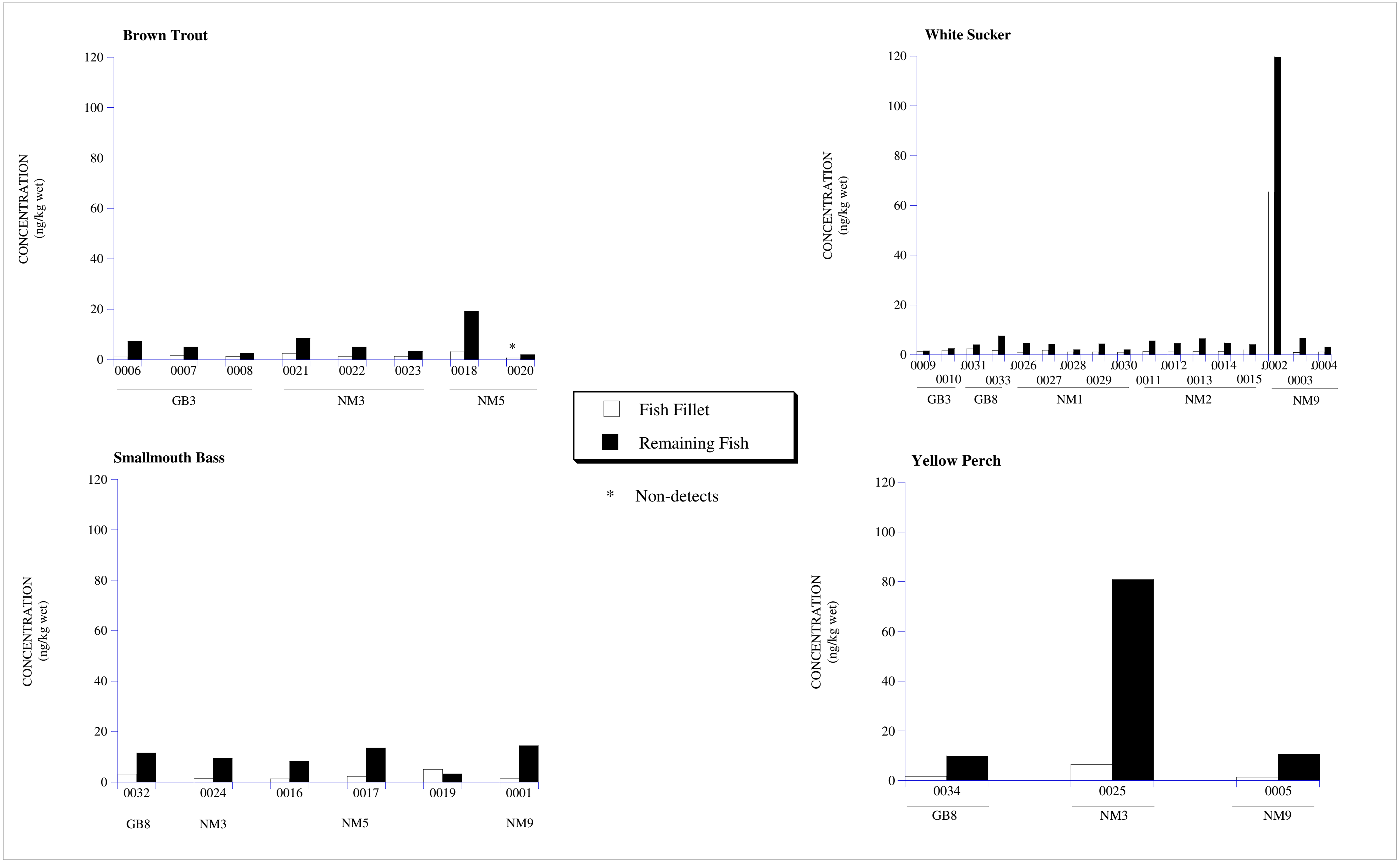
TAMS

Figure 5-55
Aroclor 1260 Concentrations in Fish Collected by Honeywell in 1998



TAMS

Figure 5-56
PCDD/PCDF TEQs (Mammal) Concentrations in Fish Collected by Honeywell in 1998



TAMS

Figure 5-57
PCDD/PCDF TEQs (Birds) Concentrations in Fish Collected by Honeywell in 1998

Table 5-1. Average and Range of Detected Metals Concentrations in Surface Sediment from the Upper and Lower Reaches of Geddes Brook and Ninemile Creek (1998/2001)

Analyte	Units	Minimum Concentration in Upper Geddes Brook	Maximum Concentration in Upper Geddes Brook	Average in Upper Geddes Brook	Minimum Concentration in Lower Geddes Brook	Maximum Concentration in Lower Geddes Brook	Average in Lower Geddes Brook	Minimum Concentration in Upper Ninemile Creek	Maximum Concentration in Upper Ninemile Creek	Average in Upper Ninemile Creek	Minimum Concentration in Lower Ninemile Creek	Maximum Concentration in Lower Ninemile Creek	Average in Lower Ninemile Creek
Aluminum	mg/kg-dw	4,310	7,180	5,293	1,910	7,730	4,740	3,120	10,700	6,768	1,050	10,900	4,886
Antimony	mg/kg-dw	ND	ND		0.26	1.20	0.50	ND	ND		0.24	0.42	0.37
Arsenic	mg/kg-dw	1.80	3.30	2.50	3.40	6.60	4.44	1.70	5.80	4.20	0.82	23.7	6.12
Barium	mg/kg-dw	45.4	50.9	47.3	46.1	91.2	60.4	23.2	96.0	60.2	35.2	167	67.8
Beryllium	mg/kg-dw	ND	ND		0.20	0.49	0.36	ND	ND		0.15	2.10	0.42
Cadmium	mg/kg-dw	ND	ND		0.08	0.46	0.17	ND	ND		0.07	0.38	0.21
Chromium	mg/kg-dw	10.7	19.9	14.9	7.10	43.1	19.1	5.00	32.1	16.1	4.10	27.1	13.8
Cobalt	mg/kg-dw	4.80	7.00	6.10	2.80	7.50	4.70	4.40	9.20	6.55	1.90	7.10	4.13
Copper	mg/kg-dw	18.9	31.3	24.3	10.9	36.3	23.7	9.30	34.1	22.3	9.20	80.8	24.6
Cyanide	mg/kg-dw	ND	ND		1.10	1.70	1.40	ND	ND		0.99	8.40	3.05
Iron	mg/kg-dw	8,130	13,100	10,443	5,550	18,100	10,083	8,410	19,700	13,953	3,260	18,600	10,262
Lead	mg/kg-dw	29.5	63.0	40.9	17.8	114	36.4	5.20	49.7	22.7	3.50	194	39.7
Magnesium	mg/kg-dw	13,000	21,400	17,867	5,480	28,800	14,978	11,700	28,400	18,150	1,780	29,000	11,390
Manganese	mg/kg-dw	168	237	213	247	1,610	425	162	831	395	112	779	377
Mercury	mg/kg-dw	0.06	0.36	0.18	0.41	15.7	2.18	0.06	1.40	0.43	0.01	21.1	3.08
Methylmercury	µg/kg-dw	1.19	2.01	1.57	0.62	4.83	2.91	0.14	2.06	0.76	0.03	6.26	2.48
Nickel	mg/kg-dw	9.90	15.0	12.1	7.90	30.1	16.9	8.30	19.00	14.0	6.40	33.0	15.1
Potassium	mg/kg-dw	1,030	1,580	1,247	468	1,590	998	539	1,820	1,152	215	1,710	932
Selenium	mg/kg-dw	ND	ND		0.38	1.30	0.63	ND	ND		0.33	1.90	0.87
Silver	mg/kg-dw	ND	ND		ND	ND		ND	ND		ND	ND	
Sodium	mg/kg-dw	278	372	340	445	1,370	750	128	2,830	1,444	334	14,900	3,907
Thallium	mg/kg-dw	ND	ND		0.69	0.82	0.76	2.00	2.00	2.00	0.56	2.10	1.13
Vanadium	mg/kg-dw	10.4	15.6	13.4	5.60	19.9	11.5	6.60	17.4	12.7	3.10	19.8	10.5
Zinc	mg/kg-dw	103	221	170	44.2	214	123	27.0	75.3	52.4	24.0	195	62.1

Notes:

ND - no detects

Samples collected from within the 0-15 cm interval.

Table 5-2. Average and Range of Detected Metals Concentrations in Floodplain Surface Soil from the Upper and Lower Reaches of Geddes Brook and Ninemile Creek (1998/2001/2002)

Analyte	Units	Minimum Concentration in Upper Geddes Brook	Maximum Concentration in Upper Geddes Brook	Average in Upper Geddes Brook	Minimum Concentration in Lower Geddes Brook	Maximum Concentration in Lower Geddes Brook	Average in Lower Geddes Brook	Minimum Concentration in Upper Ninemile Creek	Maximum Concentration in Upper Ninemile Creek	Average in Upper Ninemile Creek	Minimum Concentration in Lower Ninemile Creek	Maximum Concentration in Lower Ninemile Creek	Average in Lower Ninemile Creek
Aluminum	mg/kg-dw	5,830	10,100	7,752	5,360	17,500	7,915	7,420	24,200	11,939	2,070	12,600	7,627
Antimony	mg/kg-dw	ND	ND		0.24	0.35	0.29	ND	ND		0.19	0.54	0.34
Arsenic	mg/kg-dw	3.40	5.90	4.50	4.00	7.70	5.90	4.40	9.60	6.27	2.00	23.00	5.80
Barium	mg/kg-dw	38.8	59.9	50.5	27.4	96.1	54.4	72.8	155	94.7	26.3	157	69.9
Beryllium	mg/kg-dw	ND	ND		0.36	0.87	0.48	ND	ND		0.29	1.20	0.50
Cadmium	mg/kg-dw	1.70	1.70	1.70	0.21	0.63	0.35	ND	ND		0.04	0.90	0.24
Chromium	mg/kg-dw	11.6	26.2	18.1	12.4	29.9	18.8	19.6	41.6	30.5	8.40	46.7	22.5
Cobalt	mg/kg-dw	6.30	10.6	8.63	4.30	10.5	5.94	8.20	20.7	11.4	2.70	10.4	5.91
Copper	mg/kg-dw	16.7	35.7	26.8	19.3	65.9	34.7	30.1	82.7	53.5	8.70	51.2	30.0
Cyanide	mg/kg-dw	ND	ND		ND	ND		ND	ND		0.77	1.10	0.94
Iron	mg/kg-dw	11,000	16,700	14,417	10,400	27,400	15,043	16,700	41,700	22,400	6,320	22,100	15,473
Lead	mg/kg-dw	37.0	103	63.6	12.5	192	53.8	10.0	53.8	36.6	7.10	466	44.1
Magnesium	mg/kg-dw	19,000	53,300	35,617	10,800	47,900	22,993	9,820	27,400	20,591	449	56,800	14,693
Manganese	mg/kg-dw	260	516	384	296	441	372	347	581	439	44.9	643	370
Mercury	mg/kg-dw	0.07	0.18	0.12	0.73	14.1	4.75	0.03	0.52	0.27	0.03	58.7	2.24
Methylmercury	µg/kg-dw	0.35	1.83	0.89	2.86	4.53	3.86	0.11	3.31	1.56	0.66	27.5	6.28
Nickel	mg/kg-dw	13.4	23.4	17.8	12.2	32.4	20.4	19.4	40.0	24.2	9.40	33.8	18.5
Potassium	mg/kg-dw	882	2,090	1,373	1,050	3,950	1,655	814	2,670	1,813	294	3,190	1,601
Selenium	mg/kg-dw	ND	ND		0.35	1.30	0.65	ND	ND		0.52	2.20	1.05
Silver	mg/kg-dw	ND	ND		ND	ND		ND	ND		0.13	0.23	0.18
Sodium	mg/kg-dw	172	280	216	110	990	378	153	4,040	1,411	49.5	3,420	555
Thallium	mg/kg-dw	ND	ND		ND	ND		1.30	1.30	1.30	0.62	2.50	1.40
Vanadium	mg/kg-dw	13.0	20.1	16.6	11.3	30.8	15.8	14.3	48.5	23.0	6.40	30.6	15.3
Zinc	mg/kg-dw	71.4	208	154	36.2	181	104	66.6	133	108	20.7	186	85.6

Notes:

ND - no detects

Samples collected from within the 0-15 cm interval.

Mercury was the only metal analyzed in 2002.

Table 5-3. Calculated Particulate Total Mercury Fraction and Concentration in Surface Water of Geddes Brook and Ninemile Creek (1998)

Stream	Station	Date	Sample ID	Unfiltered Total Mercury (ng/L)	Dissolved Total Mercury (ng/L)	Fraction Particulate[a] (percent)	TSS (mg/L)	Particulate Total Mercury[b] (mg/kg)
Geddes Brook (July)								
Geddes Brook	GB1	7/15/1998	SW0004	1.84 *J*	0.46 *U*	75	3.58	0.39
Geddes Brook	GB2	7/15/1998	SW0003	1.98 *J*	0.45 *U*	77	7.0	0.22
Geddes Brook	GB3	7/17/1998	SW0011	2.14 *J*	0.51 *U*	76	6.72	0.24
West Flume	GB4	7/17/1998	SW0013	815	56.8	93	25.3	30
Unnamed Tributary	GB5	7/17/1998	SW0014	0.63 *U*	0.52 *U*	--	15.5	--
Geddes Brook	GB8	7/17/1998	SW0009	26.8	1.33 *J*	95	3.72	6.8
Geddes Brook	GB8	7/17/1998	SW0009 (rep.)	24.2	1.41 *J*	94	3.0	7.6
Geddes Brook (September)								
Geddes Brook	GB1	9/1/1998	SW0022	1.47 *U*	0.46 *U*	--	3.1	--
Geddes Brook	GB2	9/1/1998	SW0017	1.86 *U*	0.25 *U*	--	6.5	--
Geddes Brook	GB3	9/1/1998	SW0024	1.69 *U*	0.26 *U*	--	3.7	--
West Flume	GB4	9/1/1998	SW0016	1,090	41.4	96	18	58
Unnamed Tributary	GB5	9/1/1998	SW0018	0.54 *U*	0.36 *U*	--	17.8	--
Geddes Brook	GB8	9/2/1998	SW0028	15.8	0.64 *U*	96	5.7	2.7
Ninemile Creek (July)								
Ninemile Creek	NM1	7/15/1998	SW0002	4.68	0.26 *U*	94	16.1	0.28
Ninemile Creek	NM2	7/15/1998	SW0001	4.30	0.21 *U*	95	18.4	0.22
Ninemile Creek	NM3	7/16/1998	SW0010	2.3 *J*	0.29 *U*	87	8.30	0.24
Ninemile Creek	NM4	7/16/1998	SW0007	1.34 *J*	0.2 *U*	85	5.96	0.19
Ninemile Creek	NM6	7/16/1998	SW0008	3.9	0.38 *U*	90	8.70	0.41
Ninemile Creek	NM8	7/16/1998	SW0006	5.99	0.41 *U*	93	9.4	0.59
Ninemile Creek	NM10	7/16/1998	SW0005	7.55	0.43 *U*	94	9.38	0.76
Ninemile Creek	NM10	7/20/1998	SW0015	6.77	0.56 *U*	92	7.6	0.82
Ninemile Creek (September)								
Ninemile Creek	NM1	9/1/1998	SW0021	4.52 *J*	0.29 *U*	94	13.7	0.31
Ninemile Creek	NM2	9/1/1998	SW0020	6.35 *J*	0.28 *U*	96	14.4	0.42
Ninemile Creek	NM3	9/1/1998	SW0019	2.96 *U*	0.18 *U*	--	9.4	

Table 5-3. (cont.)

Stream	Station	Date	Sample ID	Unfiltered Total Mercury (ng/L)	Dissolved Total Mercury (ng/L)	Fraction Particulate[a] (percent)	TSS (mg/L)	Particulate Total Mercury[b] (mg/kg)
Ninemile Creek	NM4	9/2/1998	SW0027	2.48 *U*	0.07 *U*	--	12.6	
Ninemile Creek	NM6	9/2/1998	SW0023	5.77 *J*	1.17 *U*	80	18.4	0.25
Ninemile Creek	NM6	9/2/1998	SW0023 (rep.)	7.60 *J*	0.3 *U*	96	17.9	0.41
Ninemile Creek	NM8	9/2/1998	SW0029	9.35 *J*	0.15 *U*	98	11.2	0.82
Ninemile Creek	NM10	9/2/1998	SW0026	26.9	0.16 *U*	99	13.4	2.0
Average =						91		

Notes: -- - not calculated because both unfiltered and dissolved concentrations were undetected

J - estimated

TSS - total suspended solids

U - undetected at detection limit shown

[a] (unfiltered mercury - dissolved total mercury)/unfiltered total mercury; full detection limits included in calculation.

[b] (unfiltered mercury - dissolved total mercury)/TSS; full detection limits included in calculation.

Source: Exponent, 2001c, Table 4-2.

6. TRANSPORT AND FATE OF CHEMICAL PARAMETERS OF INTEREST

"Transport and fate" refers to the movement of contaminants in the environment, their alteration during movement, and their ultimate destination. In line with federal guidance, this chapter describes the transport and fate of the main chemical parameters of interest (CPOIs). These CPOIs were selected based on screening conducted in this Remedial Investigation (RI) report (Appendix J, Sediment, Soil, and Surface Water Screening Tables), and the contaminants and stressors of concern identified in the Geddes Brook/Ninemile Creek Human Health Risk Assessment (HHRA) and Baseline Ecological Risk Assessment (BERA) (TAMS, 2003b,a) summarized in Chapters 7 (Human Health Risk Assessment) and 8 (Baseline Ecological Risk Assessment) of this RI report. This chapter discusses the transport of contaminants from Geddes Brook to Ninemile Creek, and from Ninemile Creek to Onondaga Lake, as well as the fate of contaminants within Geddes Brook and Ninemile Creek. Mercury is of particular importance in the discussion; however, other CPOIs are also discussed.

The Onondaga Lake RI (TAMS, 2002c) established that Ninemile Creek has been and is the single most important external source of mercury to Onondaga Lake. The description of the transport and fate of mercury (and other CPOIs) in the Geddes Brook/Ninemile Creek site includes an identification of the potential sources of mercury, with an assessment of the relative importance of those sources and a determination of the ultimate fate of mercury within the site.

6.1 Conceptual Site Model

The conceptual model of the Geddes Brook/Ninemile Creek site is based on the historical changes that have occurred to Geddes Brook and Ninemile Creek, and the historical discharges of CPOIs to the site. The primary sources of contaminants to the Geddes Brook/Ninemile Creek site originated from the Honeywell LCP Bridge Street site (mercury and other CPOIs), the Honeywell Main Plant (Solvay waste and possible other CPOIs), and possibly the Honeywell Willis Avenue site (mercury, polychlorinated biphenyls [PCBs], benzene, toluene, ethylbenzene, and xylenes [BTEX], and chlorinated benzenes). The historical main potential routes of transfer from the Honeywell plant sites to the Geddes Brook/Ninemile Creek site were discharges to the West Flume and disposal in Wastebeds 1 to 15 (with subsequent migration via overflow and groundwater). Minor potential routes of transfer of CPOIs include disposal in other sites (e.g., Honeywell's currently inactive Mathews Avenue Landfill) and surface runoff from urban areas.

The current potential sources of mercury and other CPOIs to the Geddes Brook/Ninemile Creek site are the Honeywell LCP Bridge Street site (via the West Flume), surface water runoff, and groundwater discharges from Wastebeds 1 to 15, as well as the sediments and floodplain soils in and along lower Geddes Brook and lower Ninemile Creek. The mechanism by which mercury can be transported in Geddes Brook and Ninemile Creek is by surface water. Mercury and other CPOIs (e.g., hexachlorobenzene, PCBs) can enter biota from these sources through dermal contact, respiration, and ingestion.

A major factor in this conceptual model is that Geddes Brook and Ninemile Creek are not in equilibrium. In a larger sense, streams are always changing and altering their course, as a result of eroding or depositing sediment and changing flow conditions. Geddes Brook and Ninemile Creek underwent significant changes in their flow and sediment regimes during Honeywell operations. The large quantities of suspended and dissolved solids discharged by Honeywell caused deposits of Solvay waste and associated calcite to build up in Geddes Brook and Ninemile Creek sediments and to deposit within the lower Geddes Brook and lower Ninemile Creek floodplains. These deposits in Ninemile Creek were noted by CDR (1991) and BBL (2001) in Reach CD below the confluence with Geddes Brook, and the remnants of these deposits were evident in the calcite shelf in Reach AB between State Fair Boulevard and the mouth of Ninemile Creek. The elevated mercury concentrations found at depths of at least 3 ft (1 m) in the floodplain soils, and as deep as 6 ft (2 m) in the sediments, are evidence of the thickness of some of these deposits.

The characteristics of the reaches of Ninemile Creek (discussed in Chapters 3 [Site History and Physical Characteristics] and 5 [Nature and Extent of Contamination]) can be summarized as follows (see Chapter 5, Figure 5-2):

- **Upper Ninemile Creek** (above the confluence with Geddes Brook) – This reach is relatively unaltered since 1944 when disposal began at Wastebeds 9 to 11. CPOIs appear to have been deposited from wastebed overflows in this reach; however, it appears that the bulk of the discharges were below this reach.

- **Reach CD** (from the confluence with Geddes Brook to the large bend downstream of the islands) – This reach is unaltered since the 1930s, contains extensive Solvay waste and associated calcite deposits, currently appears overall to be erosional, and contains the highest concentrations of mercury (see Chapter 5) in the sediments of Ninemile Creek. Mercury concentrations were also elevated in the floodplain soils of this reach. The deposits in this area are eroding as Geddes Brook and Ninemile Creek attempt to achieve an equilibrium under the new (post-1980) flow and solids regime. The high contaminant levels and the thickness of contaminated sediment indicate that this reach was likely depositional during the main period of Honeywell's discharges.

- **Reach BC** (from the bend downstream of the islands to the bend downstream of I-690) – This reach was rerouted in the late 1960s, and little evidence of Solvay waste and associated calcite deposits has been found. Mercury concentrations in this reach are lower relative to concentrations in Reach CD. Reach BC appears to be primarily depositional.

- **Reach AB** (from the bend below I-690 to the mouth of Ninemile Creek) – This reach appears to have been channelized in the late 1960s, with remnants of the Solvay waste and associated calcite deposits in the shelf along the right (facing downstream) bank (Figure 5-2). The mercury concentrations in this reach are higher than the concentrations in Reach BC. It is likely that a portion of the mercury contaminated material in the sediments was removed during the channelization and dredging project at the mouth of Ninemile Creek. The concentrations in the floodplain of this reach (outside of the scope of the channelization project) are substantially higher than in the sediments. This reach appears to be highly depositional.

6.2 Mercury Contamination in Sediments

When added to riverine systems, CPOIs such as mercury with a high affinity for particles are adsorbed to suspended matter and removed from the water column as the particles settle to the bottom, resulting in a pool of contaminated sediments. This pool of contaminated sediments can be released to the overlying water through natural or anthropogenic processes, such as redox cycling, bioturbation, flooding, or dredging. An assessment of sediment contamination above natural or baseline conditions requires the determination of baseline conditions. This has been achieved by defining the ratio of the CPOI to that of some normalizing factor whose concentration is generally unaffected by human activity (Daskalakis and O'Connor, 1995). Aluminum, iron, total organic carbon, and grain size are among the most commonly used normalizing factors. In this analysis, iron was selected because there was no significant difference in concentrations of iron in the upper and lower reaches of Geddes Brook and Ninemile Creek. In addition, there is a moderate correlation ($r^2 = 0.51$; 7 samples) between mercury and iron in the upper reaches of Geddes Brook and Ninemile Creek. The areas in the upper reaches of Geddes Brook and Ninemile Creek are considered to represent baseline conditions to which the contamination of the lower reaches can be compared.

The mercury/iron ratios were estimated for surface sediments (0 to 0.15 m) within the Geddes Brook/Ninemile Creek site and are depicted in Figure 6-1. The results from this analysis can be summarized as follows:

- Lower Geddes Brook and lower Ninemile Creek sediments are contaminated relative to baseline conditions in the system and serve as major sources of mercury to the surface water of Geddes Brook, Ninemile Creek, and Onondaga Lake.

- The normalizing ratios suggest that at least some of the sediments in lower Ninemile Creek, especially on the right bank of Reach CD (Figure 5-2), are not the result of transport of contamination from Geddes Brook and other points upstream. Figure 6-1 shows elevated ratios in surface sediments of Ninemile Creek at Transects TN-12, TN-14, and TN-15, greater than the ratios in upper Ninemile Creek or in Geddes Brook. These results suggest that these sediments are not streambed sediments transported from upstream sources. Rather, they are possibly waste materials which were dumped alongside Ninemile Creek or have uniquely high concentrations/ratios within the heterogeneous wastes which were discharged to the creek. Note that ratios could not be calculated at all stations (e.g., Transect TN-13) since select stations were only analyzed for mercury and not the full suite of inorganics.

6.3 Transport and Fate of Mercury and Total Dissolved Solids

This section describes the surface water transport of mercury in lower Geddes Brook and Ninemile Creek. Mercury loads at various stations within the Geddes Brook/Ninemile Creek site were calculated under both base-flow and high-flow conditions. To better understand changes in mercury loads along the various reaches, loadings of total dissolved solids (TDS) were also estimated.

6.3.1 Concentrations and Loads Under Base-Flow Conditions

Under base-flow conditions, the source of the vast majority of the water entering Ninemile Creek is from a source lake (i.e., Otisco Lake) and groundwater, rather than surface runoff. During this time, runoff-based sources are largely ineffectual, permitting an assessment of sediment/groundwater sources. During base-flow conditions, there are few rapid changes in the system, making the assessment essentially that of a steady-state system. Therefore, issues such as time of travel, onset of the increase of flows, and timing of the peak flow, can generally be ignored. Since the water velocities at base flow are relatively low, the rate of erosion is low as well. Typically, at base flow, only lighter, smaller particles from the surface of the sediments are eroded, while the majority of the transport of sediments and floodplain soils occurs during short lived but intense high-flow events (see Section 6.3.2). Thus, assessment of sediment transport at base flow will represent only a minor component of the total annual transport for the system (i.e., the transport of sediments at the sediment/water interface [less than 1 cm deep]).

For this analysis, data sets which include multiple stations along Geddes Brook and Ninemile Creek were used. Only the sampling programs from 1990 (CDR, 1991) and the 1998 Geddes Brook/Ninemile Creek RI/FS investigation, included enough sampling stations (up to 22 stations) to assess multiple reaches of Geddes Brook and Ninemile Creek. Both of these programs included two base-flow sampling events, providing four dates separated by eight years on which to assess base-flow conditions in detail.

As was discussed in Chapters 3 and 5, the concentrations of TDS and mercury in lower Ninemile Creek have been declining over the years. Thus, the data from various years cannot be pooled, but are assessed on the basis of individual years. In Chapter 3, it was noted that TDS concentrations in lower Ninemile Creek declined 24 percent between 1989 and 1997. In Chapter 5, it was noted that under base-flow conditions, total mercury concentrations in 1998 were about 85 percent lower in the West Flume, 90 percent lower in lower Geddes Brook, and 70 percent lower in lower Ninemile Creek, relative to conditions in 1990. While the rates of decline are similar, the actual concentrations differ by orders of magnitude. In 1990, mercury concentrations were about 6,000 ng/L in the West Flume, about 200 ng/L in lower Geddes Brook, and about 50 ng/L in lower Ninemile Creek. The fact that the percentage declines in the three streams are similar suggests that the loadings under base-flow conditions may be linked.

6.3.1.1 Concentrations of Mercury and Total Dissolved Solids

Changes in concentrations within the Geddes Brook/Ninemile Creek site can be used to understand sources of CPOIs along the length of the streams. Increases between two stations might suggest a source between them. On the other hand, a decrease in concentration between the transects might suggest either a dilution effect from a surface water input with lower concentrations or a settling out of the CPOI if it is predominantly particle-bound. An important consideration in this type of analysis is whether a sampling point is representative of a particular reach. If there is some reason to suggest that the parameter of interest (mercury in this case) is not well mixed across the entire width of Ninemile Creek, the data may be biased relative to the true integration across the stream. Of particular concern is the sampling point in Reach CD of Ninemile Creek below the large island (Stations CDR-12 and NM6). The potential of inadequate mixing at these stations due to the effects of the islands on stream flow must be considered during data interpretation.

Total dissolved solids, including ionic waste constituents (calcium, sodium, and chloride), are considered SOCs at the site (see the Geddes Brook/Ninemile Creek BERA [TAMS, 2003a]). The concentrations of TDS in Geddes Brook and Ninemile Creek on two dates in 1990 during periods of low flow are presented in Figure 6-2 (see Chapter 2, Figure 2-3 for the locations of the sampling stations). There is little variability in TDS concentration in upper Ninemile Creek from the stations at Camillus (CDR-1) to the Allied Bridge just across from Wastebed 13 (CDR-7). The concentration of TDS increases slightly at the next station (Station CDR-8 near the Conrail bridge, near Wastebed 13), suggesting discharge of groundwater contaminated with Honeywell's ionic waste from the Solvay Wastebeds. The concentrations of TDS continue to increase at the next two stations (Station CDR-9 near the large metal culverts and Station CDR-10 near the abandoned pipeline), most likely the result of groundwater from Wastebeds 12 to 15, and/or the combined groundwaters of Wastebeds 12 to 15 and Wastebeds 9 to 11. After these stations, there are only slight changes in TDS concentrations down to the mouth of Ninemile Creek, suggesting only minor, if any, additional TDS load to Ninemile Creek downstream of the confluence with Geddes Brook. The data from 1998 (see Chapter 5, Figure 5-44) present a similar pattern.

The total mercury concentrations from the same samples in 1990 present a different pattern (Figure 5-27a). There is little variability in concentration of total mercury among the upper Ninemile Creek stations from Camillus (Station CDR-1) to past the Conrail bridge (Station CDR-8), the culverts (Station CDR-9), and the abandoned pipeline (Station CDR-10). However, significant increases in mercury concentration occurred after the confluence with Geddes Brook. Mercury concentrations within lower Ninemile Creek remained high relative to values upstream of the Geddes Brook confluence, suggesting that a source exists in the area of Geddes Brook. The mercury concentrations in 1998 (Figure 5-27b) present a pattern similar to that in 1990, with the concentrations of mercury remaining relatively stable among the stations from above Amboy Dam (Stations NM1 and NM2) to past the culverts (Station NM3), and the abandoned pipeline (Station NM4), and only increasing after the confluence with Geddes Brook. In the 1998 data, the mercury concentrations in Ninemile Creek continued to rise (although not so dramatically) downstream of the confluence with Geddes Brook, down to the mouth of Ninemile Creek (Stations NM6, NM8, and NM10), suggesting that these reaches between the Geddes Brook confluence and the mouth of Ninemile Creek contribute additional mercury to the surface water. However, these variations among the lower reaches of Ninemile Creek could also be due to variations in mixing.

Concentrations of mercury along Geddes Brook were also determined (Figures 5-27a and 5-27b). Mercury concentrations along Geddes Brook increase significantly downstream of the confluence with the West Flume (from Stations CDR-6 to CDR-21 and CDR-11 [1990] and from Stations GB3 to GB8 [1998]). The concentrations in the West Flume are much higher than those in Geddes Brook indicating that the West Flume was the major source of mercury to Geddes Brook during these sampling events.

CDR (1991) analyzed surface water samples for methylmercury on the same dates in 1990 and at most of the same stations as for total mercury. In the 1998 Geddes Brook/Ninemile Creek RI/FS investigation, dissolved methylmercury was analyzed on the same dates and at most of the same stations as for total mercury. The sampling data for methylmercury are more limited than that for total mercury, since fewer stations were sampled for methylmercury in both 1990 and 1998. The concentrations of methylmercury were typically two orders-of-magnitude lower than for total mercury. The 1998 dissolved methylmercury data tend to be more variable, most likely due to the very low concentrations (less than 0.1 ng/L). At several stations in 1998, dissolved methylmercury was not detected. Therefore, loadings could not be reliably estimated for methylmercury.

The methylmercury concentrations for the two dates in 1990 are shown in Chapter 5, Figure 5-28a. The concentrations of methylmercury in Ninemile Creek are variable but show no distinct changes among the stations from Camillus (Station CDR-1) to past the Conrail bridge (Station CDR-8), the culverts (Station CDR-9), and the abandoned pipeline (Station CDR-10), and all the way to the mouth of Ninemile Creek (Station CDR-14) (although an increase in concentration downstream of Geddes Brook was seen in the October 1990 event). The dissolved methylmercury concentrations in 1998 present a pattern similar to that of 1990. The methylmercury concentrations for the two dates in 1998 during periods of low flow, as shown in Figure 5-28b, are variable and showed no distinct pattern of change among the stations from above Amboy Dam (Stations NM1 and NM2) to past the culverts (Station NM3), and the abandoned pipeline (Station NM4), and all the way to the mouth of Ninemile Creek (Station NM10). Unlike Ninemile Creek, the methylmercury concentrations in Geddes Brook on the same dates (Figures 5-28a and 5-28b) increase after the confluence with the West Flume (from Station CDR-6 to Stations CDR-21 and CDR-11 [both 1990 events] and from Stations GB3 to GB8 [July 1998 event only]), with the West Flume exhibiting much higher concentrations of methylmercury than Geddes Brook. These data indicate that the West Flume was and probably remains the major source of methylmercury to Geddes Brook.

The contrast between the patterns exhibited by TDS, total mercury, and methylmercury suggests that the sources for these CPOIs are distinct. In Ninemile Creek, the influence of groundwater migrating from Wastebeds 9 to 15 is clearly seen by the increase in TDS concentration. The amount of groundwater from Wastebeds 1 to 8 reaching Ninemile Creek is relatively small compared to the flow from Ninemile Creek, based on the observed minor increases in TDS through this section of the creek. The fact that total mercury concentrations do not rise at the same time as TDS indicates that the Solvay Wastebeds may not currently be a significant source of mercury to the Geddes Brook/Ninemile Creek site. Rather, the source of total mercury to the site originates from the LCP Bridge Street site by way of the West Flume, and its influences are seen farther downstream. The fact that methylmercury concentrations do not rise in Ninemile Creek in a consistent manner indicates that there is not a major current source of methylmercury in the system large enough to influence the concentrations in Ninemile Creek. However, methylmercury releases from the West Flume to the site appear to be large enough to affect the methylmercury concentrations in Geddes Brook. The lack of a methylmercury response in Ninemile Creek relative to that observed in Geddes Brook may be the result of rapid oxidation of methylmercury.

6.3.1.2 Loads of Mercury and Total Dissolved Solids

While the analysis of the concentrations in surface water provides some insights to the potential sources of TDS and mercury, estimates of loads provide a better understanding of the sources and transport of CPOIs along the streams. In this analysis, daily loads of TDS and mercury were calculated at each sampling station using the average daily flows and concentrations observed at each station.

In the CDR (1991) study, flows were measured on May 9, 1990 at locations which represent major inputs of water to Geddes Brook and Ninemile Creek, including:

- Station CDR-3, Ninemile Creek downstream of the Erie Canal.
- Station CDR-4, Ninemile Creek at Amboy Bridge.
- Station CDR-5, Beaver Meadow Brook.
- Station CDR-6, upper Geddes Brook.
- Station CDR-7, Ninemile Creek near the Allied Bridge.
- Station CDR-11, lower Geddes Brook.
- Station CDR-13, Ninemile Creek at State Fair Boulevard.
- Station CDR-20, West Flume.
- Station CDR-22, unnamed tributary draining Wastebeds 12 to 15.

The use of these flow data allowed ratios to be developed for each of these locations in comparison to the flow measured at the US Geological Survey (USGS) gauging station on Ninemile Creek at Lakeland (State Fair Boulevard). CDR (1991) confirmed the ratios established from the May gauging event at three of these sites on July 26, 1990. The use of USGS flow data and these ratios allow flows to be established at each station for each date of sampling (Table 6-1).

The loads of TDS in Geddes Brook and Ninemile Creek on two dates in 1990 during periods of low flow are presented in Figure 6-3a. The TDS load in Ninemile Creek is relatively constant among the stations from Camillus (Station CDR-1) to the Allied Bridge just across from Wastebed 13 (Station CDR-7). The loads of TDS increase slightly at the next station (Station CDR-8, at the Conrail bridge, near Wastebed 13) indicating a probable input of TDS from groundwater from Wastebeds 12 to 15. Loads continue to increase downstream of this station due to additional inputs from Wastebeds 12 to 15 and Wastebeds 9 to 11 (Stations CDR-9 and CDR-10). The TDS loads then increase slightly at the next two stations (CDR-12 and CDR-13) suggesting a small additional TDS load to Ninemile Creek. The slight increase in load at these last two stations includes the TDS load from Geddes Brook (8.2 and 8.3 percent of the total) and possibly additional small groundwater loads, but may also suggest additional mixing of the load from Geddes Brook.

The TDS load remains steady or decreases slightly down to the mouth of Ninemile Creek, and there are no further increases in TDS loads at Station CDR-14 in Reach AB, downstream of Wastebeds 1 to 8. This suggests that little to no additional groundwater loads of TDS are present in this reach and that groundwater discharge from Wastebeds 1 to 8 may not be a major source of TDS to Ninemile Creek. The TDS loads from 1998 (Figure 6-3b) show a similar pattern.

Mass balances were conducted using the stations in upper Ninemile Creek (Stations CDR-10 and NM4), lower Geddes Brook (Stations CDR-11 and GB8), and lower Ninemile Creek at the USGS gauging station at Lakeland (Station CDR-13 and NM8). The use of the lower Ninemile Creek station at Lakeland, well downstream of the Geddes Brook confluence, is expected to minimize the load variability due to incomplete mixing relative to the samples collected at the large island. For the four dates of base-flow data in 1990 and 1998, the sum of the measured TDS loads from upper Ninemile Creek and lower Geddes Brook agree to within -6.4, -5.1, 0.3, and 0.19 percent of the measured loads at the station in lower Ninemile Creek at the USGS Lakeland gauging station (Figures 6-4a and 6-4b). The average imbalance for these data is -2.8 percent (less than 0.2 percent for the 1998 data), suggesting that the sampling location in lower Ninemile Creek at the USGS station is representative of the combined TDS loads of upper Ninemile Creek and Geddes Brook for these sampling dates. Note that only about eight percent of the TDS load originates from Geddes Brook. Based on these observations, the data also suggest that load contributions generated within Geddes Brook are well mixed into Ninemile Creek by the time a water parcel arrives at the Lakeland gauging station.

The total mercury loads present a different pattern from the TDS loads. The loads of total mercury in Geddes Brook and Ninemile Creek on four dates in 1990 and 1998 during periods of base flow are presented in Figures 6-5a and 6-5b. There is little variability in the mercury loads in Ninemile Creek from the stations at Camillus and above Amboy Dam (Stations CDR-1 and NM1) to the stations near the abandoned pipeline (Stations CDR-10 and NM4) indicating that there are currently no significant inputs of mercury due to groundwater from Wastebeds 9 to 15, even in those areas obviously affected by the groundwater discharges identifiable by the rise in TDS loads. Significant increases in total mercury loads occurred at the stations at the large island (Stations CDR-12 and NM6) showing at least in part, the influence from Geddes Brook. From the stations at the large island down to the mouth of Ninemile Creek (Stations CDR-14 and NM10), the loads of mercury fluctuated but were always higher relative to upstream values in upper Ninemile Creek. The variation in the mercury loads in lower Ninemile Creek may be due to variations in the sediments and mercury transport regime, but could also be due to variations in the mixing of the mercury loads from Geddes Brook into Ninemile Creek.

The results of the analysis of total mercury loads along Geddes Brook and Ninemile Creek can be summarized as follows:

- The ratio of mercury loads at the mouth of Geddes Brook to the corresponding loads at the USGS Lakeland gauging station in lower Ninemile Creek ranges from 15 to 43 percent (mean of 33 percent), suggesting that Geddes Brook plays a much larger role in the mercury loads of Ninemile Creek than it does for TDS. These results suggest that Geddes Brook supplies about 30 percent of the mercury load to Ninemile Creek as compared to 8 percent of the TDS load. However, it also indicates that Geddes Brook does not supply all of the mercury loads to lower Ninemile Creek.

- Total mercury mass balances were conducted for the four dates of base-flow data in 1990 and 1998 (Figures 6-6a and 6-6b, respectively). The imbalances between the measured inputs from upper Ninemile Creek and the mouth of Geddes Brook, and the loads for lower Ninemile Creek (as measured at the USGS station) are 39, 56, 38, and 54 percent for the four dates (mean of 47 percent). These mercury mass imbalances clearly suggest that there is a significant load gain within lower Ninemile Creek. Because there are no significant tributaries flowing into lower Ninemile Creek downstream of its confluence with Geddes Brook, and because groundwater inputs from Wastebeds 9 to 15 do not add significant amounts of mercury nor does there appear to be significant groundwater discharges from Wastebeds 1 to 8 to lower Ninemile Creek, it is likely that this increase in mercury load is from internal sources (e.g., sediments and floodplain soils) within Reach CD of lower Ninemile Creek.

- A similar analysis was conducted for the loads in Geddes Brook and the West Flume (Figures 6-5a and 6-5b). The ratios of the loads in the West Flume to lower Geddes Brook for the first three (of four) events were 52, 63, and 67 percent, respectively, as measured at the mouth of Geddes Brook and at the mouth of the West Flume, suggesting that lower Geddes Brook carried more mercury than the West Flume delivered to it during these events. However, the ratio from the September 1998 event (150 percent) suggests that the West Flume supplied more mercury than appeared at the mouth of Geddes Brook, suggesting that Geddes Brook may also act as a sink at times. This change in conditions is also reflected in the mercury mass balances comparing the load at the mouth of Geddes Brook to the sum of the inputs from upper Geddes Brook and the West Flume (44, 35, 25, and -60 percent). These comparisons (for four dates) suggest both lower Geddes Brook and the West Flume are sources of mercury to the site, and that the relationship between loads generated in the West Flume and loads carried by Geddes Brook are more variable than for the Ninemile Creek comparisons, with lower Geddes Brook acting as sink under certain conditions.

- The surface water concentrations of mercury in lower Ninemile Creek, lower Geddes Brook, and the West Flume at base flow declined between 1990 and 1998 at roughly the same rate, yet the ratio of the loads between lower Ninemile Creek and lower Geddes Brook remained about the same. This suggests that, at base flow, mercury releases from the West Flume affect the magnitude of mercury releases from the downstream reaches (i.e., lower Geddes Brook and lower Ninemile Creek). If the in-place sediments in these lower reaches were the only influence on mercury loads in these reaches, any changes in the mercury loads upstream over time should be independent of changes in the downstream reaches and, thus, the ratio of the loads should change.

- A possible explanation for this influence is that the sediments transported from the upstream reaches partially or completely supply the surficial inventory of mercury responsible for the base-flow loads from the downstream reaches. In this manner, base-flow loads in all the reaches below the mercury source would be expected to decline in a similar manner.

- Alternatively, there is a possibility that the West Flume actually supplies the entire mercury load in the lower reaches at base flow and the apparent increase in mercury loads at each of the reaches downstream of the West Flume may be due to the difficulty in estimating flows. As discussed below in Section 6.3.2, it is difficult to estimate flow in the lower reaches of these streams due to backwater conditions. Although care was taken to assess data during sampling events in which a factor such as backwater conditions would be minimized, if the flow estimates were consistently biased, this would yield the apparent load gains in the downstream reaches under base-flow conditions. This would also cause the close correlations in the decline in mercury loads with time in all reaches.

- The possibility also exists that the apparent gain in mercury load is due to some artifact in the sampling such as incomplete mixing in the streams or difficulty in assessing flows. However, for this to be the case, the artifact would have to be consistent for numerous sampling dates spanning 11 years and five different sampling programs, not all of which used the same exact sampling locations. Thus, it seems unlikely that the mercury concentration patterns are due to such an artifact.

Despite these uncertainties under base-flow conditions, as discussed in the following section, the sediments of lower Ninemile Creek (and most likely lower Geddes Brook as well) are clearly major sources of mercury during high-flow conditions, confirming the importance of these reaches to the total mercury transport.

Further analysis was done on data collected in 2001 by Onondaga County (K. Murphy, pers. comm., 2002; these data are included in Table L-12 in Appendix L [Summary of Data Collected Independently of the Geddes Brook/Ninemile Creek RI] of this RI). Onondaga County measured mercury concentrations at base flows in Geddes Brook, Ninemile Creek, and the West Flume on three dates in 2001 (February 13, June 28, and August 21; data for Geddes Brook and the West Flume only were collected on additional dates in 1999 and 2000). The mean ratio of water flow in Geddes Brook to that in Ninemile Creek at base flow in 2001 (13 percent) is slightly higher than the ratios in 1990 (9 percent). Since no samples were collected from upper Ninemile Creek in this study, complete mass balances cannot be determined, but the ratios between the loads can be compared. The ratios between mercury loads in lower Geddes Brook and lower Ninemile Creek at the USGS Lakeland gauging station were 34, 40, and 52 percent, similar to the ratios measured in the 1990 and 1998 sampling programs.

The mercury loads at the USGS Lakeland gauging station estimated in this analysis for 1990 (14 and 10 g/day, Figure 6-6a) and 1998 (0.8 and 1.1 g/day, Figure 6-6b) are similar to the 1.7 to 5.3 g/day estimated for the three base-flow events from the 1992 data (Table 6-2) at the mouth of Ninemile Creek (Station W10) considering the overall decline in mercury concentrations between 1990 and 1998.

6.3.2 Concentrations and Loads under High-Flow Storm Event Conditions

As discussed in Chapter 5, mercury carried in Geddes Brook and Ninemile Creek surface water is primarily associated with particles. For all 1998 water samples, particle-bound mercury ranged from 75 to 99 percent of total mercury, with an average of 91 percent. Strong particle associations are characteristic of mercury and result from adsorption to mineral colloids (Schuster, 1991) and a strong affinity for sulfide (conditional stability constant of $[Hg^{2+}][S^{2-}] = 10^{-53.9}$ [Dyrssen and Wedborg, 1991]), including that composing sulfhydryl groups in organic matter. Total mercury associated with particles in Geddes Brook surface water has two possible fates: 1) transport by surface water flow into Ninemile Creek and then into Onondaga Lake and 2) deposition to the sediment bed or floodplain soil in Geddes Brook and/or Ninemile Creek. Under dry-weather conditions, mercury in surface water is adsorbed to small, easily transported organic and inorganic particles, and referred to as the wash load. During periods of high flow, additional sediment can be resuspended from the bed. The largest inputs of sediment during high flow, however, come from erosion of the channel bank. During even higher flows, when water flows over the channel banks and on to the floodplain, bank erosion is still the major source of particles. Water velocities over the floodplain are lower than that in the channel, so that floodplains are generally depositional rather than erosional and deposition usually consists of fine particles (Wolman and Leopold, 1957).

For the period prior to 1999, USGS only released mean daily flows for Ninemile Creek rather than instantaneous flows, because of difficulty in measuring the flow at the USGS Lakeland gauging station on Ninemile Creek. Due to the relatively flat gradient of the stream near the mouth of Ninemile Creek, if the water level of Onondaga Lake is above 362 feet above mean sea level (amsl), then water from the lake backs up into lower Ninemile Creek, causing the stage to rise (or remain high) without an increase in water flow. Thus, during high lake levels, the estimated flows measured at the Lakeland gauging station can be biased high. This condition is typically more pronounced on the descending limb of the hydrograph, since the lake level will rise most after the bulk of the stream flow from the event enters the lake. These lake backwater effects cast some uncertainty on the USGS estimates of instantaneous flows for gauging data at least up to 1999, when more sophisticated equipment was installed (J. Hornlein, pers. comm., 2003). However, while the actual instantaneous flows may not be directly estimated from those data, important aspects (onset of rise, rising limb, peak, descending limb) of the hydrograph can be identified, and the mean daily flow can be estimated.

Within the Geddes Brook/Ninemile Creek site, the USGS has maintained gauging stations only on Ninemile Creek. Flows for Geddes Brook, West Flume, the unnamed tributary, and Beaver Meadow Brook, can all be estimated at base flow based on the flow in Ninemile Creek by using the ratios established from the CDR (1991) data (Table 6-1). However, these ratios will only hold at high flows if the streams have similar responses to a rainfall event, (e.g., lag time from onset of rainfall to peak flow). The West Flume, Geddes Brook, and Ninemile Creek were all gauged during five rainfall events in 1995 (PTI, 1996). For these storms, response times for the onset of increase in flow, and the lag period from the onset to the peak flow for each storm for both Geddes Brook and Ninemile Creek were very similar. The mean daily flows of both Geddes Brook and Ninemile Creek for the October 21, 1995 storm were compared. The stage/flow for Geddes Brook was measured from 3:39 to 11:19 on October 21. The average flow for this period was compared to the flow for the corresponding period in Ninemile Creek (USGS data provided by J. Hornlein, pers. comm., 2003). Although USGS only provides mean daily flow, the average stage (calculated from instantaneous stage measurements provided by USGS) for this period was compared to the average stage for the entire day. The mean daily flow for Ninemile Creek was multiplied by this ratio to provide the mean flow for the same time period as the Geddes Brook gauging data. The ratio of the flow in Geddes Brook to that of Ninemile Creek for this portion of the rising limb was 0.084, relatively close to the 0.09 seen at base-flow conditions. This suggests that the flows from Geddes Brook can be estimated from the flows in Ninemile Creek as measured by the USGS Lakeland gauging station.

For the five storm-related events sampled in 1995, only one of them involved a truly high flow. The October 21, 1995 event involved a storm with a mean daily flow of 500 cfs (14.2 m^3/s) (J. Hornlein, pers. comm., 2003). The peak flows for the other four storms were all under 100 cfs (2.83 m^3/s). During the October 21, 1995 storm, the stage started rising early (about 4:00) and continued to rise throughout the day, and peaked in the morning of October 22 at 6:00. Three water samples for mercury were collected on October 21, 1995. The load for the October 21, 1995 storm was estimated by using the average mercury concentration of the three samples, and multiplying it by the mean daily flows for October 21 and October 22.

A comparison of total mercury loads in surface water of Geddes Brook and Ninemile Creek during the October 21 and October 22 high-flow event in 1995 is presented in Figure 6-7. A distinct change in the pattern from the base-flow mercury loads is evident. The total load passing the USGS Lakeland gauging station is estimated as 443 grams for the two-day event, representing an increase in load of two orders of magnitude from the 1998 base-flow loads (about one gram per day). In addition to the change in the total load, the ratio between the load from Geddes Brook to Ninemile Creek changed from an average of 33 percent at base flow to 14 percent at high flow. In the mass balance calculation, the percentage of the mercury load originating from lower Ninemile Creek (i.e., load not accounted for by the upstream loads) rose from an average of 47 percent at base flow (1990 and 1998) to 82 percent during the 1995 high-flow event. All of these changes represent an increase in loads in both Geddes Brook and Ninemile Creek. However, the increases in load are most pronounced in lower Ninemile Creek. These results in Ninemile Creek are consistent with the increase in surface water flow causing increased water velocities and expansion of the stream into the floodplain, which in turn causes increased erosion of mercury contaminated sediments and soils (see Chapter 5, Figure 5-2). Thus, in contrast to the base-flow conditions, surface water flow during high-flow events appears to erode and transport much more of the in-place sediments in lower

Ninemile Creek. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of mercury being transported to Onondaga Lake, and because of the scale of these short-duration loads, they are a major component of the annual mercury loads to the lake.

The mercury loads at the USGS Lakeland gauging station estimated in this analysis for the October 21 to 22, 1995 event (183 and 260 g/day, Figure 6-7) are higher than the 47.8 g/day measured in the highest flow event measured in 1992 on July 27 (Table 6-2). However, the 1992 flow (290 cfs) was significantly lower than the 1995 event (500 cfs) and reflected a sample collected far out on the descending limb of an event rather the rising limb sampled in 1995.

The Onondaga County sampling program conducted in 2000 and 2001 concentrated on days in which the hydrograph for Ninemile Creek was generally flat (base flow), with no rapid changes in flow, although on two dates (October 25, 2000 and April 13, 2001), the sampling took place during the descending limb of a high-flow event. On June 21, 2000, Onondaga County collected samples from Geddes Brook both upstream and downstream of the West Flume during a large event (peak flow of 500 cfs in Ninemile Creek), but no flow measurements were taken, nor were any samples collected from Ninemile Creek. While limited in its nature, an observation for this one event was that the mercury concentration for upper Geddes Brook increased by an order of magnitude (from a mean of 2.4 ng/L during base-flow conditions in 1998 to a mean of 33.9 ng/L), unlike the 1995 storm-event results for upper Ninemile Creek, which indicated that the mercury concentration increased only slightly (from a mean of 3.6 ng/L to a mean of 5.65 ng/L). This suggests that there could be a source of mercury in upper Geddes Brook, that is subject to erosion only during a large storm event.

6.4 Transport and Fate of Inorganics Other than Mercury

The sources, transport, and fate of inorganics other than mercury and the major TDS constituents are evaluated in this section using their observed distributions in surface water, sediment, and soil to infer current and historical conditions within the context of well known processes.

6.4.1 Distribution in Surface Water

Mercury and TDS have already been discussed in Sections 6.2 and 6.3. The inorganics calcium, chloride, magnesium, sodium, and potassium are the major constituents of TDS. Figures 5-41 to 5-43 in Chapter 5 present the concentrations of the three most significant of these inorganics in Geddes Brook and Ninemile Creek surface water. These inorganics all have trends that are very similar to the TDS trends discussed above, indicating that Wastebeds 9 to 15 are the major sources of these inorganics to the Geddes Brook/Ninemile Creek site.

As was done for mercury, the changes in concentration along the streams can be used to infer the potential for sources or sinks of a particular CPOI. Figures 5-35 to 5-40 in Chapter 5 present the total concentrations of inorganics other than mercury that were consistently detected in surface water in samples collected from Geddes Brook and Ninemile Creek during the RI, and are primarily associated with particles. As was noted in Chapter 5, the concentrations of these CPOIs in the dissolved phase were significantly lower than the total concentrations. A summary for these inorganics is provided below:

- Total aluminum concentrations (Figure 5-35) appear to decrease from upper Ninemile Creek (about 300 to 400 µg/L) to lower Ninemile Creek (less than 200 µg/L), and decrease along in Geddes Brook (less than 100 µg/L to less than 50 µg/L). These decreases, which are more than can be explained by flow dilution, suggest that the primary source of aluminum to the Geddes Brook/Ninemile Creek site may be from Ninemile Creek upstream of the site.

- Total antimony concentrations (Figure 5-36) do not appear to change throughout the Geddes Brook/Ninemile Creek site, suggesting that there is no localized source of antimony to the site.

- Total barium concentrations (Figure 5-37) appear to increase slightly from upper Ninemile Creek (about 75 µg/L) to lower Ninemile Creek (about 110 µg/L), and remain approximately constant in upper and lower Geddes Brook (about 50 µg/L). These observations suggest that most of the barium in the water column is derived from upper Ninemile Creek, although there may be a smaller additional contribution from lower Ninemile Creek.

- Total iron concentrations (Figure 5-38) do not appear to change consistently from upper Ninemile Creek to lower Ninemile Creek, but increase slightly along Geddes Brook (less than 200 µg/L in upper Geddes Brook to greater than 300 µg/L in lower Geddes Brook). These data suggest that a small source of iron may exist in Geddes Brook.

- Total lead concentrations (Figure 5-39) appear to decrease from upper Ninemile Creek to lower Ninemile Creek, but the low concentrations with numerous non-detects makes this trend uncertain, suggesting that there is no large localized source of lead to the site.

- Total manganese concentrations (Figure 5-40) appear to increase from upper Ninemile Creek (about 50 µg/L) to lower Ninemile Creek (about 100 µg/L), and from upper Geddes Brook (about 30 µg/L) to lower Geddes Brook (about 90 µg/L). This suggests that there is a source of manganese in lower Ninemile Creek and lower Geddes Brook.

6.4.2 Distribution in Surface Sediments and Floodplain Soils

A qualitative assessment of the sediment and floodplain soil figures in Chapter 5 suggests that the elevated concentrations of several inorganics (e.g., arsenic, nickel, and zinc) are correlated with elevated mercury levels, and thus may have a similar source. To further explore this observation, a more quantitative statistical assessment was prepared using the observed distributions of CPOI inorganics in sediment and soil. The analysis performed can be grouped into two categories as follows:

- Statistical tests comparing surface sediment concentrations in the four reaches of the Geddes Brook/Ninemile Creek site as well as comparisons of floodplain soil to stream sediments.

- Calculation of ratios of inorganic concentrations in surface sediments in the four reaches of the Geddes Brook/Ninemile Creek site to a normalizing factor (i.e., concentrations of iron).

The four reaches of the Geddes Brook/Ninemile Creek site were defined as follows: upper Ninemile Creek, lower Ninemile Creek, upper Geddes Brook, and lower Geddes Brook. These analyses were performed using data from surface sediments and surface soils only.

6.4.2.1 Methodology

Statistical Comparison of Inorganic Concentrations

The statistical comparisons of concentrations in the various reaches of both streams, as well as between sediment and floodplain soil, were performed using a simple non-parametric test called Wilcoxon's rank sum test (also known as the Mann-Whitney test). The concentrations at the various reaches within the streams and floodplain were considered as independent data sets for this analysis. Non-parametric tests do not assume that the data follow the normal distribution or any other specific distribution. Moreover, the Wilcoxon's rank sum test can handle a moderate number of non-detect values. In this analysis, one-half of the detection limit values were used as the concentration for samples with results reported as non-detect. However, it is important to note that when the number of non-detect samples is more than 50 percent of the total number of samples for each analyte, the results must be interpreted with caution. The number of non-detects for antimony, cadmium, selenium, silver, and thallium exceeds 50 percent of all analyzed samples in both stream sediment and floodplain soil samples; therefore, these inorganics were not compared quantitatively in this analysis.

Normalization of Inorganic Sediment Concentrations

Contaminants in sediments can be released to the overlying water through natural or anthropogenic processes, such as redox cycling, bioturbation, flooding, or dredging. Determination of sediment contamination above natural or baseline conditions requires the determination of baseline conditions. This is frequently achieved by defining the ratio of the contaminant to that of some normalizing factor whose concentration is unaffected by human activity (Daskalakis and O'Connor, 1995). In this analysis, iron was selected as the normalizing factor and the areas in the upper reaches of Geddes Brook and Ninemile Creek were considered to represent baseline conditions to which the concentrations in the lower reaches were compared.

6.4.2.2 Results

Statistical Comparison of Stream Sediment Concentrations between the Upper and Lower Reaches

The average concentrations of inorganics in the surface sediments in the four different reaches of the Geddes Brook/Ninemile Creek site, as presented in Table 6-3, can be summarized as follows:

- There were no significant differences (p-value greater than 0.05) in surface sediment concentrations of aluminum, chromium, copper, iron, lead, nickel, vanadium, and zinc between upper and lower reaches of both Geddes Brook and Ninemile Creek, indicating the likely absence of major sources of these inorganics in the lower reaches.

- In Ninemile Creek surface sediments, concentrations of beryllium were significantly higher in lower Ninemile Creek relative to upper Ninemile Creek, while concentrations of cobalt were significantly higher in upper Ninemile Creek.

- In Geddes Brook surface sediments, concentrations of arsenic, barium, beryllium, and manganese were significantly higher in lower Geddes Brook relative to upper Geddes Brook, while no inorganics were observed to have concentrations significantly higher in upper Geddes Brook relative to lower Geddes Brook.

Statistical Comparison of Inorganic Concentrations Between Stream Sediment and Floodplain Soil

The comparison between stream sediment and floodplain soil concentrations, as presented in Table 6- 4, can be summarized as follows:

- In upper Ninemile Creek, concentrations of aluminum, chromium, cobalt, copper, iron, nickel, vanadium, and zinc were significantly higher (p-value less than 0.05) in floodplain soil compared to stream sediment.

- In upper Geddes Brook, concentrations of arsenic and manganese were significantly higher in floodplain soil compared to stream sediment.

- In lower Ninemile Creek, concentrations of aluminum, beryllium, chromium, cobalt, copper, iron, nickel, vanadium, and zinc were significantly higher in floodplain soil compared to stream sediment.

- In lower Geddes Brook, concentrations of aluminum, arsenic, cobalt, iron, and vanadium were significantly higher in floodplain soil compared to stream sediment, while manganese was significantly lower.

Normalization of Inorganic Sediment Concentrations

Unlike total mercury in which the normalized ratios were different between lower and upper reaches (see Section 6.2 and Figure 6-1), the ratios for other inorganics did not show generalized trends between upper and lower reaches but rather showed the presence of localized sources in certain locations in the lower reaches of the streams. If the sediments in these reaches resulted from the natural processes of transport from upstream and erosion/deposition, these distinct localized high ratios would not be present. This is because, in general, the ratios are unaffected by dilution during transport. Only additions or preferential dissolution of one inorganic constituent relative to the other will change the ratio during transport. The results can be summarized as follows:

- Arsenic to iron ratios (Figure 6-8) at Transect TN-5 and Station NM9 were distinct relative to baseline conditions and other stations within the site.

- Chromium to iron ratios (Figure 6-9) at Transects TN-6 and TG-1 were distinct relative to baseline conditions and other stations within the site.

- Copper to iron ratios (Figure 6-10) at Transects TN-8 and TN-2 were distinct relative to baseline conditions and other stations within the site.

- Lead to iron ratios (Figure 6-11) at Stations GBCulvt-1 and NM7 and at Transect TN-6 were distinct relative to baseline conditions and other stations within the site.

- Nickel to iron ratios (Figure 6-12) at Transects TN-6 and TN-5 were distinct relative to baseline conditions and other stations within the site.

- Vanadium to iron ratios (Figure 6-13) were slightly greater at Station NM9 and Transects TN-1 and TN-5 relative to baseline conditions and other stations within the site.

- Zinc to iron ratios (Figure 6-14) were slightly greater in upper Geddes Brook (Station GB3) relative to downstream stations.

6.4.2.3 Summary of Analysis of Inorganics Other than Mercury

A summary of the fate and transport analyses conducted for inorganics other than mercury is as follows:

- The surface water sampling results indicate that changes in surface water concentrations for inorganics associated with particles (other than mercury) are small. The analysis suggests that the primary source of aluminum to the Geddes Brook/Ninemile Creek site is in upper Ninemile Creek and the primary source of barium and manganese is in lower Ninemile Creek. The primary sources of inorganic constituents associated with TDS (calcium, sodium, chloride, and magnesium) are Wastebeds 9 to 15.

- Cobalt exhibits significantly higher concentrations in upper Ninemile Creek surface sediments, while beryllium concentrations are significantly higher in lower Ninemile Creek. With the exception of these constituents, there are no statistically significant differences in concentrations of inorganics other than mercury in the surface sediments in upper and lower Ninemile Creek. In Geddes Brook, arsenic, barium, beryllium, and manganese have significantly higher concentrations in lower Geddes Brook relative to upper Geddes Brook.

- In general, inorganics are found at higher concentrations in the floodplain, which suggests preferential settling of fined-grained material in the floodplains or dilution in the stream bed with cleaner/coarser sediment. In the latter case, the higher floodplain values may represent higher contamination in the waste materials that comprise the floodplain soil.

- The inorganic to iron ratios do not suggest a major shift in the ratios between upper and lower Ninemile Creek or upper and lower Geddes Brook, as is seen for mercury. This suggests that while there appears to be variations in the ratios due to localized contamination or simple variations in the material, there are no major sources of these inorganics to the Geddes Brook/Ninemile Creek site on the scale that is seen for mercury.

- The ultimate fate of soluble CPOIs and any CPOIs associated with sediments would be eventual transport to Onondaga Lake, similar to the fate of mercury.

6.5 Transport and Fate of Organic Contaminants

The transport and fate of organic contaminants is governed in large part by their physiochemical properties. Table 6-5 presents these properties for several organic contaminants, including most of those identified as CPOIs in the BERA and HHRA. Measured half-lives for the degradation of these contaminants are presented in Table 6-6. Degradation rates are influenced by a compound's chemical structure and ambient environmental conditions that may include oxygen activity and the availability of light. Table 6-7 summarizes the criteria that were applied for determining the environmental fate and mobility of organic contaminants. Compounds with a high aqueous solubility are generally dispersed rapidly in an aquatic environment and will be distributed homogeneously. Non-aqueous-phase liquids (NAPLs) will either migrate to the water surface or sink to the bottom of the water column depending on whether their specific gravity is less than or greater than one.

The partitioning behavior of organic compounds between water and natural solids (e.g., sediments and suspended particles) or organisms is frequently quantified using the octanol-water partition coefficient (K_{ow}). Chemicals with a high K_{ow} are more likely to sorb to solids and to bioaccumulate. Finally, the air-water distribution ratio is referred to as the Henry's Law constant (K_H), which quantifies the fugacity of a compound. When formulated using units of atm-m^3/mole, larger values of K_H indicate that a chemical will be more likely to volatilize. Based on the criteria established in Table 6-7, the tendency of each contaminant to migrate into aqueous, solid, or gaseous phase is listed in Table 6-8. Table 6-8 also specifies whether or not each contaminant is expected to degrade readily.

Most of the organic CPOIs are highly persistent and remain associated with sediment. As with mercury and other metals, they can be transported downstream if resuspended. Based on Onondaga Lake sediment data near the mouth of Ninemile Creek presented in the Onondaga Lake RI report (TAMS, 2002c), the Geddes Brook/Ninemile Creek site is a possible source of some organic contaminants to Onondaga Lake. These organic contaminants include hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs. Furthermore, the Onondaga Lake RI concluded that transport of CPOIs did not isolate those CPOIs from the environment.

6.6 Transport and Fate of Ionic Waste Constituents

Calcite ($CaCO_3$), as well as sodium chloride (NaCl) and calcium chloride (CaCl), were significant fractions of the Solvay waste that was discharged into Geddes Brook and Ninemile Creek. These historical discharges resulted in the accumulation of Solvay waste material in obvious formations in the stream beds and floodplains (Figure 6-15). Calcite or its components (Ca^{2+} and CO_3^{2-}) may be transported downstream in either a particulate or dissolved form, respectively, depending on whether the water is saturated with respect to calcite. Calcite deposited to the sediments of Geddes Brook and Ninemile Creek may be resuspended, and its components may be dissolved.

The transport and fate of ionic waste constituents (calcium, sodium, chloride, carbonates, etc.) within the Geddes Brook/Ninemile Creek site is important because of the water quality and habitat implications of these constituents, both in dissolved and solid form. Not only do these constituents increase the ionic content of the water column, the depositional areas of Solvay waste and associated calcite along the stream bottom limit habitat available to the benthic invertebrate community. The concentrations of ionic waste constituents and loadings of TDS, under base-flow conditions, were used to understand the loadings of mercury within the Geddes Brook/Ninemile Creek site (Section 6.2). Under base-flow conditions in 1998, TDS loadings increased by a factor of four from Stations NM2 to NM4, highlighting the groundwater inputs from Wastebeds 9 to 15 (see Figure 6-3b). The results from sampling performed during base-flow conditions in 1990 showed a similar pattern (see Figure 6-3a).

The concentrations of the ionic waste constituents (chloride, calcium, and sodium; Figures 5-41 to 5-43) in upper Ninemile Creek under base-flow conditions showed significant inputs between Stations NM2 and NM4. Under base-flow conditions in 1998, these elements were found almost exclusively in the dissolved phase. These facts indicate that, at base flow, little if any of the ionic waste constituents are being eroded away and transported as particles; rather, they are entering the streams as dissolved solids in the groundwater from Wastebeds 9 to 15.

To help identify the chemical species which are being transported in Ninemile Creek, an assessment of the ionic (charge) balances of the increased loads of the major ionic waste constituents is presented below:

- Chloride concentrations increased from 52.5 mg/L (1.5 milliequivalents per liter [meq/L]) to 778 mg/L (22 meq/L) from Stations NM2 to NM4, a net increase of 20.5 meq/L.

- Calcium concentrations increased from 170 mg/L (8.5 meq/L) to 398 mg/L (19.9 meq/L) from Stations NM2 to NM4, a net increase of 11.4 meq/L.

- Sodium concentrations increased from 26.6 mg/L (1.2 meq/L) to 207 mg/L (9 meq/L) from Stations NM2 to NM4, a net increase of 7.8 meq/L.

The combined concentration increases of the cations (calcium and sodium) between Stations NM2 and NM4 of 19.2 meq/L is close to balancing with the anion (chloride) concentration increase of 20.5 meq/L. That the chloride concentrations more than balance the two major cations indicates that little of the anion contribution is from carbonate or other anions (i.e., sulfate or nitrate). This balance suggests that from a charge balance perspective, the ionic waste constituents that enter the lower reaches of the Geddes Brook/Ninemile Creek site are predominately dissolved calcium chloride and sodium chloride, and not dissolved calcite.

Using the results of sampling performed under high-flow conditions in 1995 and under the assumption that the composition of the suspended solids gained in lower Ninemile Creek is about 50 percent calcite, the transport of particulate calcite through the site was estimated using TSS concentrations and flows. Figure 6-16 compares the TSS loads from upper Ninemile Creek, lower Ninemile Creek, and Geddes Brook, and indicates that the inputs from upper Ninemile Creek and Geddes Brook account for only about 25 percent of the TSS total load in lower Ninemile Creek. This suggests that lower Ninemile Creek supplies most of the eroded TSS load during high-flow events, and is consistent with the field observations (BBL, 2001) that Reach CD is the only erosional section of Ninemile Creek for roughly the last 3 mi (5 km) of the stream. This is also consistent with the model that Reach CD, which has the largest remaining deposits of Solvay waste materials, is attempting to return to an equilibrium after the cessation of Honeywell discharges by eroding away the calcite deposits.

This TSS load gain of 103,200 kg/day from lower Ninemile Creek translates to 51,600 kg/day of particulate calcite. The total load of particulate calcite delivered to Onondaga Lake during the high-flow event in 1995 is on the order of 67,200 kg/day.

In summary, large deposits of ionic waste constituents are found in the Solvay Wastebeds and in the lower reaches of the Geddes Brook/Ninemile Creek site. These deposits alter the substrate of the streams substantially. At base flow, ionic waste constituents are transported in the dissolved phase, and the primary sources of those constituents are groundwater discharges from Wastebeds 9 to 15. The primary forms of these ionic waste constituents are likely calcium chloride and sodium chloride. At high flow, large amounts of sediments are eroded from lower Ninemile Creek, which is the dominant source of these TSS loads to the water column. Assuming that these sediments are about 50 percent calcite, about 67,000 kg/day of calcite are eroded away during high-flow events.

6.7 Summary of Transport and Fate

An analysis of the transport and fate of CPOIs (primarily mercury) within the Geddes Brook/Ninemile Creek site was conducted. The distribution of CPOIs in sediments and floodplain soils, and concentrations and loads of mercury and TDS in surface water were used in this assessment. The major conclusions of this analysis include the following:

- From 1944 (possibly as early as 1926) to 1980, wastes from the Honeywell Syracuse Works were discharged into Geddes Brook and Ninemile Creek via the West Flume and overflow from the Solvay Wastebeds. These wastes contained primarily Solvay waste, but included other waste streams as well, and settled into depositional areas downstream of these discharges.

- Mercury and other CPOIs (e.g., hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs) appear to be primarily associated with depositional zones containing Solvay waste materials downstream of the Honeywell LCP Bridge Street site and the West Flume.

- Some of the historical CPOI-contaminated materials in Ninemile Creek were removed during various non-remedial construction operations.

- The changes in the hydraulic regime of Geddes Brook and Ninemile Creek, caused by the cessation of Honeywell discharges in 1980, have resulted in some of these historically depositional areas becoming more erosional.

- Reach CD sediments and floodplain soils contain the highest concentrations of CPOIs in Ninemile Creek, and the reach as a whole is the most erosional in lower Ninemile Creek. The right-hand channel of Reach CD (facing downstream) is depositional at base flow and erosional at high flow.

- Normalization of surface sediment mercury concentrations to iron indicates that there are localized sources of mercury within lower Ninemile Creek.

- Based on load analysis, the sediments and floodplain soils of lower Geddes Brook and lower Ninemile Creek are important sources of mercury to the water column and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake at base-flow conditions. However, the source of the mercury measured in lower Ninemile Creek at base flow appears to be heavily influenced by releases from the West Flume, which is the largest external source of mercury to the site.

- The transport of mercury in Geddes Brook and Ninemile Creek surface water increases significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loadings from lower Ninemile Creek sediments and floodplain soils increases dramatically. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of mercury being transported to Onondaga Lake, and are a major component of the annual mercury load to the lake.

- An analysis of loads of TDS in surface water confirms that groundwater from Wastebeds 9 to 15 continues to be a source of ionic waste constituents primarily in the form of calcium chloride and sodium chloride to the Geddes Brook/Ninemile Creek site.

- The transport of TSS and ionic waste constituents in Geddes Brook and Ninemile Creek surface water increases significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loadings from lower Ninemile Creek sediments and floodplain soils increases dramatically. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of TSS being transported to Onondaga Lake, and are a major component of the annual loading of TSS and ionic waste constituents to the lake.

- CPOIs other than mercury (i.e., hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs) that are primarily associated with the mercury-contaminated sediments would be expected to have similar transport and fate as mercury. The sediments and soils containing these CPOIs would be expected to be eroded under high-flow conditions and ultimately transported to Onondaga Lake.

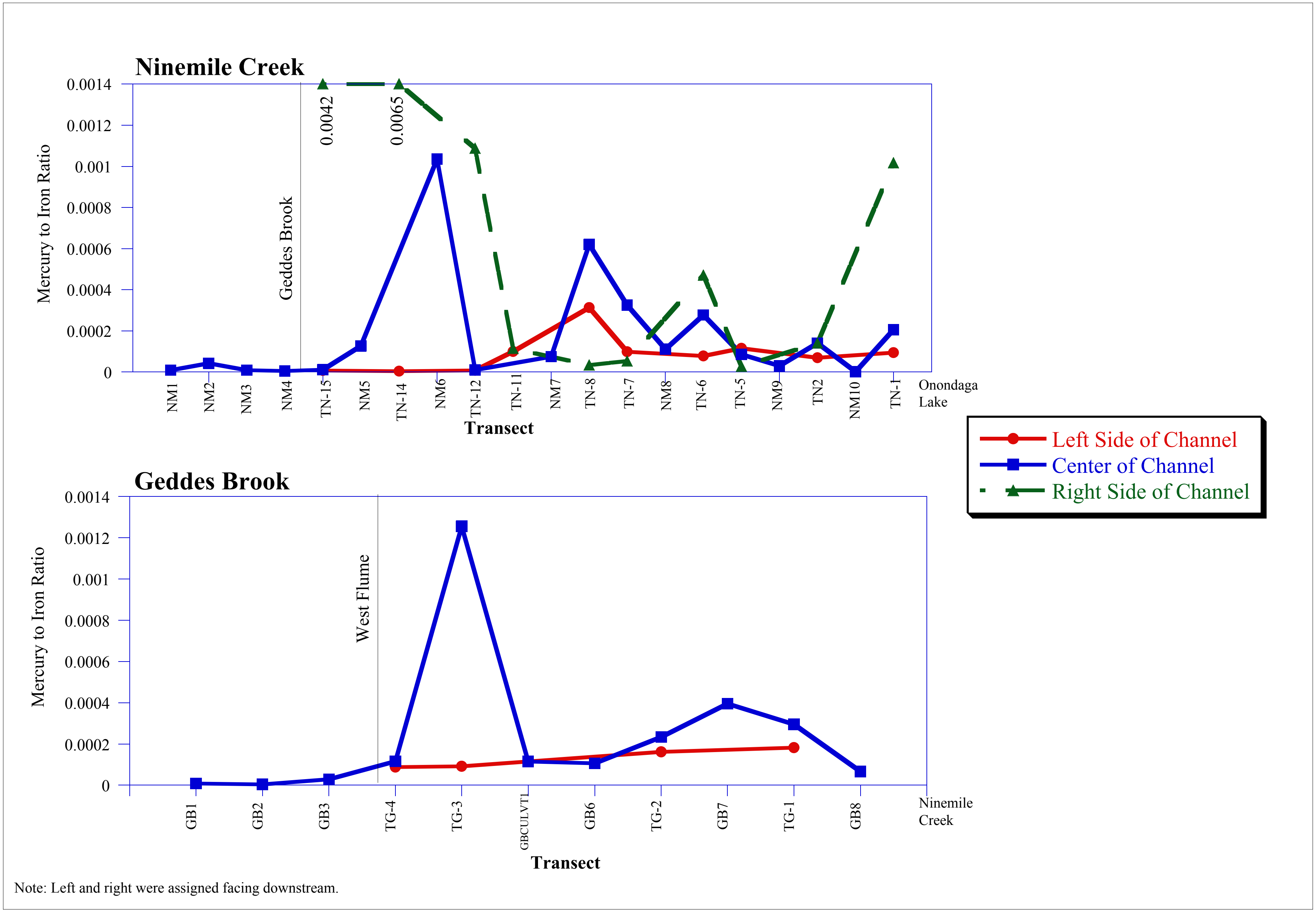
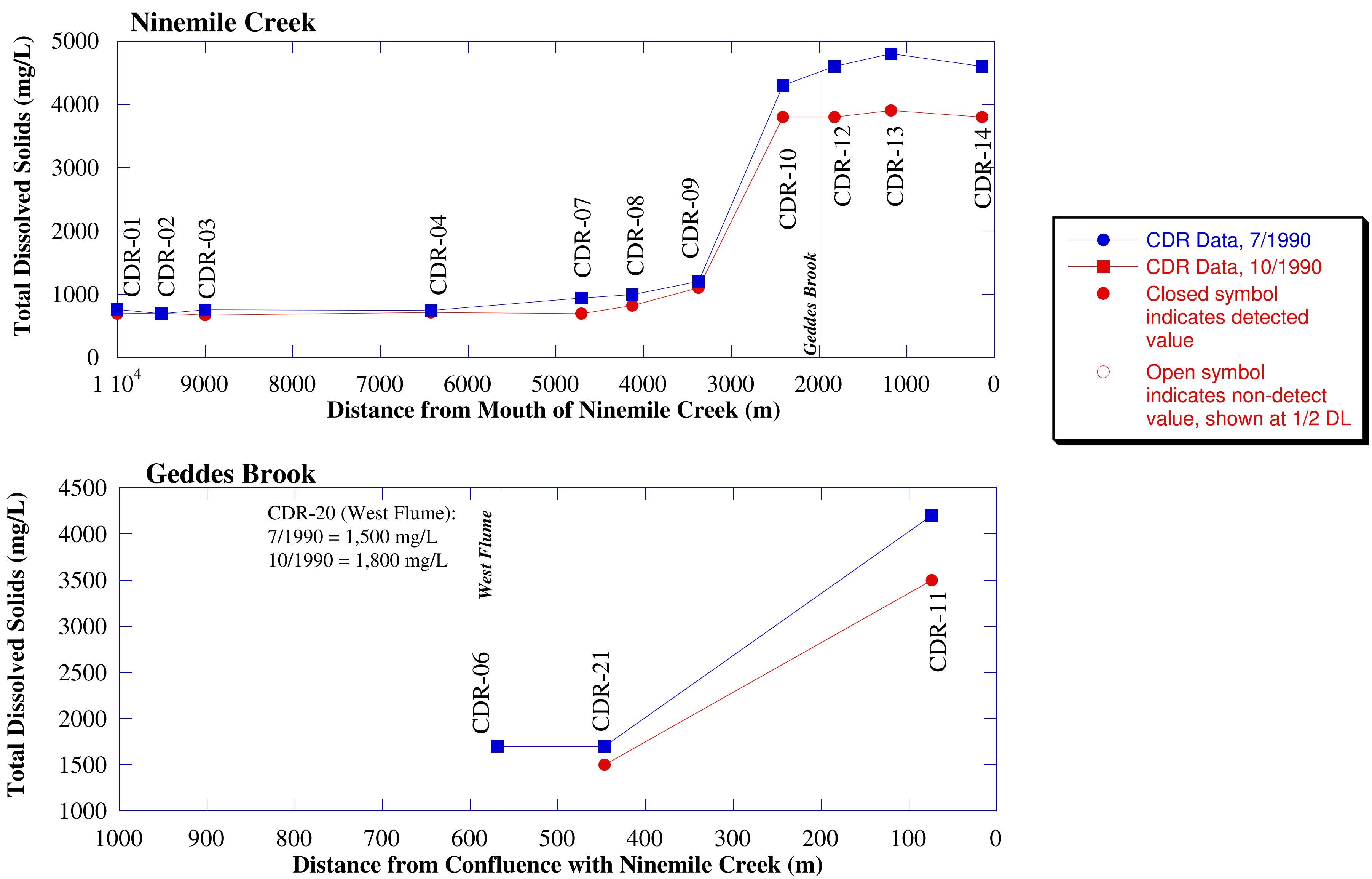


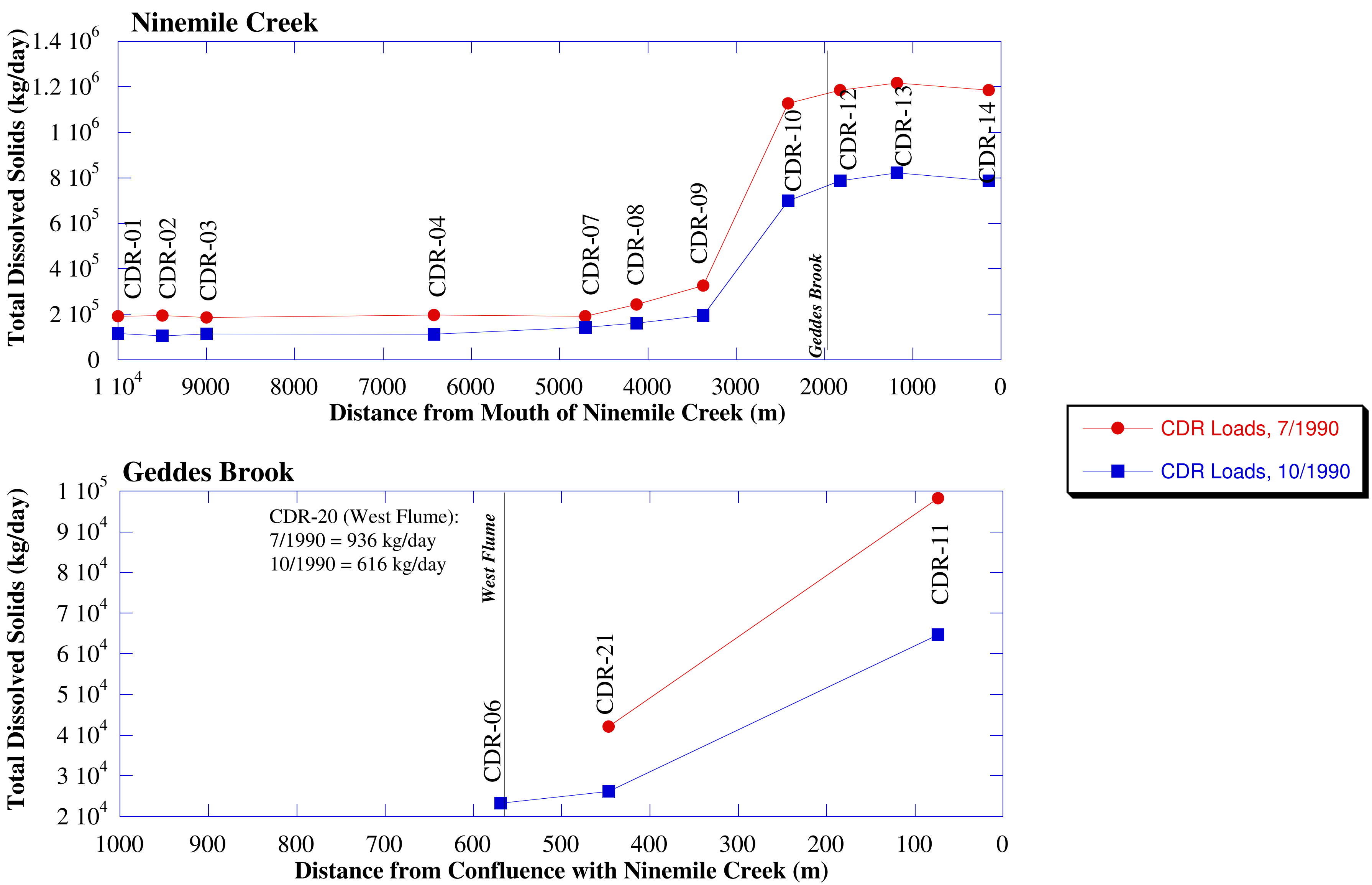
Figure 6-1
Mercury to Iron Ratio in Surface Sediment of
Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS



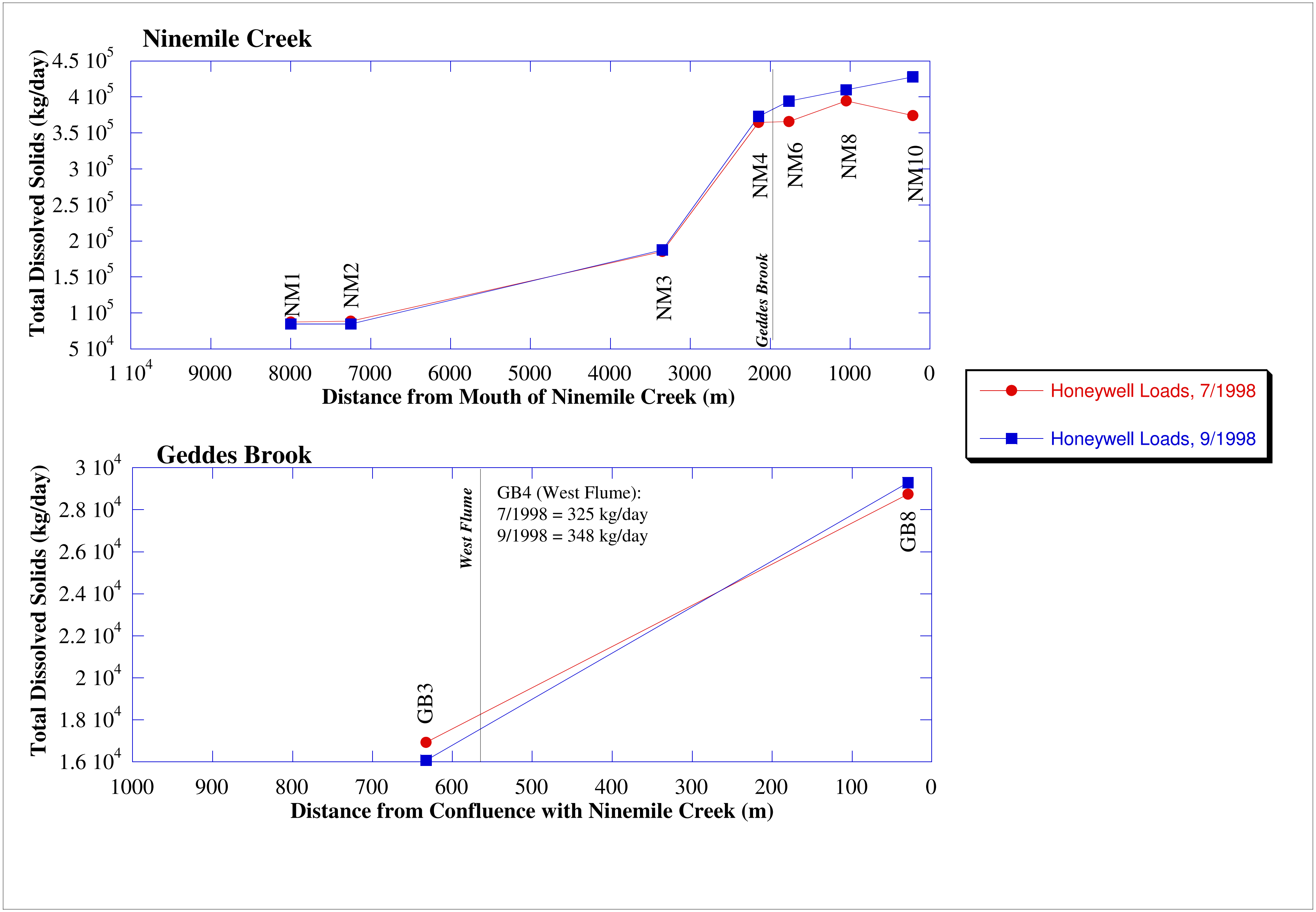
TAMS

Figure 6-2
Total Dissolved Solids Concentrations in Surface Water of Geddes Brook and Ninemile Creek in 1990



TAMS

Figure 6-3a
Total Dissolved Solids Loads in Surface Water of Geddes Brook and Ninemile Creek in 1990



TAMS

Figure 6-3b
Total Dissolved Solids Loads in Surface Water of Geddes Brook and Ninemile Creek in 1998

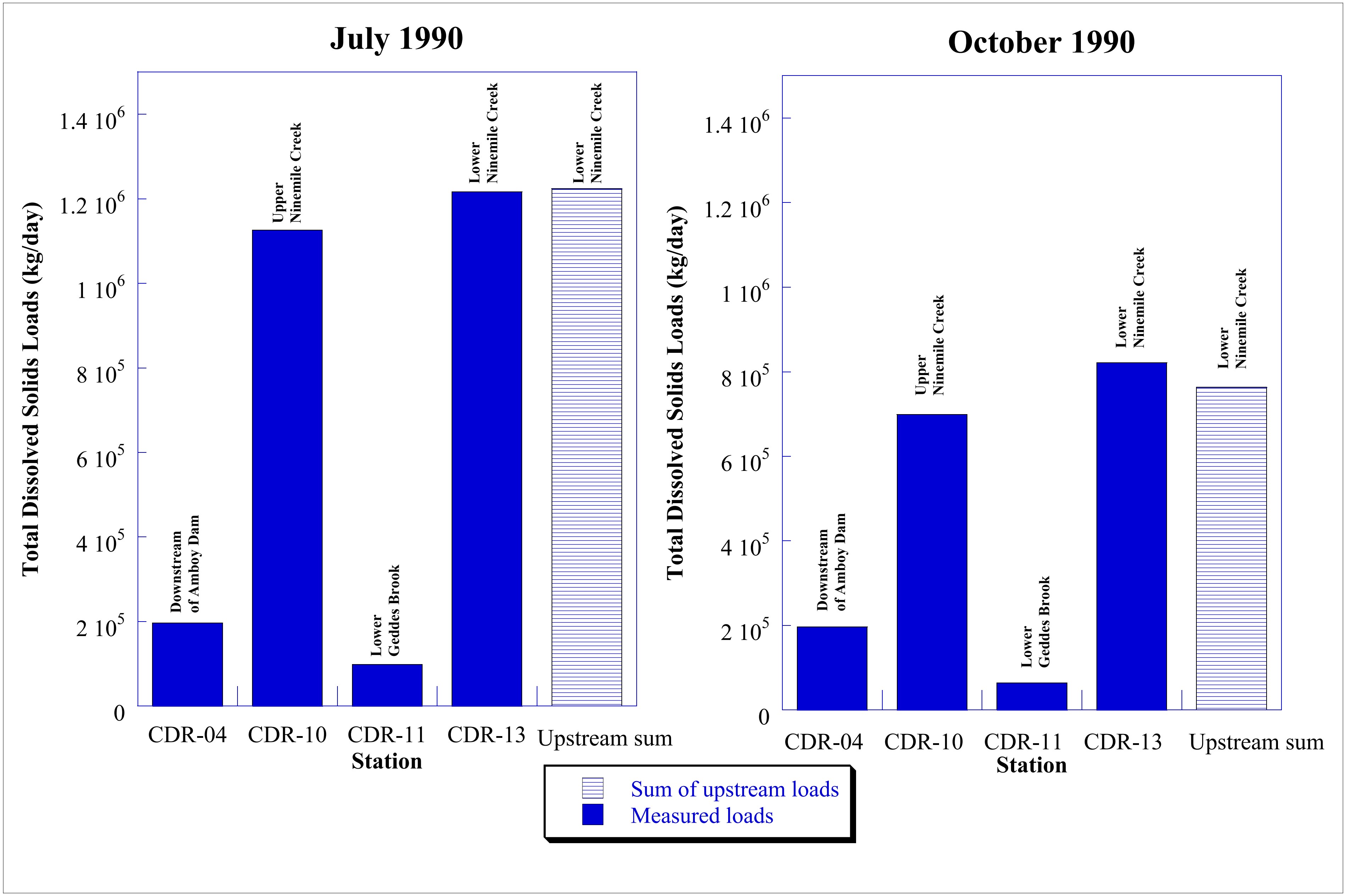
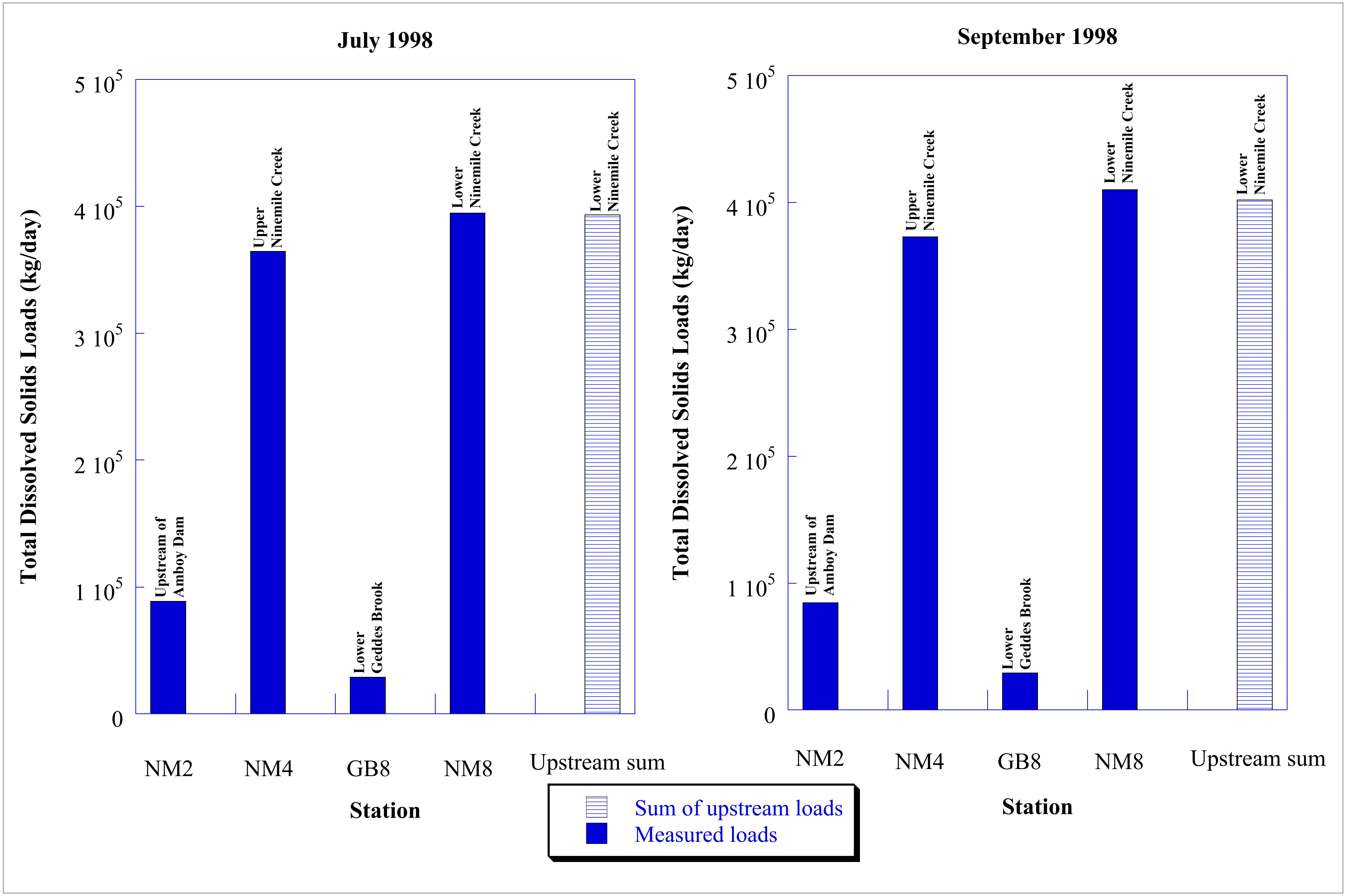


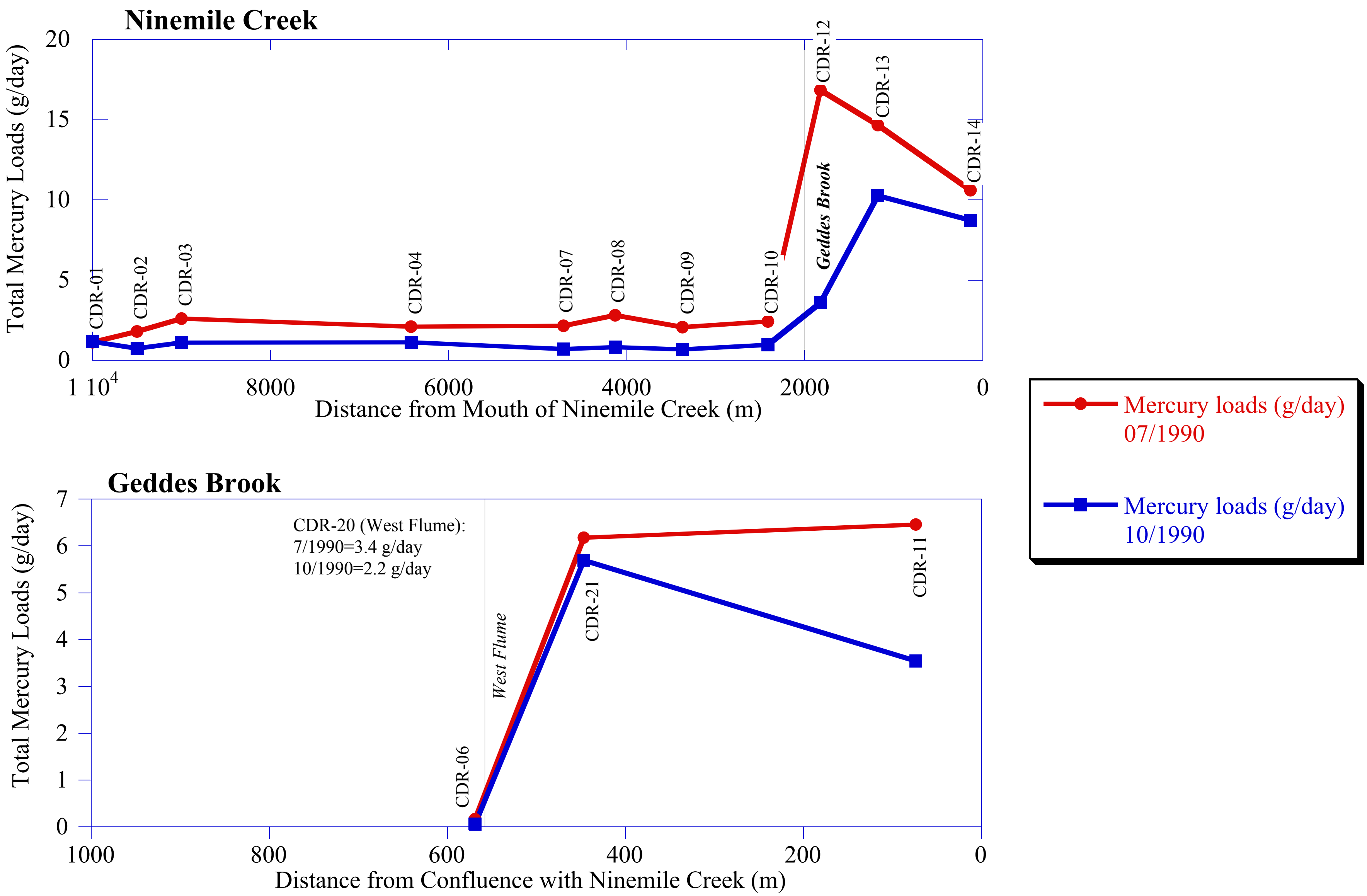
Figure 6-4a
Comparison of Total Dissolved Solids Loads in Surface Water of Geddes Brook and Ninemile Creek in 1990

TAMS



TAMS

Figure 6-4b
Comparison of Total Dissolved Solids Loads in Surface Water of Geddes Brook and Ninemile Creek in 1998



TAMS

Figure 6-5a
Total Mercury Loads in Surface Water of Geddes Brook and Ninemile Creek in 1990

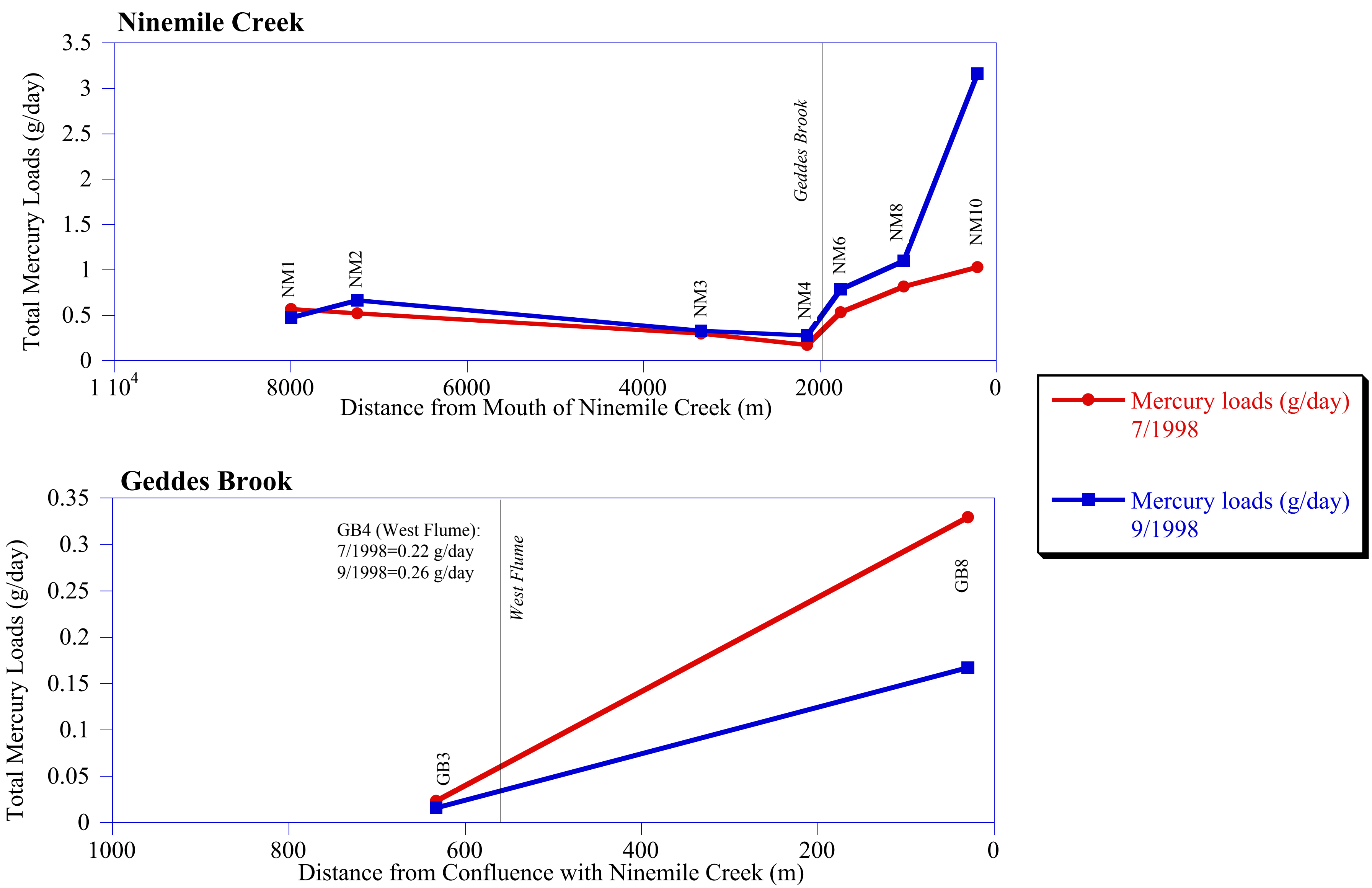


Figure 6-5b

Total Mercury Loads in Surface Water of Geddes Brook and Ninemile Creek in 1998

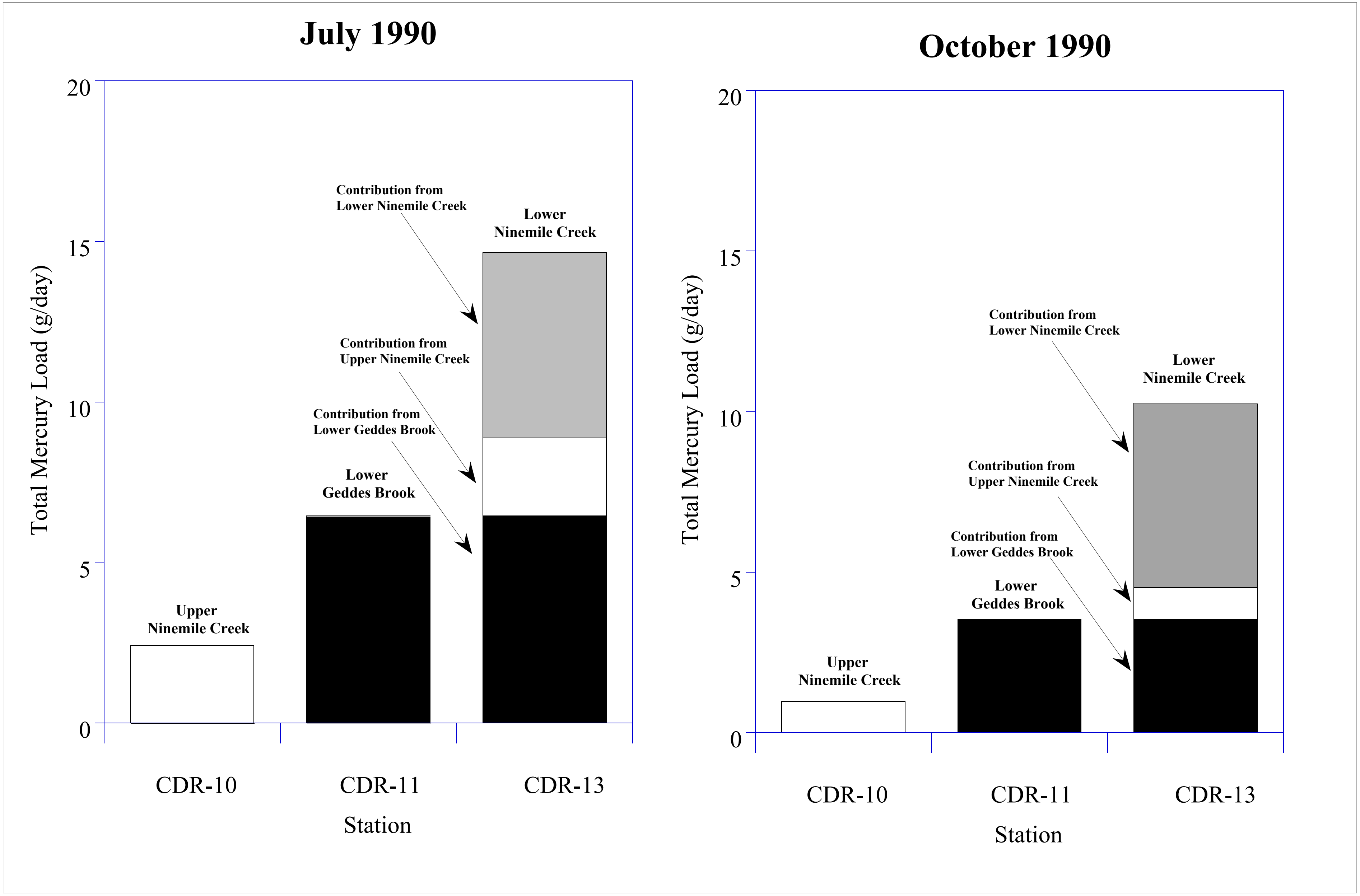


Figure 6-6a
Comparison of Total Mercury Loads in Surface Water of Geddes Brook and Ninemile Creek in 1990

TAMS

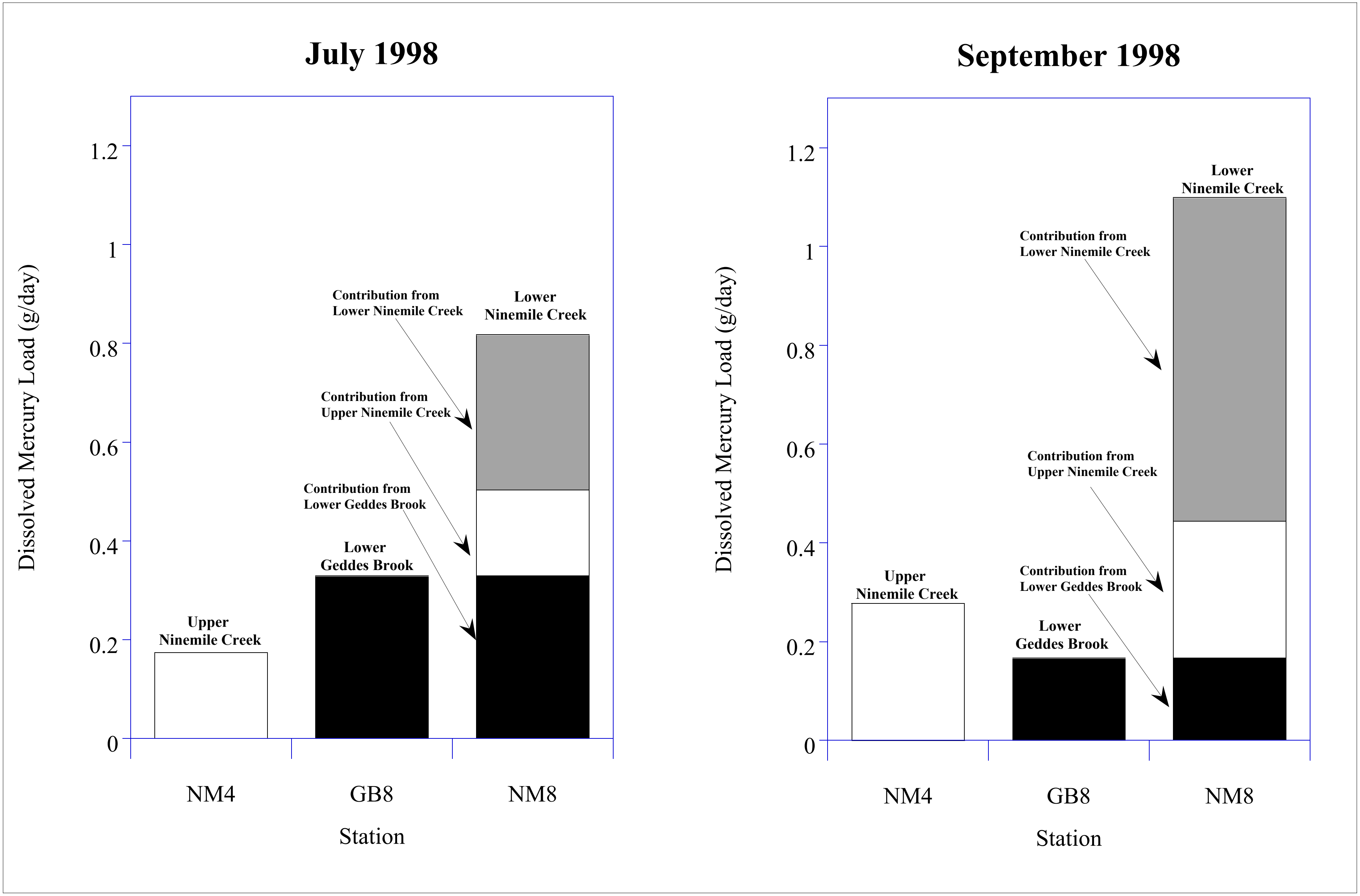
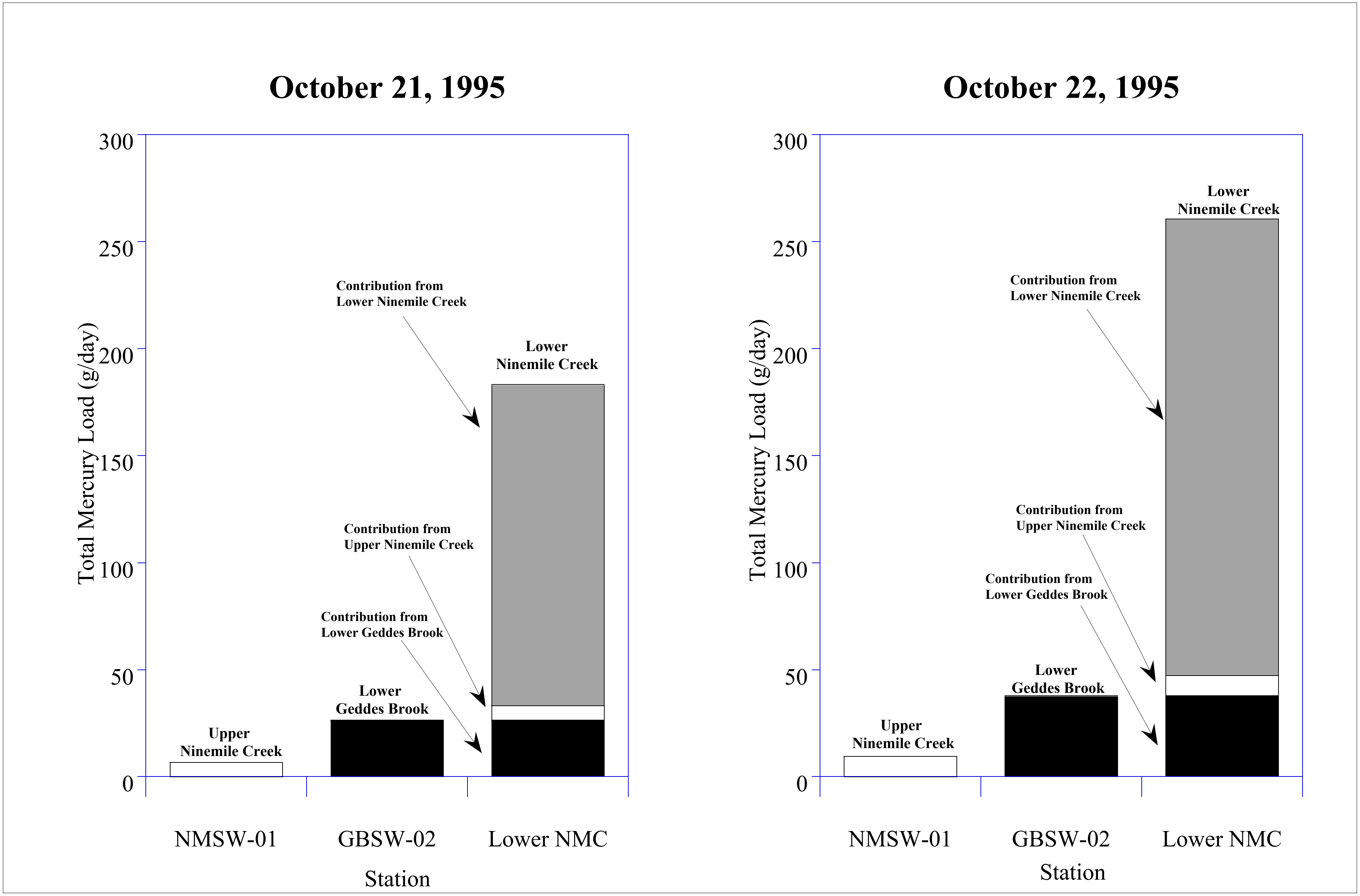


Figure 6-6b
Comparison of Dissolved Mercury Loads in Surface Water of Geddes Brook and Ninemile Creek in 1998

TAMS



TAMS

Figure 6-7
Comparison of Total Mercury Loads in Surface Water of
Geddes Brook and Ninemile Creek During the October 21 and October 22 High Flow Event in 1995

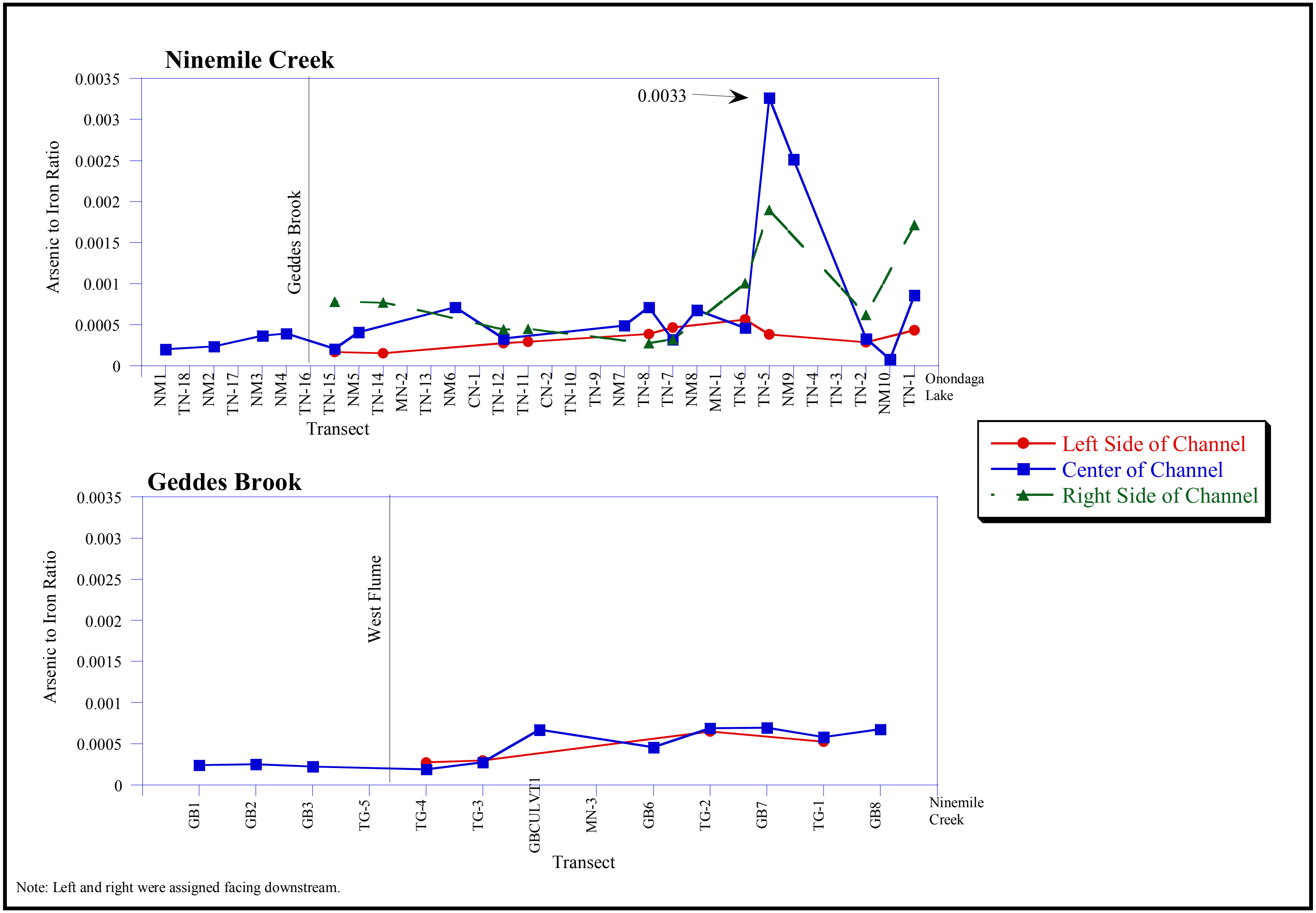


Figure 6-8
Arsenic to Iron Ratio in Surface Sediment of
Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS

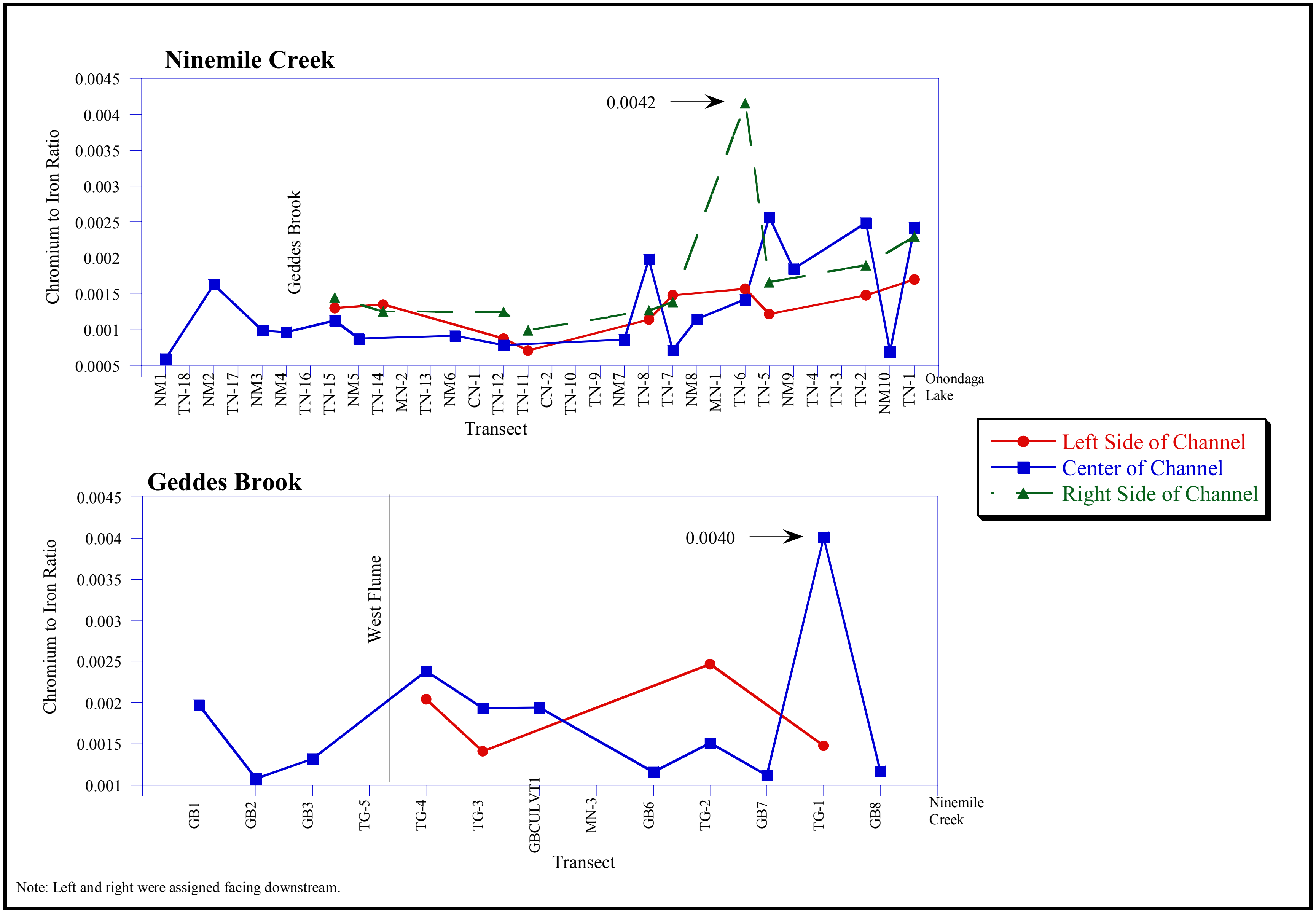


Figure 6-9
Chromium to Iron Ratio in Surface Sediment of Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS

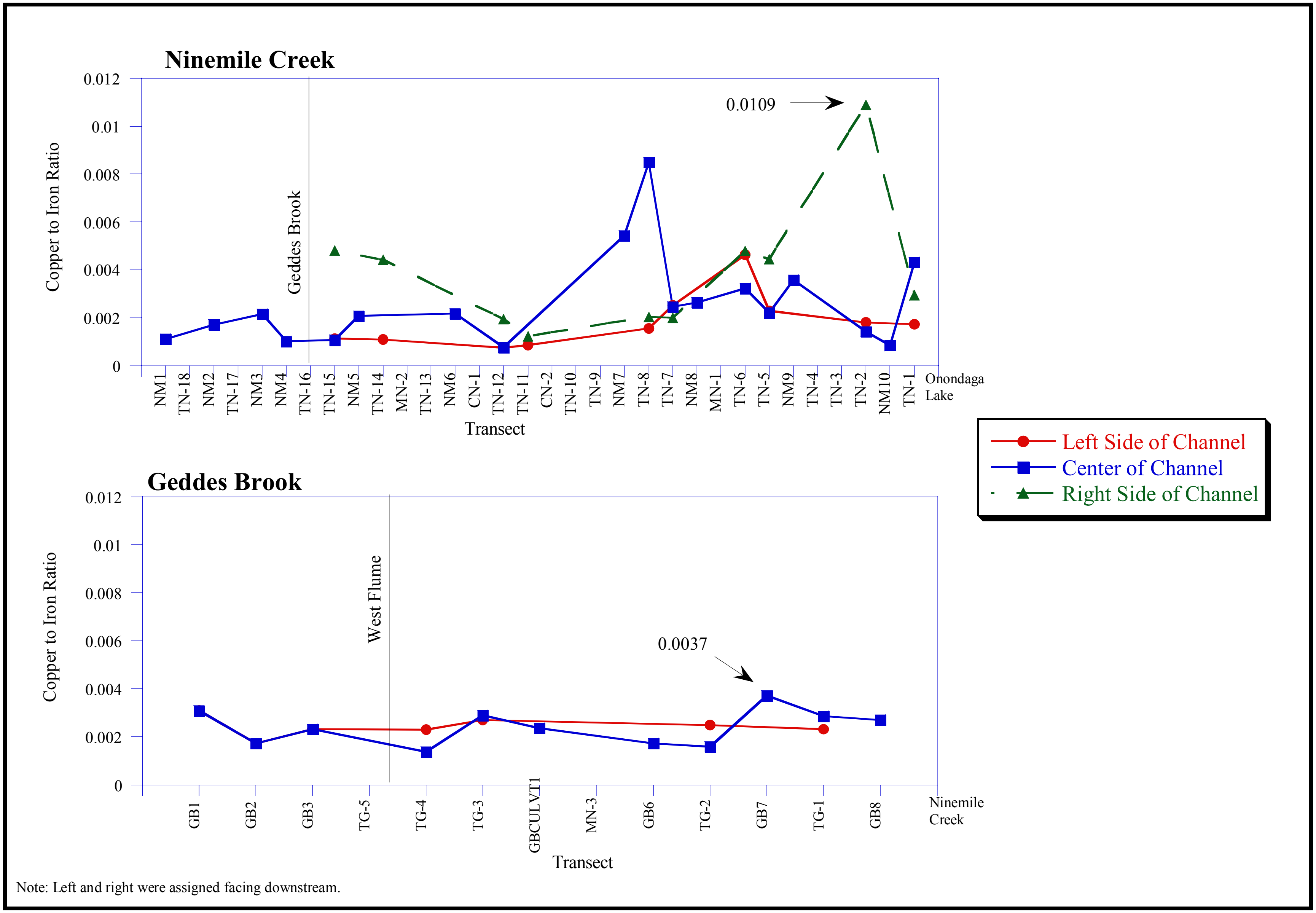


Figure 6-10
Copper to Iron Ratio in Surface Sediment of Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS

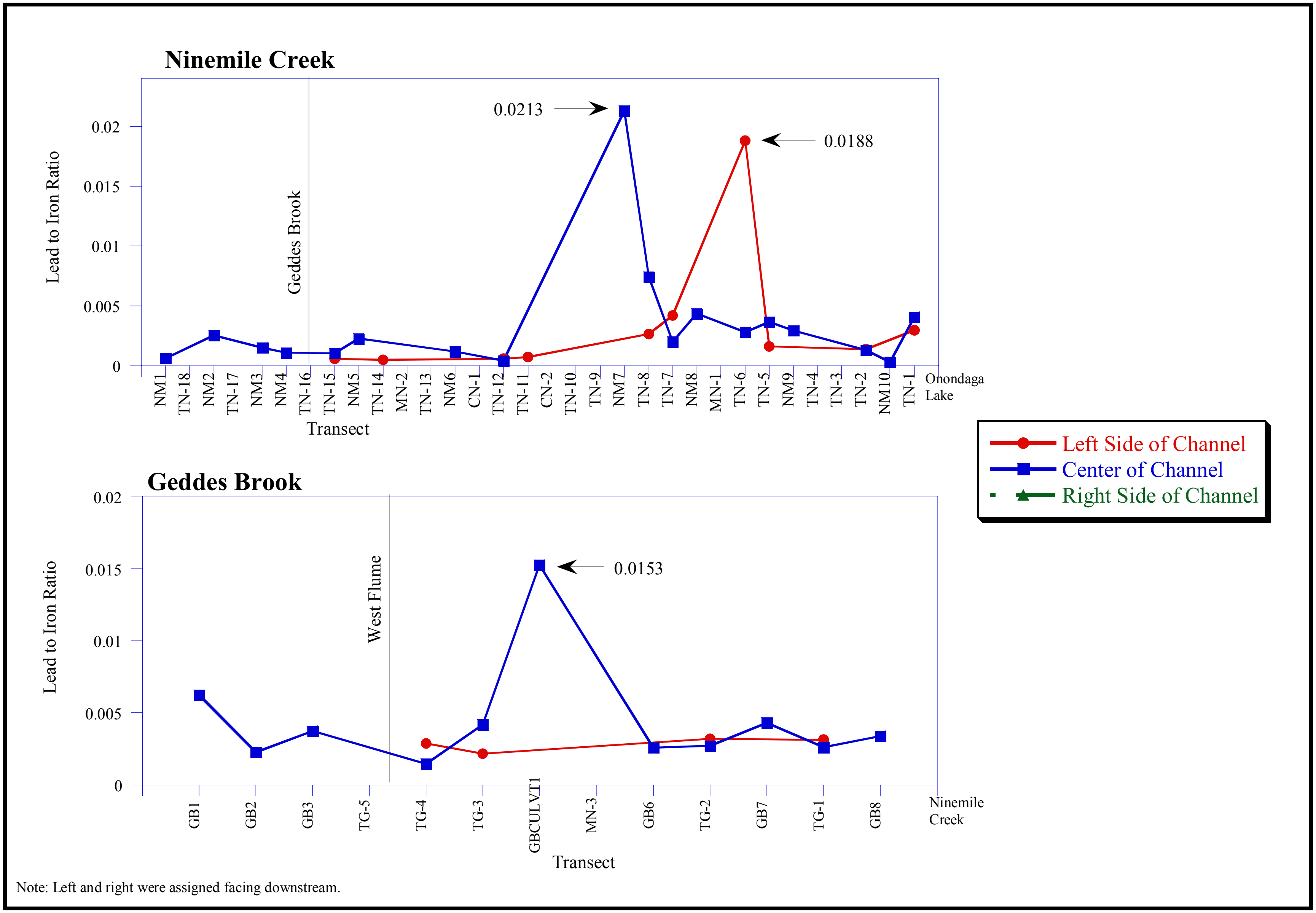
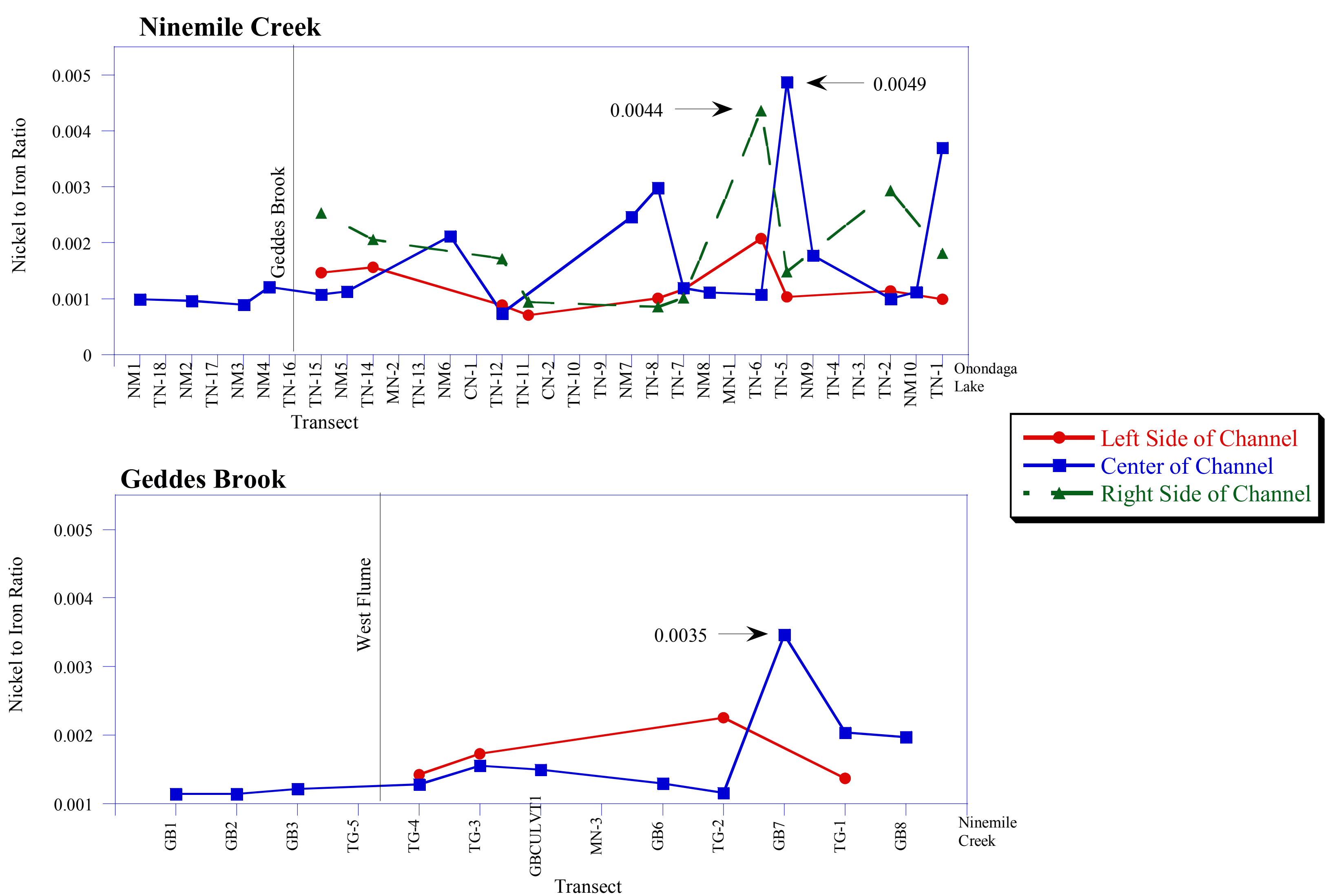


Figure 6-11
Lead to Iron Ratio in Surface Sediment of
Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS



Note: Left and right were assigned facing downstream.

Figure 6-12
Nickel to Iron Ratio in Surface Sediment of
Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS

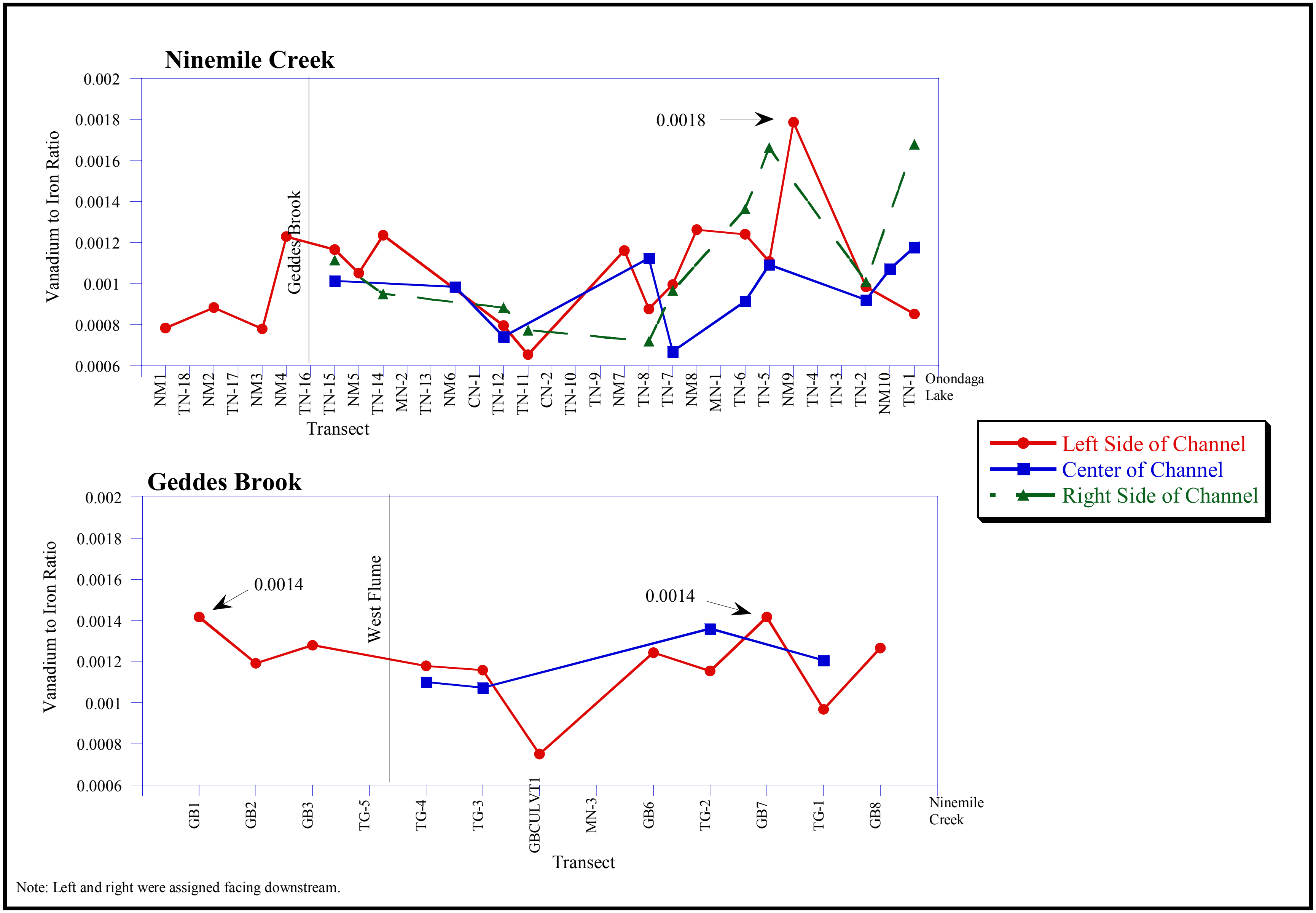


Figure 6-13
Vanadium to Iron Ratio in Surface Sediment of Geddes Brook and Ninemile Creek in 1998 and 2001

TAMS

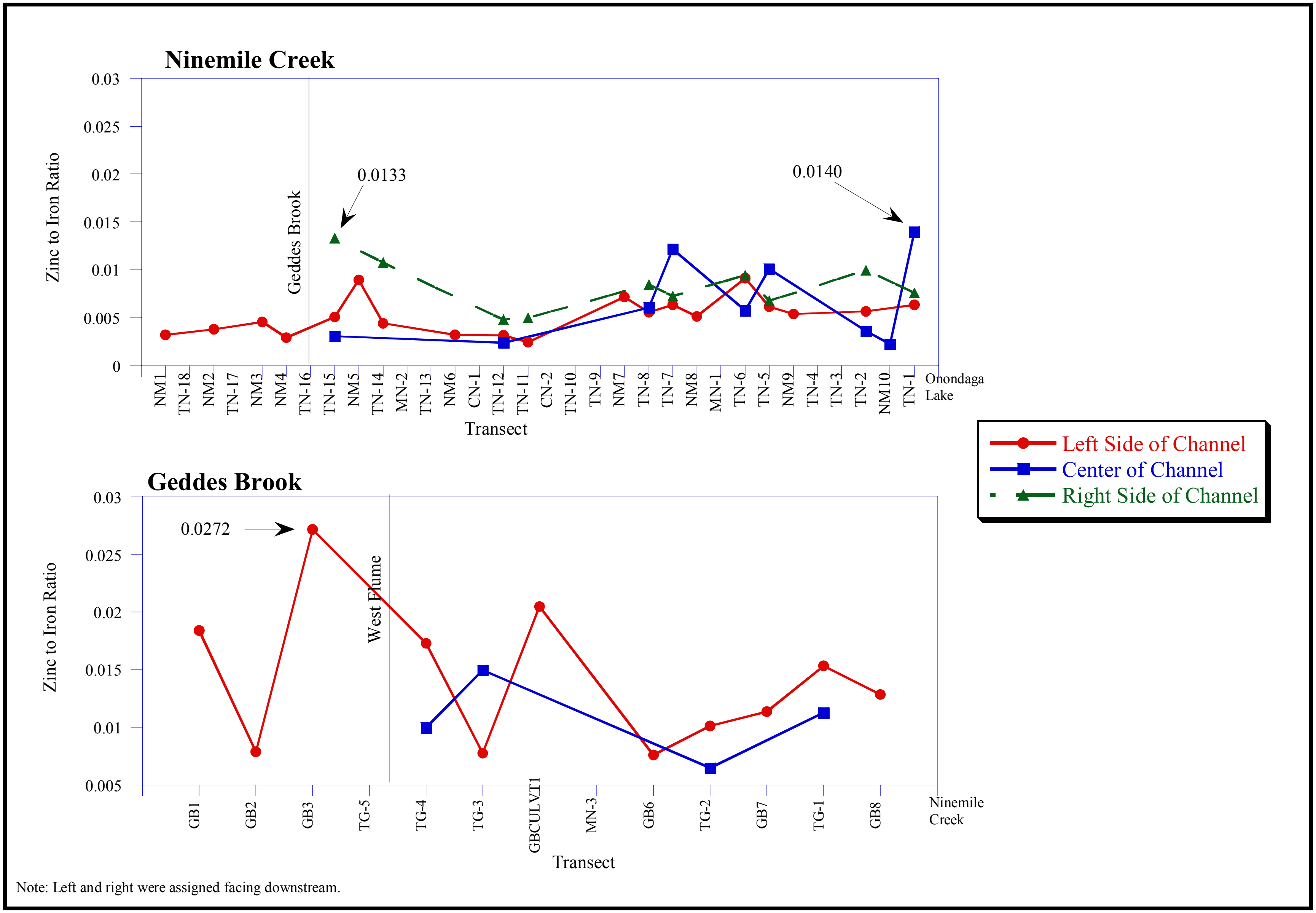
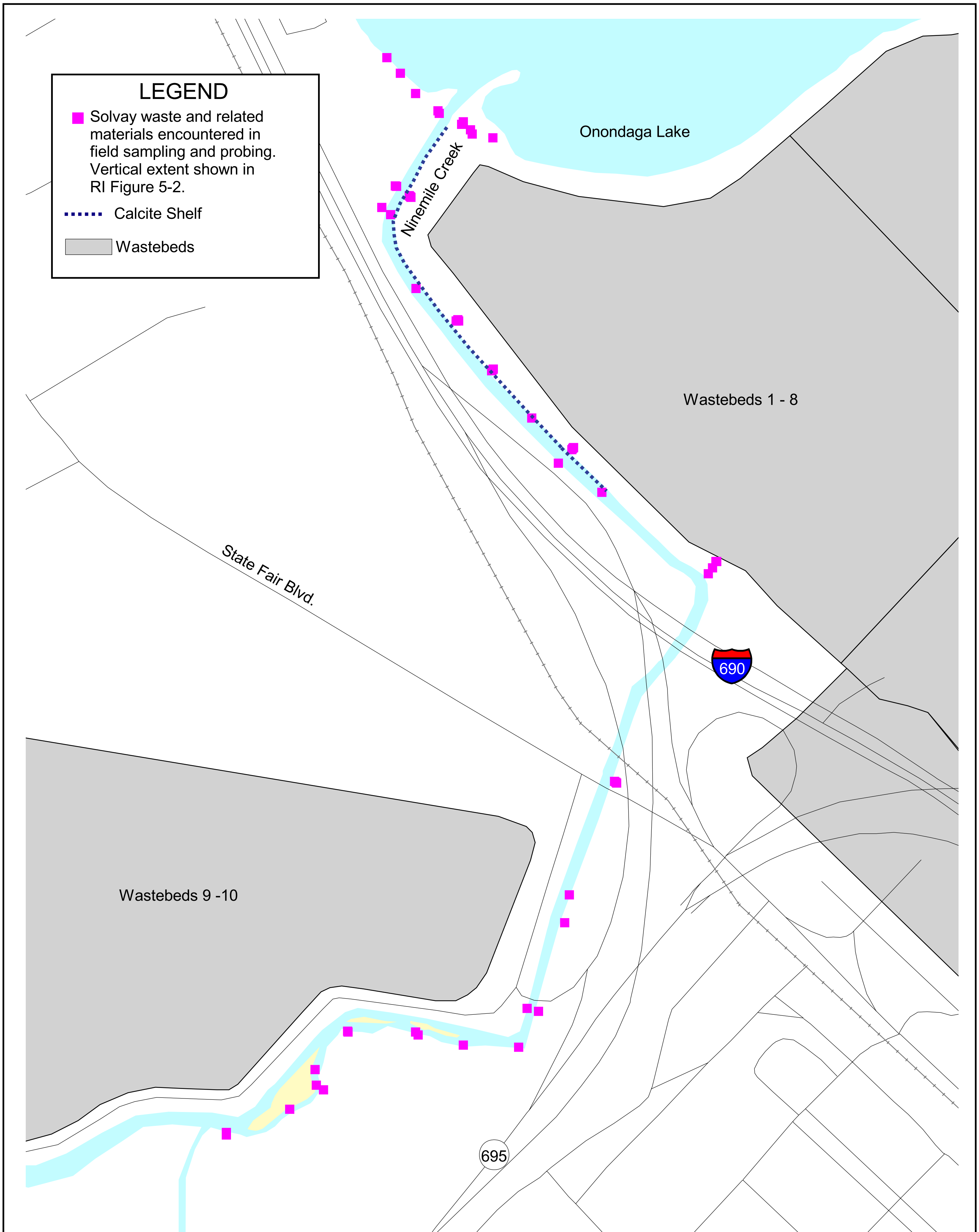


Figure 6-14

Zinc to Iron Ratio in Surface Sediment of
Geddes Brook and Ninemile Creek in 1998 and 2001

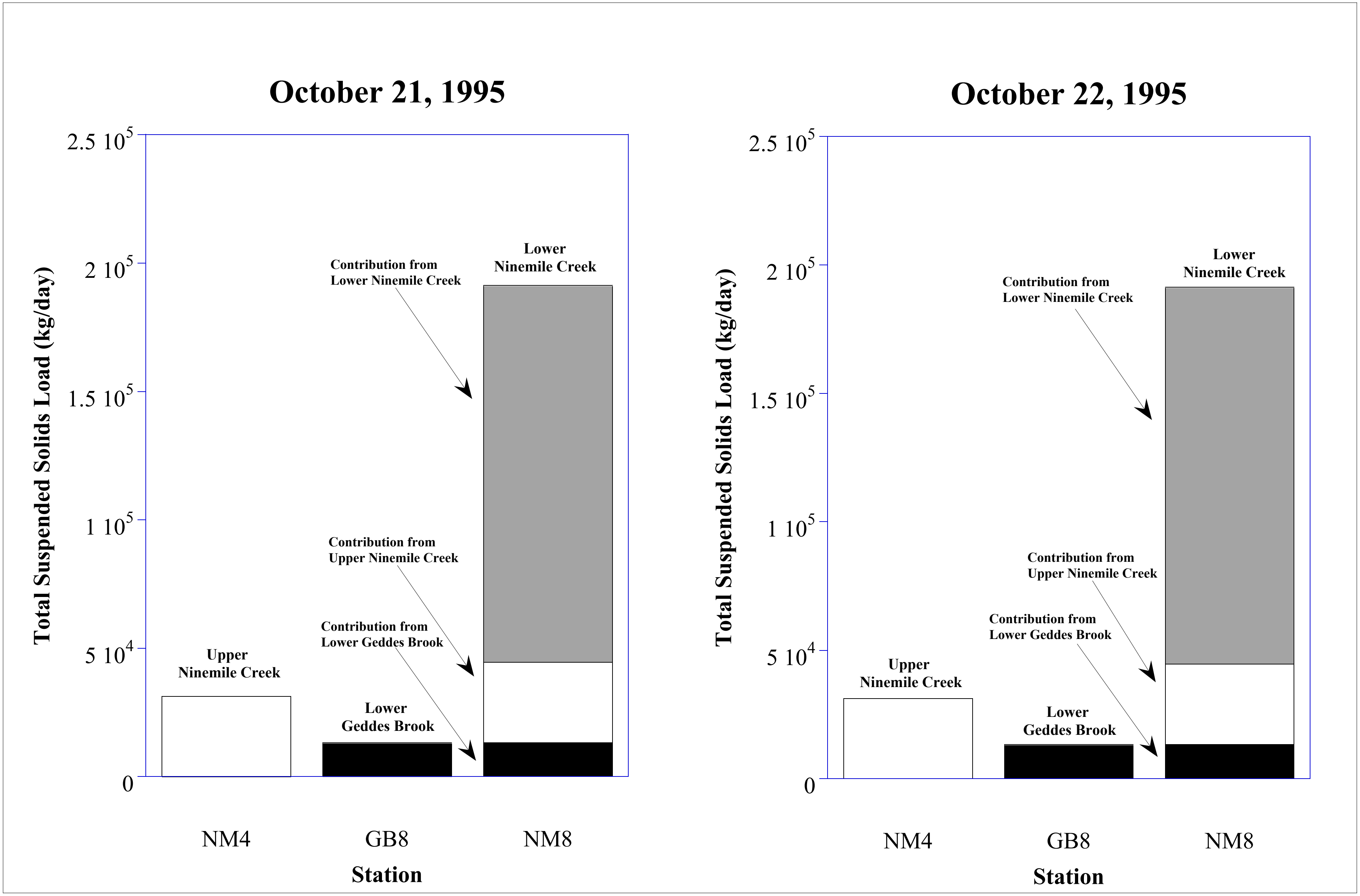
TAMS



Geddes Brook/
Ninemile Creek RI

Figure 6-15
Location of Solvay Waste and
Calcite Formations in Ninemile Creek

TAMS



TAMS

Figure 6-16
Comparison of Total Suspended Solids Loads in Surface Water of Geddes Brook and Ninemile Creek During the October 21 and October 22 High Flow Event in 1995

Table 6-1. Comparison of Flow for Geddes Brook and Ninemile Creek Stations to Flow at USGS Station

Station Description	Station	Flow %USGS
Ninemile Creek		
Camillus	CDR1	0.89
Erie Canal - upstream	CDR2	0.89
Erie Canal - downstream	CDR3	0.89
Downstream of Amboy Bridge	CDR4	0.89
Upstream of Allied Bridge - Wastebed 13	CDR7	0.89
Downstream of Conrail - Wastebed 13	CDR8	0.95
Culverts - Wastebeds 11 and 13	CDR9	0.95
Pipeline/old bridge - Wastebeds 10-12	CDR10	0.95
Below large island (Reach CD)	CDR12	1
USGS gauging station (Reach BC)	CDR13	1
Mouth (Reach AB)	CDR14	1
Beaver Meadow Brook	CDR5	0.06
Geddes Brook		
Upper Geddes Brook	CDR6	0.08
Lower Geddes Brook	CDR21	0.09
Lower Geddes Brook - mouth	CDR11	0.09
West Flume	CDR20	0.002
Unnamed Tributary	CDR22	0.006

Table 6-2. Total Mercury Loading Calculations for Geddes Brook and Ninemile Creek (1992)

Station	Date	Flow (cfs)	Total Mercury (ng/L)	Total Mercury Load (g/d)
Upper Ninemile Creek (W14)[a]				
	04/23/92	171.8	2.3	0.97
	05/26/92	71.8	5.9	1.04
	06/16/92	54	2.4	0.32
	07/27/92	215.6	6.3	3.32
	08/16/92	164.6	7.8	3.14
	09/16/92	51.8	3.2	0.41
	09/26/92	185.6	6.7	3.04
	10/06/92	130.1	7.5	2.39
	10/17/92	154.6	17.1	6.47
	11/10/92	130	1.8	0.57
	11/22/92	131.2	16	5.14
	12/08/92	110.5	1.5	0.41
	12/16/92	121.9	4.3	1.28
Geddes Brook (W13)[b]				
	04/23/92	23.6	46.4	2.68
	05/26/92	11.6	71.4	2.03
	06/17/92	10.3	31.3	0.79
	07/27/92	26.8	17.8	1.17
	08/16/92	21.4	211	11.05
	08/28/92	24.3	85.6	5.09
	09/16/92	13.3	133	4.33
	09/26/92	24.2	183	10.83
	10/06/92	17.8	71.8	3.13
	10/17/92	19.8	84.6	4.10
	11/10/92	19.9	130	6.33
	12/08/92	18.1	41	1.82
	12/16/92	20.1	100	4.92
Lower Ninemile Creek (W10)[c]				
	04/24/92	230	13.3	7.48
	05/26/92	100	8.6	2.10
	06/17/92	80	8.7	1.70
	07/27/92	290	67.4	47.82
	08/15/92	190	18.4	8.55
	08/28/92	230	33.8	19.02
	09/16/92	105	20.8	5.34
	09/26/92	240	73.4	43.10
	10/06/92	165	88.1	35.56
	10/24/92	190	70.8	32.91
	11/10/92	135	8.3	2.74
	12/08/92	130	8.9	2.83
	12/16/92	125	17.6	5.38

Notes: Based on data from PTI (1993).

[a] Located upstream of Amboy Dam.

[b] Located at the mouth of Geddes Brook.

[c] Located at the mouth of Ninemile Creek.

Source: Table 5-1 from Exponent, 2001c.

Table 6-3. Comparison of Non-Mercury Inorganic Concentrations in Surface Sediment Based on 1998 and 2001 Data

Analyte	Units	Average Concentration in Upper Geddes Brook	Average Concentration in Lower Geddes Brook	Ratio (lower sed : upper sed)	Average Concentration in Upper Ninemile Creek	Average Concentration in Lower Ninemile Creek	Ratio (lower sed : upper sed)
Aluminum	mg/kg	5,293	4,740	0.90	6,768	4,886	0.72
Antimony	mg/kg	ND	0.50	NA	ND	0.37	NA
Arsenic	mg/kg	2.50	4.44	**1.78**	4.20	6.12	1.46
Barium	mg/kg	47.3	60.4	**1.28**	60.2	67.8	1.13
Beryllium	mg/kg	ND	0.36	**NA**	ND	0.42	**NA**
Cadmium	mg/kg	ND	0.17	NA	ND	0.21	NA
Chromium	mg/kg	14.9	19.1	1.28	16.1	13.8	0.86
Cobalt	mg/kg	6.10	4.70	0.77	6.55	4.13	**0.63**
Copper	mg/kg	24.3	23.7	0.98	22.3	24.6	1.10
Iron	mg/kg	10,443	10,083	0.97	13,953	10,262	0.74
Lead	mg/kg	40.9	36.4	0.89	22.7	39.7	1.75
Manganese	mg/kg	213	425	**2.00**	395	377	0.95
Nickel	mg/kg	12.1	16.9	1.39	14.0	15.1	1.08
Selenium	mg/kg	ND	0.63	NA	ND	0.87	NA
Silver	mg/kg	ND	ND	NA	ND	ND	NA
Thallium	mg/kg	ND	0.76	NA	2.00	1.13	0.56
Vanadium	mg/kg	13.4	11.5	0.86	12.7	10.5	0.82
Zinc	mg/kg	170	123	0.72	52.4	62.1	1.18

Notes:
ND indicates there were no detections.
NA-ratio not reported because all values in upper and/or lower reach were non-detects.
Bold text indicates values are significantly different ($p = 0.05$).

Table 6-4. Comparison of Non-Mercury Inorganic Concentrations of Adjacent Surface Soils and Sediments Based on 1998 and 2001 Data

Analyte	Units	Average Concentration in Upper Geddes Brook Soil	Average Concentration in Upper Geddes Brook Sediment	Ratio (soil:sed)	Average Concentration in Lower Geddes Brook Soil	Average Concentration in Lower Geddes Brook Sediment	Ratio (soil:sed)	Average Concentration in Upper Ninemile Creek Soil	Average Concentration in Upper Ninemile Creek Sediment	Ratio (soil:sed)	Average Concentration in Lower Ninemile Creek Soil	Average Concentration in Lower Ninemile Creek Sediment	Ratio (soil:sed)
Aluminum	mg/kg	7,752	5,293	1.46	7,915	4,740	**1.67**	11,939	6,768	**1.76**	7,627	4,886	**1.56**
Antimony	mg/kg	ND	ND	NA	0.29	0.50	0.58	ND	ND	NA	0.34	0.37	0.93
Arsenic	mg/kg	4.50	2.50	**1.80**	5.90	4.44	**1.33**	6.27	4.20	1.49	5.80	6.12	0.95
Barium	mg/kg	50.5	47.3	1.07	54.4	60.4	0.90	94.7	60.2	1.57	69.9	67.8	1.03
Beryllium	mg/kg	ND	ND	NA	0.48	0.36	1.31	ND	ND	NA	0.50	0.42	**1.18**
Cadmium	mg/kg	1.70	ND	NA	0.35	0.17	2.05	ND	ND	NA	0.24	0.21	1.17
Chromium	mg/kg	18.1	14.9	1.21	18.8	19.1	0.98	30.5	16.1	**1.90**	22.5	13.8	**1.64**
Cobalt	mg/kg	8.63	6.10	1.42	5.94	4.70	**1.26**	11.44	6.55	**1.75**	5.91	4.13	**1.43**
Copper	mg/kg	26.8	24.3	1.10	34.7	23.7	1.46	53.5	22.3	**2.40**	30.0	24.6	**1.22**
Iron	mg/kg	14,417	10,443	1.38	15,043	10,083	**1.49**	22,400	13,953	**1.61**	15,473	10,262	**1.51**
Lead	mg/kg	63.6	40.9	1.55	53.8	36.4	1.48	36.6	22.7	1.61	44.1	39.7	1.11
Manganese	mg/kg	384	213	**1.80**	372	425	**0.88**	439	395	1.11	370	377	0.98
Nickel	mg/kg	17.8	12.1	1.47	20.4	16.9	1.21	24.2	14.0	**1.74**	18.5	15.1	**1.23**
Selenium	mg/kg	ND	ND	NA	0.65	0.63	1.04	ND	ND	NA	1.05	0.87	1.21
Silver	mg/kg	ND	ND	NA	ND	ND	NA	ND	ND	NA	0.18	ND	NA
Thallium	mg/kg	ND	ND	NA	ND	0.76	NA	1.30	2.00	0.65	1.40	1.13	1.24
Vanadium	mg/kg	16.6	13.4	1.24	15.8	11.5	**1.37**	23.0	12.7	**1.81**	15.3	10.5	**1.47**
Zinc	mg/kg	154	170	0.91	104	123	0.85	108	52.4	**2.06**	85.6	62.1	**1.38**

Notes:
ND indicates there were no detections.
NA-ratio not reported because all values in upper and/or lower reach were non-detects.
Bold text indicates values are significantly different (p = 0.05).

Table 6-5. Physiochemical Properties of Organic Contaminants

Compound	Aqueous Solubility (mg/L)	Mean Log K_{ow}	Vapor Pressure (mm Hg) [a]	Henry's Law Constant (atm-m^3/mole)[b]	Specific Gravity[c]
Single Ring Aromatics					
Benzene	1,770	2.05	76	0.00548	0.877
Chlorobenzene	460	2.84	9.0	0.0037	1.106
Ethylbenzene	181	3.11	7.08	8.68E-03	0.867
Phenol	77,900	1.47	0.2	3.97E-07	1.058
Toluene	546	2.58	22	0.00674	0.867
o-Xylene	221	3.11	10 (at 25.9°C)	0.00535	0.880
m-Xylene	162.7	3.20	8.29 (at 25°C)	0.0063	0.864
p-Xylene	189	3.17	8.76 (at 25.9°C)	0.0063	0.881
Two to Six Ring Aromatics					
Anthracene	0.059	4.34	1.7E-05	1.77E-05	1.283 (25/4°C)
Benz[a]anthracene	0.012	5.91	2.2E-08	6.6E-07	1.274
Benzo[a]pyrene	0.0038	6.06	5.0E-07	<2.4E-06	1.351
Benzo[b]fluoranthene	0.0012	6.57	5.E-07	1.2E-05	--
Benzo[g,h,i]perylene	0.00026	7.10	1.01E-10 (at 25°C)	1.4E-07	--
Benzo[k]fluoranthene	0.00055	6.45	9.59E-11 (at 25°C)	0.00104	--
Chrysene	0.00327	5.71	6.3E-07	7.26E-20	1.274
Dibenz[a,h]anthracene	0.0005	6.17	1.00E-10	7.33E-09	1.282
Fluoranthene	0.233	5.22	0.01	0.0169	1.252 (0/4°C)
Fluorene	1.84	4.38	0.005	2.1E-04	1.203 (0/4°C)
Indeno[1,2,3-c,d]pyrene	0.062	6.84	1.00E-10 (at 25°C)	2.96E-20	--
Naphthalene	31.9	3.51	0.054	4.6E-04	1.145
Phenanthrene	1.09	4.52	2.1E-04	2.56E-04	0.980 (4/4°C)
Pyrene	0.134	5.32	2.5E-06 (at 25°C)	1.87E-05	1.271 (23/4°C)
Heavily Chlorinated Organic Molecules					
Aroclor 1254	0.011	6.31	6.E-05	0.0027	1.505 (15.5/4°C)
a-Chlordane	0.009	5.93	1.E-05	4.8E-05	1.59–1.63
g-Chlordane	0.009	9.17	1.E-05	4.8E-05	1.59–1.63
Chloroform	7,870	1.94	160	0.0032	1.483
Dieldrin	0.198	5.16	1.78E-07	5.8E-05	1.75
Endrin	0.243	5.02	7.E-07	5.0E-07	1.75
Hexachlorobenzene	0.005	5.65	1.089E-05	0.0017	1.569 (23.6/4°C)

Table 6-5. (cont.)

Compound	Aqueous Solubility (mg/L)	Mean Log K_{ow}	Vapor Pressure (mm Hg) [a]	Henry's Law Constant ($atm\text{-}m^3/mole$)[b]	Specific Gravity[c]
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	2.4E-06	8	6.E-12	1.3E-06	--
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	4.4E-06	7.8	3.8E-11	4.4E-05	--
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	0.00032	5.77	6.4E-10	5.40E-23 (at 18–22°C)	1.827
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.4E-06	--	--	--	--
1,2,3,4,7,8-Hexachlorodibenzofuran	8.2E-06	--	--	--	--
1,2,3,6,7,8-Hexachlorodibenzofuran	1.8E-05	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	0.000236	--	--	--	--
2,3,7,8-Tetrachlorodibenzofuran	0.000419	5.8	--	--	--

Notes: -- - not applicable or not available

[a] Measured at 20°C.

[b] Measured at 25°C.

[c] Measured at 20/4°C (i.e., the compound at 20°C and water at 4°C) unless noted.

[d] Solubility dependent on pH, oxidation-reduction potential, ionic strength, and complexation.

Source: Table 5-5 from Exponent, 2001c. Exponent sources: NACEC (1998); Lide (1990); Watts (1998).

Table 6-6. Environmental Half-Lives of Organic Contaminants

	Environmental Setting							
Compound	Aerobic	Anaerobic	Groundwater	Fresh Water	Salt Water	Soil	Abiotic (Photolytic)	Abiotic (Non-photolytic)
Single Ring Aromatics								
Benzene	@73 days	@9.5 yrs	--	--	--	--	--	--
Chlorobenzene	0.9–2.4 yrs	37–50 days	--	150 days	--	--	--	--
Ethylbenzene	53 days–1.3 yrs	53 days–1.3 yrs	--	--	--	--	--	--
Phenol	<10 days	<280 days	--	--	9 days	--	--	83 days
Toluene	8 days–1 yrs	8 days–1 yrs	--	--	--	--	--	--
Xylenes	80 days–2.1 yrs	80 days–2.1 yrs	--	--	--	--	--	--
Two to Six Ring Aromatics								
Anthracene	<1 yrs	1–7 yrs	--	--	--	100–150 days	--	--
Benz[a]anthracene	>5 yrs	>5 yrs	--	--	--	--	--	--
Benzo[a]pyrene	>5 yrs	>5 yrs	--	--	--	--	--	--
Benzo[b]fluoranthene	>5 yrs	>5 yrs	--	--	--	--	--	--
Benzo[g,h,i]perylene	>5 yrs	>5 yrs	--	--	--	173 days–1.8 yrs	--	--
Benzo[k]fluoranthene	>5 yrs	>5 yrs	--	--	--	--	--	--
Chrysene	<1 yrs	1–7 yrs	175 days	--	--	--	--	--
Dibenz[a,h]anthracene	>5 yrs	>5 yrs	--	--	--	--	--	--
Fluoranthene	<1 yrs	1–7 yrs	--	--	--	--	--	--
Fluorene	<1 yrs	1–7 yrs	--	--	--	--	--	--
Indeno[1,2,3-c,d]pyrene	>5 yrs	>5 yrs	--	--	--	--	--	--
Naphthalene	<1 yrs	1–7 yrs	--	--	--	--	--	--
Phenanthrene	<1 yrs	1–7 yrs	--	--	--	--	--	--
Pyrene	<1 yrs	1–7 yrs	227 days	--	--	--	--	--
Heavily Chlorinated Organic Molecules								
Aroclor 1254 (PCB-1254)	>5 yrs	>5 yrs	--	--	--	--	10 days–1.5 yrs	--
a-Chlordane	--	--	--	--	--	3.3 yrs	--	--
g-Chlordane	--	--	--	--	--	3.3 yrs	--	--
Chloroform	50–143 days	21–42 days	--	--	--	--	23 weeks	--
Dieldrin	--	--	--	--	--	7 yrs	--	10.5 yrs
Endrin[a]	>14 yrs	5–14 days	--	--	--	12 yrs	--	>4 yrs
Hexachlorobenzene	--	--	--	--	--	1,530 days	--	2 yrs
PCDD/Fs[b]	--	>10 yrs	--	--	--	>10 yrs	21–118 hrs	--

Notes: -- - not applicable or not available

[a] Endrin most likely degrades incompletely under anaerobic conditions.

[b] Dioxin, and likely, furan congeners undergo varying degrees of dechlorination under anaerobic conditions, but none of them exceed 20 percent.

Source: Table 5-6 from Exponent, 2001c. Exponent sources:

Adriens et al. (2000); Awata et al. (1998); Brauner et al. (1999); Bolio et al. (1999) and references within; Cox et al. (1998); Flanagan and May (1993); Fed. Reg. 64(2):687–729; Herrington et al. (2000); Howard (1990); Klecka et al. (1990); NACEC (1998); Rifai et al. (1995); UNEP (2001).

Table 6-7. Criteria for Predicting the Environmental Fate of Organic Contaminants of Concern

	Aqueous Solubility (mg/L)	Lipophilicity (Mean Log K_{ow})	Volatility (Vapor Pressure) (mm Hg)	Persistence (Half-life)
Low	<1,000	--	<1	<2 months
Moderate	1,000–10,000	≤3	1–10	2–6 months
High	>10,000	>3	>10	>6 months

Note: -- - not applicable

Source: Table 5-7 from Exponent, 2001c. Exponent sources:

Innovations in Ground Water and Soil Cleanup, National Academy Press, Washington D.C., 1997.

Pesticides in Stream Sediment and Aquatic Biota (http://water.wr.usgs.gov/pnsp/rep/fs09200/fs09200.pdf).

Persistent Bioaccumulative Toxic (PBT) Chemicals; Proposed Rule (http://www.epa.gov/fedrgstr/EPA-TRI/1999/January/Day-05/tri34835.htm).

Table 6-8. Evaluation of Environmental Behavior of Organic Contaminants

Compound	Solubility	Lipophilicity	Volatility	Persistence
Single Ring Aromatics				
Benzene	Moderate	Moderate	High	Moderate-High
Chlorobenzene	Low	Moderate	Moderate	Variable
Ethylbenzene	Low	High	Moderate	Variable
Phenol	High	Moderate	Low	Low
Toluene	Low	Moderate	High	Variable
o-Xylene	Low	High	Moderate	Moderate-High
m-Xylene	Low	High	Moderate	Moderate-High
p-Xylene	Low	High	Moderate	Moderate-High
Two to Six Ring Aromatics				
Anthracene	Low	High	Low	Variable
Benz[a]anthracene	Low	High	Low	High
Benzo[a]pyrene	Low	High	Low	High
Benzo[b]fluoranthene	Low	High	Low	High
Benzo[g,h,i]perylene	Low	High	Low	High
Benzo[k]fluoranthene	Low	High	Low	High
Chrysene	Low	High	Low	Variable
Dibenz[a,h]anthracene	Low	High	Low	High
Fluoranthene	Low	High	Low	Variable
Fluorene	Low	High	Low	Variable
Indeno[1,2,3-c,d]pyrene	Low	High	Low	High
Naphthalene	Low	High	Low	Variable
Phenanthrene	Low	High	Low	Variable
Pyrene	Low	High	Low	Variable
Heavily Chlorinated Organic Molecules				
Aroclor 1254	Low	High	Low	High
a-Chlordane	Low	High	Low	High
g-Chlordane	Low	High	Low	High
Chloroform	Moderate	Moderate	High	Low
Dieldrin	Low	High	Low	High
Endrin	Low	High	Low	High
Hexachlorobenzene	Low	High	Low	High
PCDD/Fs	Low	High	Low	High

Source: Table 5-8 from Exponent, 2001c.

7. HUMAN HEALTH RISK ASSESSMENT

This chapter presents a summary of the baseline human health risk assessment (HHRA) report (TAMS, 2003b) for the remedial investigation and feasibility study (RI/FS) for the Geddes Brook/Ninemile Creek site. The objective of the HHRA is to evaluate the potential for adverse human health effects associated with current or potential future exposures to contaminants of potential concern (COPCs) present in the fish, sediments, soils, and surface water of the Geddes Brook/Ninemile Creek site, in the absence of any action to control or mitigate those chemicals (i.e., under the no action alternative).

The Geddes Brook/Ninemile Creek HHRA addresses Geddes Brook and Ninemile Creek and adjacent areas within the approximate limits shown in Chapter 1, Figure 1-2. The West Flume, which discharges to Geddes Brook, was investigated, in terms of potential human health risks related to exposures to COPCs, as part of the separate RI and HHRA for the former LCP Bridge Street facility (NYSDEC/TAMS, 1998).

For the purposes of the HHRA, the Geddes Brook/Ninemile Creek site includes the following:

- Geddes Brook sediment and surface water from approximately 2,500 feet (ft) (760 meters [m]) upstream of its intersection with Gerelock Road to the point of discharge into Ninemile Creek and associated floodplain soil from its intersection with the West Flume to the point of discharge into Ninemile Creek.

- Ninemile Creek sediment and surface water from Amboy Dam to the point of discharge into Onondaga Lake and associated floodplain soil from its intersection with Geddes Brook to the point of discharge into Onondaga Lake.

- State and federal wetlands associated with the Geddes Brook/Ninemile Creek site (i.e., Wetland SYW-18 and Wetland SYW-10, east of Interstate 690 [I-690]). Wetland SYW-10 west of I-690 is being evaluated as part of the Maestri 2 site.

The Onondaga Lake area, including the tributaries and principal Honeywell sites, is shown in Chapter 1, Figures 1-2 and 1-3, and the general extent of the exposure areas utilized in the HHRA is presented in Figure 7-1. For the purposes of the HHRA, the Geddes Brook/Ninemile Creek site is divided into four areas: Upper Geddes Brook, Lower Geddes Brook, Upper Ninemile Creek, and Lower Ninemile Creek. This division, which is discussed in greater detail in Chapters 2 (Background) and 4 (Exposure Assessment) of the HHRA, is used for assessing exposure to water, sediment, and floodplain and wetland soils, although floodplain soil exposure is assessed only for Lower Geddes Brook and Lower Ninemile Creek. For assessment of risks associated with exposure to (i.e., consumption of) contaminants in fish, data from all four of these areas are combined into a single data set.

The HHRA, and this summary chapter, follow the USEPA Risk Assessment Guidance format and sequence. The HHRA consists of the following chapters and appendices:

- Chapter 1, Introduction – Discusses the general framework and format of the document.
- Chapter 2, Background – Provides background information on the site, such as site history, features, and climate.
- Chapter 3, Identification of Contaminants of Potential Concern – Discusses the available data for all site media (e.g., fish tissue, sediment, water) for each exposure area, discusses the results of the contaminant screening process, and identifies the contaminants that are considered COPCs in each site medium after the screening.
- Chapter 4, Exposure Assessment – Presents the exposure setting and exposed populations (receptors); in other words, what types of people may be exposed to contaminants in various site media (e.g., adult construction workers exposed to subsurface contaminants in soil by dermal contact and incidental ingestion). Next, the exposure is quantified (how much of a contaminated medium each receptor may be exposed to is estimated). Finally, the calculations of the exposure point concentrations (EPCs) of each COPC in each contaminated medium are discussed.
- Chapter 5, Toxicity Assessment – Discusses the chemical-specific cancer risk or non-cancer hazard toxicity data used to calculate the potential adverse health effects from exposure to site contaminants.
- Chapter 6, Risk Characterization – Presents the results of the quantitative risk assessment, including estimates of both cancer risks and non-cancer hazards for each medium and each receptor population.
- Chapter 7, Uncertainty Assessment – Discusses aspects of the HHRA that are likely to overestimate or underestimate site risks.
- Chapter 8, Conclusions – Summarizes risk assessment results.
- Chapter 9, References – Presents references for all documents and personal communications cited in the main body of the report.
- Appendix A, Summary of Site Data Used in the HHRA – Includes discussion and tabulation of data collected by Honeywell and NYSDEC that are used in the HHRA.
- Appendix B, RAGS Part D Tables.

- Appendix C, USEPA Regions 3 and 9 Screening Values.

- Appendix D, Toxicological Profiles for Contaminants of Potential Concern.

7.1 Introduction

The Geddes Brook/Ninemile Creek HHRA was conducted in accordance with the Geddes Brook/Ninemile Creek RI/FS Work Plan (NYSDEC, 1998, 2000a), as well as the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and other applicable guidance documents from the US Environmental Protection Agency (USEPA) (see HHRA Chapter 1, Section 1.1). The specifics of implementation of the HHRA are not identical to those outlined in the work plan due to subsequent changes in regulations and guidance documents and advancements in analytical and risk assessment science.

As science and policy evolve over time, some of the guidance documents used in the HHRA were superseded or supplemented during the time the HHRA was being prepared. To the extent practical, the most current USEPA guidance documents and data have been utilized. For example, all of the USEPA screening values were updated in 2002 prior to performing the screening for the HHRA (HHRA Appendix C), USEPA's ProUCL software was used for statistical calculations, and the toxicity files on USEPA's Integrated Risk Information System (IRIS) were all accessed in 2003 to verify that current peer-reviewed toxicity data were being used (HHRA Chapter 5 and HHRA Appendix D).

The only known exception to this approach involves the format of the USEPA Risk Assessment Guidance for Superfund (RAGS) Part D tables presented in HHRA Appendix B. In June 2002, USEPA indicated that the December 2001 revision of RAGS Part D was to be used for all new risk assessments (superseding the January 1998 version of RAGS Part D). However, RAGS Part D is merely a standardized reporting format utilized by USEPA to generate consistency among risk assessments at different sites and in different regions, and does not affect how risks are calculated. The risk assessment was initiated prior to issuance of the new guidance. Therefore, the 1998 version was used for the HHRA, with USEPA's concurrence; however, not utilizing the December 2001 revision has no impact on the findings of the HHRA.

Risk assessments conducted for regulatory purposes, such as the HHRA, are designed to be protective of human health and consistent with requirements for risk assessment provided by USEPA. Two different types of exposure scenarios are presented in the HHRA – the reasonable maximum exposure (RME) scenario, and the central tendency (CT; sometimes referred to as the "typical") scenario. For the RME scenario, two or three of the most sensitive input parameters (typically the intake rate, such as the amount of fish consumed) are set to the 90th or 95th percentile values, while the rest of the inputs to the risk calculation are set to the average, or median (50th percentile), value. As such, the RME is not a "worst case" scenario. Although the cumulative impact of the 95th percentile exposure and toxicity assumptions used in the RME scenario may overestimate risks for many site users (receptors), there could be some receptors for whom exposure and risks are underestimated even in the RME scenario.

For the CT scenario, all variables in the risk calculations are set to the average or median values. (The same toxicity values and EPCs are almost always used for both the RME and CT scenarios.) Factors that may overestimate or underestimate risks are discussed in HHRA Chapter 7.

7.2 Background

The background chapter of the HHRA summarizes the physical attributes of the site, the history of contamination, and the regulatory history. This information is presented in greater detail in Chapters 1 through 4 of this RI.

7.3 Contaminants of Potential Concern

The HHRA uses a screening process to select COPCs that is structured to maximize the likelihood that the contaminants that could be of concern are retained for further analysis. All available contaminant concentration data were reviewed for fish (fillets only; samples meeting legal size limits [for species with established limits], or a minimum size of 6 inches [for species without legal size limits]), and for water and sediments in Upper and Lower Geddes Brook and Upper and Lower Ninemile Creek, and floodplain soils in Lower Geddes Brook and Lower Ninemile Creek. Sediments at water depths of more than about 6.5 ft (2 m) were not included, as it is unlikely that humans would have much, if any, direct contact with such sediments.

Site concentration data were compared with risk-based concentrations developed by USEPA Regions 3 and 9. For the screening, the highest concentration of a contaminant in a specific medium (e.g., surface sediments) was compared to the more conservative of the Region 3 or Region 9 screening criteria. The published screening criteria for carcinogens are set at a cancer risk level of 10^{-6}; these criteria were used as published. However, USEPA Region 2 (along with many other risk assessors) utilizes a hazard index (HI) of 0.1 for screening non-cancer hazards; as the Region 3 and Region 9 screening criteria are based on a HI of 1.0. Accordingly, the published values were divided by ten prior to use in screening non-carcinogenic effects for the risk assessment.

In addition to mercury (including methylmercury), which was identified in the Geddes Brook/Ninemile Creek RI/FS Work Plan (NYSDEC, 1998, 2000a) as one of the principal COPCs to be evaluated in the HHRA, a total of about 40 other contaminants were identified as COPCs (as chemicals or chemical mixtures) in one or more site media and were retained for further analysis in the HHRA. These are listed in Table 7-1.

7.4 Exposure Assessment

Geddes Brook and Ninemile Creek are surrounded by lands used for industrial, commercial, and recreational purposes (Figure 7-1). No residential property directly abuts the site. Recreational visitors are the receptors with the greatest potential for exposure to COPCs. Thus, the HHRA focuses mainly on recreational visitors to the site, although it also evaluates potential exposures to construction workers who may contact contaminated media during work in these areas.

Under current conditions, potential exposures for recreational visitors to the site are limited by the lack of public swimming areas. The New York State Department of Health (NYSDOH) has also issued specific, restrictive fish consumption advisories for Onondaga Lake and its tributaries, including Geddes Brook and Ninemile Creek (NYSDOH, 2003). The HHRA assesses risk under both current and future use scenarios. Potential future uses are evaluated under the assumption that there are no restrictions, advisories, or limitations in place. Exposure pathways evaluated quantitatively are shown on Table 7-2 and include the following:

- Consumption of fish from Geddes Brook and Ninemile Creek.
- Incidental ingestion of and dermal contact with surface and subsurface sediments in Upper and Lower Geddes Brook and Upper and Lower Ninemile Creek.
- Incidental ingestion of and dermal contact with surface and subsurface soil in Lower Geddes Brook and Lower Ninemile Creek.
- Incidental ingestion of and dermal contact with Upper and Lower Geddes Brook and Upper and Lower Ninemile Creek surface water.

A Phase II Investigation conducted for Onondaga Lake by NYSDEC (NYSDEC, 1989a, as cited in PTI, 1991) concluded that there was little potential for releases of contaminants to air. The data for volatile organic compounds (VOCs) in Geddes Brook and Ninemile Creek surface water and near-surface floodplain soils were reviewed as part of the HHRA, and confirmed the conclusions of the Phase II Investigation.

In addition, there are currently no structures on the site nor are any likely to be built, due to regulatory restrictions (e.g., zoning and wetlands), although there are some structures close to Ninemile Creek (e.g., the USGS gaging station and the hotel on State Fair Boulevard). Therefore, the inhalation pathway was considered to be incomplete for all media and was not assessed further in the HHRA.

As site-specific information was not available for all the input parameters for exposure assessment or risk calculation, assumptions based on professional judgment or USEPA-recommended generic default values were used in the exposure assessment. For example, the RME fish consumption rate of 25 grams per day (g/day) applied in the risk calculations is the default 95th percentile recommendation in the USEPA Exposure Factors Handbook (1997b). This fish consumption rate is equivalent to approximately 40 eight-ounce meals. The uncertainties associated with the use of this fish consumption rate and other exposure assumptions are discussed in HHRA Chapter 7.

In accordance with USEPA guidance, the future use scenarios evaluated quantitatively in the HHRA were based on those considered to be reasonably foreseeable. HHRA Chapter 7 includes a discussion of some future use scenarios that were considered unlikely, and therefore were not evaluated quantitatively in the risk assessment.

7.5 Toxicity Assessment

Risk estimates for all COPCs were based on use of toxicity values, including carcinogenic slope factors (CSFs) to assess potential carcinogenic effects and reference doses (RfDs) to assess potential non-cancer effects, that were derived by USEPA and published on its peer-reviewed IRIS database and the USEPA Health Effects Assessment Summary Tables (HEAST), and were supplemented by additional guidance from USEPA National Center for Environmental Assessment (NCEA), USEPA Region 2, NYSDOH, and NYSDEC. The three COPCs (or COPC groups) responsible for a majority of estimated site risks are polychlorinated biphenyls (PCBs), polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs), and methylmercury.

- **PCBs** – RME carcinogenic risk estimates for PCBs were based on the CSF of 2 $(mg/kg\text{-}day)^{-1}$, which is the highest of a range of upper-bound CSFs derived from studies in rats. This value is recommended by USEPA for evaluating food-chain exposures, sediment or soil ingestion, and dermal contact exposures for all Aroclors. CT carcinogenic risk estimates for PCBs were based on the CSF of 1 $(mg/kg\text{-}day)^{-1}$, which is the central estimate CSF cited in IRIS. Non-cancer effects for highly chlorinated PCBs were evaluated using the toxicity data for Aroclor 1254, for which USEPA has published RfDs.

- **PCDD/PCDFs** – Carcinogenic risk estimates for PCDD/PCDFs were based on a toxicity equivalent quotient (TEQ) approach. USEPA does not currently have any quantitative toxicity factors (e.g., oral RfD) for the non-cancer health effects of PCDD/PCDFs; therefore, no quantitative assessment of non-cancer health hazards associated with PCDD/PCDFs is provided in the HHRA. However, a qualitative assessment is provided in HHRA Chapter 7, along with alternate cancer risks estimates based on the current peer-review draft of USEPA's dioxin reassessment document.

- **Methylmercury** – USEPA's RfD for methylmercury of 0.0001 mg/kg-day has been applied in estimates of non-cancer hazards for the fish consumption pathway and for Geddes Brook/Ninemile Creek surface water, sediments, and soils in which methylmercury was detected. The USEPA RfD of 0.0003 mg/kg-day has been applied for evaluation of non-cancer hazards of mercury (as inorganic mercury) in other media. Methylmercury/mercury has not been assessed quantitatively for cancer risks in the HHRA as no oral CSFs have been established by USEPA.

7.6 Risk Characterization

USEPA toxicity values (i.e., CSFs or RfDs) were combined with exposure estimates to derive estimates of potential health risks related to exposure to COPCs in Geddes Brook/Ninemile Creek site media. For cancer risks, the acceptable risk levels, as specified by the NCP (40 CFR § 300.430[e][2][i][A][2]), range from an excess upper-bound lifetime cancer risk to an individual of

1×10^{-4} to 1×10^{-6}, with 1×10^{-6} as the point of departure for determination of remedial goals. A 1×10^{-6} excess cancer risk represents an additional one-in-one-million probability that an individual may develop cancer over a 70-year lifetime as a result of the exposure conditions evaluated. Non-cancer effects are expressed as the ratio of the estimated exposure, or intake rate over a specified exposure period, to the RfD derived for a similar exposure period. This ratio is termed a hazard quotient (HQ). HQs for multiple COPCs or pathways are summed to generate an HI for a specific exposure route or receptor. Exposures resulting in an HI less than or equal to 1.0 are unlikely to result in non-cancer health effects. Estimated cancer risks and non-cancer hazards for both RME and CT scenarios for the 39 pathways evaluated in the HHRA are summarized in Table 7-3. The principal COPCs contributing to cancer risks and non-cancer hazards are listed in Tables 7-4 and 7-5, respectively.

7.6.1 Cancer Risks

The RME cancer risks associated with fish consumption by recreational users (adults, as well as young and older children) were within the 10^{-6} to 10^{-4} risk range for the RME scenario, ranging from 2.9×10^{-5} (for young children) to 9.3×10^{-5} for adults. These RME risk estimates were principally related to exposure to PCBs and PCDD/PCDFs, each of which individually contributed risks of about 4×10^{-5} for the adult receptor (HHRA Appendix B, RAGS Table 8.1). Cancer risk estimates exceeded 10^{-6} for many pathways, as summarized on Tables 7-3 and 7-6.

The calculated CT cancer risks for fish consumption were slightly greater than 1×10^{-6}, ranging from 1.2×10^{-6} to 1.3×10^{-6} for all recreational receptors (adults, young children, and older children), with the same chemicals (i.e., PCBs and PCDD/PCDFs) contributing the bulk of the risk, as shown on Table 7-4.

RME cancer risk estimates associated with several other exposure pathways related to sediments and floodplain soils in recreational scenarios were greater than 1×10^{-6}. The highest of these was about 7.8×10^{-5} for older child exposure to Upper Geddes Brook sediments. RME cancer risks were more than 10^{-5} for older child recreational exposure (ingestion and dermal combined) to Lower Geddes Brook and Lower Ninemile Creek sediments and floodplain soils and for adult recreational exposure to Upper Geddes Brook sediments and Lower Geddes Brook floodplain soils. In CT scenarios, the highest excess cancer risk (other than fish consumption) was about 1.6×10^{-6} for the older child recreational exposure to Upper Geddes Brook sediments. CT risks for all other soil and sediment pathways were less than 10^{-6}. RME cancer risks for most soil and sediment pathways were primarily driven by arsenic and carcinogenic polycyclic aromatic hydrocarbons (PAHs), principally benzo(a)pyrene (see Table 7-4).

RME and CT risks associated with the Upper Geddes Brook surface water pathways exceeded the 1×10^{-6} risk level for recreational receptors. This exceedance is entirely attributable to PCDD/PCDFs. RME and CT risks associated with the Lower Geddes Brook and Upper and Lower Ninemile Creek surface water pathways were not quantifiable, as no carcinogenic COPCs were detected.

7.6.2 Non-Cancer Hazards

The RME HIs for the recreational angler fish consumption pathway were approximately 4.1 for adults, 6.4 for young children, and 4.5 for older children (Table 7-3). CT HIs were below 1.0, ranging from approximately 0.3 for adults to 0.5 for young children. The elevated HIs for the fish consumption pathways were primarily related to PCBs (highly chlorinated Aroclors, assessed as Aroclor 1254), methylmercury, and, to a lesser extent, dieldrin. The COPCs contributing the largest amount of non-cancer hazards for each pathway are summarized on Table 7-5, and include PCBs and methylmercury. All other HIs for pathways other than fish ingestion were less than 1.0.

The risks to children for the fish consumption pathway (presented above) are based on the assumption that older children consume two-thirds as much fish as adults, and young children (under age 6) consume one-third as much fish as adults. As there are only limited data on which this assumption of children's fish ingestion rates could be based, it is possible that the ingestion rates for children may be higher or lower than those used in the HHRA. Therefore, risks to children may be higher or lower than those presented in the HHRA and shown on Table 7-3.

Based on the exposure assumptions and toxicity values used in the risk evaluations, these results indicate the potential for adverse non-cancer health effects as a result of long-term exposures via ingestion of Geddes Brook and Ninemile Creek fish. This conclusion is consistent with the fact that methylmercury concentrations in some Geddes Brook and Ninemile Creek fish exceed the US Food and Drug Administration (USFDA) action limit.

7.7 Uncertainty Assessment

The USEPA risk assessment methods discussed above and used in the HHRA are designed to be protective of human health. Thus, when the uncertainties associated with the use of these methods are accounted for, "true" site risks for most receptors are likely to be less than the RME risks presented for the HHRA. However, as indicated in the uncertainty assessment (HHRA Chapter 7), many of the aspects of the exposure assumptions applied in the HHRA are based on professional judgment, default values, or estimates. Therefore, the actual risks to any particular individual could be higher or lower than those presented in the HHRA. Examples include, but are not limited to, the following:

- Application of an assumed RME fish consumption rate of 25 g/day, which is USEPA's default 95th percentile consumption rate. Individual studies have suggested RME fish consumption rates both higher (e.g., up to 170 g/day for subsistence fishers; 32 g/day for Hudson River anglers) and lower (e.g., less than 25 g/day) than the RME fish consumption rate used in the HHRA. In addition, the consumption rate utilized is derived from studies on adults; only limited data were available for estimating fish consumption by children (see HHRA Chapter 4, Section 4.2.1 and HHRA Chapter 7, Section 7.3.2).

- The RME assumptions that 30 percent of the freshwater fish consumed come from Geddes Brook and Ninemile Creek (i.e., application of a RME fractional intake of 0.3) and that no PCBs or PCDD/PCDFs are lost during cooking may overestimate risk to some receptors. However, as it is not known to what extent persons who consume Geddes Brook and Ninemile Creek fish adhere to the NYSDOH recommendations to remove the skin and fat and not consume the drippings, it is likely that these assumptions are realistic for at least some of the potentially exposed recreational angler population. Central tendency scenarios include a lower assumed fraction intake (0.1), a lower freshwater fish consumption rate (8 g/day), and a one-third loss of PCBs and PCDD/PCDFs from cooking and preparation.

- There is some uncertainty in the USEPA CSF of 2 $(\text{mg/kg-day})^{-1}$ for PCBs. However, as discussed in HHRA Chapter 7, it is not clear whether the uncertainty may lead to an underestimate or overestimate of cancer risks associated with PCBs.

- The application of toxicity values for PCDD/PCDFs used in the HHRA may underestimate cancer risks from these compounds. If the conclusions of the dioxin reassessment that is currently underway (USEPA, 2000) are unchanged after finalization, the calculated cancer risks from PCDD/PCDFs would be about seven times greater than presented in the HHRA.

- The lack of published non-cancer toxicity values for PCDD/PCDFs may underestimate non-cancer hazards from dioxins. The reassessment currently being conducted by USEPA suggests that there are likely non-cancer hazards from these compounds, in addition to cancer risks. The absence of non-cancer toxicity values for PCDD/PCDFs precluded their inclusion in the quantitative HHRA and may result in an underestimate of non-cancer hazards in media in which these COPCs are present.

- The lack of peer-reviewed cancer and non-cancer toxicity values for some of the PAH compounds detected in sediments and floodplain soils may result in an underestimate or overestimate of risks or hazards.

Derivation of appropriate and protective toxicity values for mercury/methylmercury, PCDD/PCDFs, and PCBs in human populations is the subject of extensive study and debate. The toxicity values derived by USEPA and used in the HHRA represent a protective interpretation of the available toxicological data, and incorporate uncertainty and modifying factors to account for the need to extrapolate from animal studies to humans, among other issues. HHRA Chapter 7 provides a discussion of the basis for and the reliability of the toxicity values used in the risk assessment. In general, confidence in the methylmercury toxicity data is considered high, and the IRIS value has recently been confirmed by a study conducted by the National Research Council (NRC).

Although the CSFs and RfDs used for quantitative assessment of PCBs were taken from USEPA's peer-reviewed IRIS database, there is more uncertainty about the PCB toxicity data than for the methylmercury data. For example, USEPA characterizes the confidence in the oral RfDs for Aroclor 1254 as medium, while the confidence in the oral RfD for methylmercury is high. A number of factors contribute to the relative uncertainty of the PCB toxicological data, including the following:

- Aroclors are a mixture of many (typically 30 or more) individual chlorinated biphenyl compounds ("congeners").

- The commercial mixtures studied in the laboratory are altered when released to the environment by physical, biological, and metabolic processes.

- There are a wide range of observed effects and concentrations at which effects were observed in laboratory studies.

- There are issues associated with most chemicals in extrapolating toxicological data from animal studies.

Although there are incidences of human exposure to PCBs, data from human exposure are only useful on a qualitative basis due to lack of information about the specific composition of the mixture to which persons were exposed, exposure concentrations, and route of exposure, as well as a lack of long-term monitoring data in a number of these cases. Recent studies also suggest that some PCB congeners have dioxin-like effects and may contribute to PCDD/PCDF-related health effects. However, the lack of PCB congener-specific data precluded any assessment of this possibility.

Another area of uncertainty is the available data for characterizing specific exposure areas and media. Characterization of the sediment and surface water in the Upper Geddes Brook and Upper Ninemile Creek exposure areas is based on a small number of samples. As a result, the maximum detected value is used as the EPC for characterizing these areas. The relative lack of data for these areas may contribute to some apparent anomalies, such as EPCs of some contaminants (PCDD/PCDFs in Upper Geddes Brook surface water; PAHs in Upper Geddes Brook sediments) exceeding the EPCs in Lower Geddes Brook surface water and sediment.

7.8 Conclusions

The objective of the HHRA was to evaluate the potential for adverse human health effects associated with current or potential future exposures to chemicals present in the fish, sediments, soils, and surface water of the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those chemicals. Under this no action alternative, the HHRA principally assessed future conditions that further assumed unrestricted recreational use and the absence of a specific, restrictive fish consumption advisory.

A total of about 40 COPCs or groups of COPCs (including mercury and methylmercury) were identified for further analysis in the HHRA. Consistent with USEPA guidance, RME and CT scenarios for these COPCs were evaluated for several pathways, including a recreational fish consumption pathway, as summarized below:

- Cancer risks and non-cancer hazards calculated for the consumption of Geddes Brook and Ninemile Creek fish exceeded specified risk levels (Table 7-6), as follows:

  - The calculated RME cancer risks (ranging from 2.9×10^{-5} to 9.3×10^{-5}) exceeded the low end (1×10^{-6}) of the cancer risk range (10^{-6} to 10^{-4}) by more than an order of magnitude. The CT fish ingestion cancer risk (about 1.3×10^{-6} for all recreational receptors) also slightly exceeded the lower end of the range.

  - The RME non-cancer HIs (ranging from about 4.1 to 6.4) exceeded the target HI (1.0). The calculated CT non-cancer HIs, ranging from about 0.3 to 0.5, were less than the target threshold for all receptors.

- RME cancer risks for 17 of the 36 pathways other than fish ingestion equaled or exceeded the low end (1×10^{-6}) of the cancer risk range (10^{-6} to 10^{-4}), with the highest of these being 9.1×10^{-5} for adult exposure to Upper Geddes Brook surface water and 7.8×10^{-5} for older child exposure to Upper Geddes Brook sediments.

- For the CT cancer risk calculations, the low end of the cancer risk range was equaled or exceeded in three of the 36 pathways other than fish ingestion, with a maximum CT risk of about 4.5×10^{-6} for older child exposure to Upper Geddes Brook surface water.

- None of the calculated non-cancer hazards for both the RME and CT scenarios associated with pathways other than fish ingestion exceeded the target threshold of 1.0. The highest RME hazard other than fish ingestion was about 0.61 for older child exposure to Upper Geddes Brook surface sediments.

Cumulative risks and hazards were calculated for receptors that may be exposed to COPCs in multiple site media – for example, eating contaminated fish and being exposed to contaminated sediments. The receptors evaluated were adult recreators, older child recreators, and construction workers. For many of the cumulative risk and hazard calculations, including fish ingestion, the cumulative risk or hazard was dominated by the risk or hazard associated with the fish ingestion pathway alone. Therefore, to assess the cumulative risks associated with pathways other than fish ingestion (i.e., exposure to sediment, soil, and surface water), the cumulative risk for each receptor was also calculated excluding the fish ingestion pathway (see HHRA Chapter 6, Table 6-2), as summarized below:

- Cumulative RME cancer risks for adults (recreational scenario, excluding fish ingestion) were calculated as 1.5×10^{-4} and non-cancer hazards (excluding fish ingestion) were calculated as about 0.5 for adults.

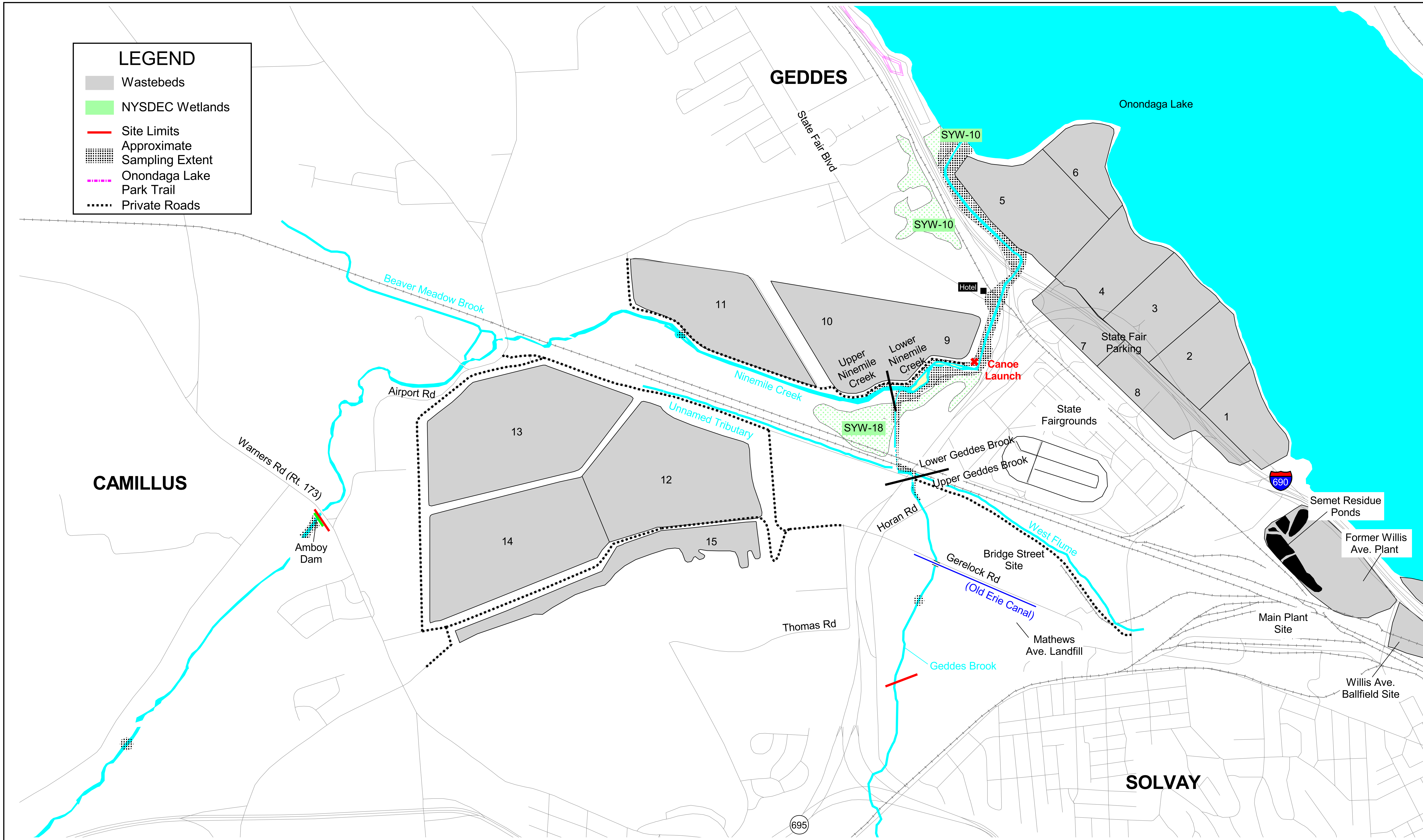
- Cumulative RME cancer risks for older children (recreational scenario, excluding fish ingestion) were calculated as 2.3×10^{-4}. The receptor-specific RME HI (excluding fish ingestion) was calculated as about 1.4 for the older child.

- Cumulative RME cancer risks were calculated as 3.6×10^{-6} for construction workers. As defined for the HHRA, the construction worker scenario does not include fish ingestion. The receptor-specific RME HI was calculated as about 0.5 for construction workers.

It should be noted that these cumulative estimates are probably unrealistically high, especially for the adult and older child recreational receptors, as the cumulative risk calculation assumes RME frequencies totaling 264 days per year to Geddes Brook and Ninemile Creek sediments and floodplain soils.

The uncertainty assessment portion of the HHRA (Chapter 7) provides a discussion of the reliability of the input parameters to the quantitative risk calculations, and provides a qualitative and, in some cases, semi-quantitative assessment of the effect of alternative values in risk calculations. As indicated there, actual cancer risks and non-cancer hazards may vary from those presented in the quantitative risk characterization tables.

The HHRA addresses reasonably foreseeable future use scenarios (USEPA, 1995c); therefore, it is important to note that the conclusions of the HHRA are applicable only to the scenarios considered. Should future use or conditions vary from those assumed in the HHRA (e.g., construction of occupied structures within the site limits or other activities that may result in significant areas of contaminated subsurface soil being brought to the surface), the conclusions of the report may not be valid and specific assessment of risks associated with such activities may be appropriate.



Geddes Brook/ Ninemile Creek RI

Figure 7-1
Geddes Brook/Ninemile Creek Exposure Areas

TAMS

Table 7-1. Summary of Contaminant Screening in the Geddes Brook/Ninemile Creek Human Health Risk Assessment

Contaminant	GB/NMC Fish Fillets (2.1)	GB/NMC Surface Sediment (2.2)	GB/NMC Surface and Subsurface Sediment (2.3)	GB/NMC Surface (Floodplain) Soils (2.4)	GB/NMC Surface and Subsurface (Floodplain) Soils (2.5)	GB/NMC Surface Water (2.6)
Metals/Inorganics						
Aluminum		X	X	X	X	
Antimony		X	X		X	X
Arsenic (inorganic)	X	X	X	X	X	
Cadmium	X					X
Chromium		X	X	X	X	X
Copper	X					
Cyanide		X	X	X	X	
Iron	X	X	X	X	X	
Lead			X	X	X	X
Manganese		X	X	X	X	X
Methylmercury	X	X	X	X	X	X
Mercury (inorganic)	NA [1]	X	X	X	X	X
Nickel	X					
Selenium	X	X	X			
Thallium		X	X	X	X	X
Vanadium	X					
Zinc	X					
VOCs						
No VOC COPCs identified in any Geddes Brook/Ninemile Creek medium						
SVOCs						
3-Nitroaniline				X	X	
N-nitroso-di-n-propylamine					X	
Hexachlorobenzene	X	X	X	X	X	

Table 7-1. (cont.)

Contaminant	GB/NMC Fish Fillets (2.1)	GB/NMC Surface Sediment (2.2)	GB/NMC Surface and Subsurface Sediment (2.3)	GB/NMC Surface (Floodplain) Soils (2.4)	GB/NMC Surface and Subsurface (Floodplain) Soils (2.5)	GB/NMC Surface Water (2.6)
PAHs						
Benz(a)anthracene		X	X	X	X	
Benzo(a)pyrene		X	X	X	X	
Benzo(b)fluoranthene		X	X	X	X	
Benzo(g,h,i)perylene				X	X	
Benzo(k)fluoranthene				X	X	
Dibenz(a,h)anthracene		X	X	X	X	
Indeno(1,2,3-cd)pyrene		X	X	X	X	
Phenanthrene		X	X	X	X	
Pesticides						
4,4-DDD	X					
4,4'-DDE	X					
4,4'-DDT	X					
Dieldrin	X		X			
Heptachlor Epoxide	X	X	X			
PCBs						
Aroclor 1248	X				X	
Aroclor 1254	X	X	X	X	X	
Aroclor 1260	X		X		X	
Aroclor 1268			X	X	X	
Total PCBs (sum)	X	X	X	X	X	
Dioxins/Furans						
2,3,7,8-TCDD TEQ	X	X	X	X	X	X

Notes: X - Specified contaminant identified as a contaminant of potential concern (COPC). See HHRA Appendix B table referenced in parenthesis.
NA - This analyte or parameter group not analyzed in specified exposure area.
GB/NMC - Geddes Brook/Ninemile Creek
Contaminants not listed were not identified as COPCs in any site medium.
[1] - All mercury in fish addressed as methylmercury.

Table 7-2. Selection of Exposure Pathways for the Geddes Brook/Ninemile Creek Human Health Risk Assessment

Scenario Time Frame	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis[a]	Rationale for Selection or Exclusion of Exposure Pathway
Current/ Future	Soil (floodplain and wetlands)	Soil	Soil	Resident	Adult	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
					Child (all ages)	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
	Sediment (Upper and Lower Ninemile Creek and Geddes Brook)	Sediment (Ninemile Creek and Geddes Brook)	Sediment	Resident	Adult	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
					Child (all ages)	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
	Water (Ninemile Creek and Geddes Brook)	Potable water supply	Tap water	Resident	Adult	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	Groundwater and Geddes Brook and Ninemile Creek water not used for potable water supply.
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
					Child (all ages)	Dermal	On-Site	None	Residential populations not evaluated in the RA due to lack of current residential use and unlikely future development for residential use.
						Ingestion	On-Site	None	Groundwater and Geddes Brook and Ninemile Creek water not used for potable water supply.
						Inhalation	On-Site	None	No occupied structures currently exist and none are likely to be built in the future; concentrations of VOCs are low; available data and Phase II Investigation for Onondaga Lake indicate inhalation unlikely. See text (HHRA Section 4.2.7) for discussion.
	Edible fish caught in Ninemile Creek and Geddes Brook	Fish tissue	Fish tissue[b]	Anglers and fish consumers	Adult	Ingestion	On-Site	Quant	Consumption of contaminants in fish identified as a potential pathway and evaluated in the RA.
					Young Child	Ingestion	On-Site	Quant	Consumption of contaminants in fish identified as a potential pathway and evaluated in the RA.
					Older Child	Ingestion	On-Site	Quant	Consumption of contaminants in fish identified as a potential pathway and evaluated in the RA.
				Other (subsistence fisher)	Adult	Ingestion	On-Site	Qual	Because a possible subsistence fishing community does exist near the site, a subsistence fish diet will be addressed qualitatively.
					Child (all ages)	Ingestion	On-Site	Qual	Because a possible subsistence fishing community does exist near the site, a subsistence fish diet will be addressed qualitatively.
Current/ Future	Game (flesh)	Edible waterfowl and turtles	Edible flesh	Hunters	Adult and Child (all ages)	Ingestion	On-Site	None	Although the hunting of waterfowl on Onondaga Lake and its tributaries is legally permitted under New York State law, the hunting season is significantly shorter than the fishing season. There is anecdotal evidence of hunting (e.g., traps) in the Lower Ninemile Creek exposure area considered in this HHRA. There is a state-wide advisory regarding consumption of waterfowl and snapping turtles. However, the absence of available data on contaminant concentrations in waterfowl and the paucity of data on ingestion rates of waterfowl precluded a quantitative analysis of this pathway. See text (HHRA Section 4.2.6) for discussion.

Table 7-2. (cont.)

Scenario Time Frame	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis[a]	Rationale for Selection or Exclusion of Exposure Pathway
Current/ Future	Sediments (surface)	Surface sediments in Ninemile Creek and Geddes Brook	Sediments at 0 to 15 cm depth in Ninemile Creek and Geddes Brook	Recreational Visitor	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in Geddes Brook and Ninemile Creek surface sediments by visitors identified as a potential pathway and evaluated in the RA.
					Older Child	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in Geddes Brook and Ninemile Creek surface sediments by visitors identified as a potential pathway and evaluated in the RA. Young children (under 6 years old) unlikely to be exposed.
	Sediments (surface and subsurface)	Sediment (Ninemile Creek and Geddes Br)	Sediments at depths of 0 to 10 ft	Construction Worker (future only)	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in sediments of Geddes Brook and Ninemile Creek (sediment to 10 ft depth) by construction workers (adults only) identified as a potential pathway and evaluated in the RA.
	Soil - surface (floodplain and wetlands)	Surface soil in floodplain and wetlands	Soil at 0 to 15 cm depth	Recreational Visitor	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in surface (floodplain and part of Wetlands SYW-10 and SYW-18) soils by visitors identified as a potential pathway and evaluated in the RA.
					Older Child	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in surface (floodplain and part of Wetland SYW-10 and SYW-18) soils by visitors identified as a potential pathway and evaluated in the RA. Young children (under 6 years old) unlikely to be exposed.
	Soil - surface and subsurface (floodplain and wetlands)	Surface and subsurface soil in floodplain and wetlands	Soil at 0 to 3 ft depth (limited by sample depth)	Construction Worker (future only)	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in deeper (surface and subsurface) soil by construction workers (adults only) identified as a potential pathway and evaluated in the RA.
Current/ Future	Surface water - Ninemile Creek and Geddes Brook	Surface water	Surface water in tributaries	Recreational Visitor	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in Geddes Brook and Ninemile Creek surface water by visitors identified as a potential pathway and evaluated in the RA.
					Older Child	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in Geddes Brook and Ninemile Creek surface water by visitors identified as a potential pathway and evaluated in the RA. Young children (under 6) unlikely to be exposed.
				Construction Worker (future only)	Adult	Dermal Ingestion	On-Site On-Site	Quant Quant	Dermal contact with, and incidental ingestion of, contaminants in Geddes Brook and Ninemile Creek surface water by construction workers (adults only) identified as a potential pathway and evaluated in the RA.

Notes: See HHRA Appendix A for locations of samples used in evaluating potential exposures.

Lower Ninemile Creek; Upper Ninemile Creek; Lower Geddes Brook; and Upper Geddes Brook areas are considered separately for sediment and water exposure scenarios, due to differences in contamination. Some samples in the Ninemile Creek and Lower Geddes Brook exposure areas are located in Wetlands SYW-10 and SYW-18; but wetland areas are not explicitly assessed in the HHRA.

Floodplain and wetland soil evaluated for Lower Geddes Brook and Lower Ninemile Creek exposure areas only.

RA = Risk Assessment.

[a] Quant = Quantitative risk analysis performed. Qual=Qualitative analysis performed. None = Not considered a complete pathway; not evaluated in the RA.

[b] Fish species collected that were considered edible and for which fillets were analyzed include smallmouth bass, brown trout, white sucker, carp, channel catfish, and yellow perch. Consistent with New York's fishing regulations, size was limited to fish of approximately legal size or larger (e.g., 12 inches for smallmouth bass). Fishing regulations allow "any size" for other species, but individual fish smaller than about 6 inches were excluded, as fish that small are unlikely to be consumed by humans.

Table 7-3. Summary of Cancer Risks and Non-Cancer Hazards

	Non-Cancer Hazard		Cancer Risk	
Pathway	**RME**	**CT**	**RME**	**CT**
Fish Ingestion - Adult Angler	**4.1**	0.33	**9.3E-05**	**1.2E-06**
Fish Ingestion - Young Child	**6.4**	0.52	**2.9E-05**	**1.3E-06**
Fish Ingestion - Older Child	**4.5**	0.36	**4.1E-05**	**1.3E-06**
Surface Sediments - Upper Geddes - Adult Recreational	0.180	0.020	**2.6E-05**	8.7E-07
Surface Sediments - Upper Geddes - Older Child Recreational	0.610	0.035	**7.8E-05**	**1.6E-06**
Surface Sediments - Upper Geddes - Construction Worker	0.133	0.120	**1.2E-06**	3.9E-07
Subsurface Sediments - Upper Geddes - Construction Worker	0.134	0.120	**1.2E-06**	3.9E-07
Surface Sediments - Lower Geddes - Adult Recreational	0.030	0.003	**5.3E-06**	1.8E-07
Surface Sediments - Lower Geddes - Older Child Recreational	0.106	0.006	**1.9E-05**	3.4E-07
Surface Sediments - Lower Geddes - Construction Worker	0.023	0.020	2.5E-07	6.9E-08
Subsurface Sediments - Lower Geddes - Construction Worker	0.213	0.111	**1.0E-06**	2.2E-07
Surface Sediments - Upper Ninemile - Adult Recreational	0.024	0.003	**1.5E-06**	4.9E-08
Surface Sediments - Upper Ninemile - Older Child Recreational	0.061	0.005	**4.0E-06**	9.0E-08
Surface Sediments - Upper Ninemile - Construction Worker	0.018	0.017	7.0E-08	2.4E-08
Subsurface Sediments - Upper Ninemile - Construction Worker	0.017	0.016	7.0E-08	2.4E-08
Surface Sediments - Lower Ninemile - Adult Recreational	0.035	0.004	**3.9E-06**	1.3E-07
Surface Sediments - Lower Ninemile - Older Child Recreational	0.132	0.007	**1.3E-05**	2.4E-07
Surface Sediments - Lower Ninemile - Construction Worker	0.026	0.023	1.8E-07	5.3E-08
Subsurface Sediments - Lower Ninemile - Construction Worker	0.032	0.028	2.1E-07	6.7E-08
Surface Soils - Lower Geddes - Adult Recreational	0.038	0.004	**1.5E-05**	5.0E-07
Surface Soils - Lower Geddes - Older Child Recreational	0.155	0.007	**5.7E-05**	9.5E-07
Surface Soils - Lower Geddes - Construction Worker	0.028	0.024	6.9E-07	1.8E-07
Subsurface Soils - Lower Geddes - Construction Worker	0.037	0.031	5.2E-07	1.3E-07
Surface Soils - Lower Ninemile - Adult Recreational	0.031	0.004	**5.6E-06**	1.9E-07
Surface Soils - Lower Ninemile - Older Child Recreational	0.118	0.006	**2.0E-05**	3.6E-07
Surface Soils - Lower Ninemile - Construction Worker	0.023	0.020	2.7E-07	7.4E-08
Subsurface Soils - Lower Ninemile - Construction Worker	0.022	0.020	2.9E-07	7.8E-08
Surface Water - Upper Geddes - Adult Recreational	0.003	0.0003	**9.1E-05**	**3.8E-06**
Surface Water - Upper Geddes - Older Child Recreational	0.004	0.0004	**4.3E-05**	**4.5E-06**
Surface Water - Upper Geddes - Construction Worker	0.0001	0.00004	2.7E-07	9.5E-08
Surface Water - Lower Geddes - Adult Recreational	0.048	0.0042	0.0E+00	0.0E+00
Surface Water - Lower Geddes - Older Child Recreational	0.068	0.0060	0.0E+00	0.0E+00
Surface Water - Lower Geddes - Construction Worker	0.001	0.0006	0.0E+00	0.0E+00
Surface Water - Upper Ninemile - Adult Recreational	0.056	0.0049	0.0E+00	0.0E+00
Surface Water - Upper Ninemile - Older Child Recreational	0.068	0.0059	0.0E+00	0.0E+00
Surface Water - Upper Ninemile - Construction Worker	0.002	0.0008	0.0E+00	0.0E+00
Surface Water - Lower Ninemile - Adult Recreational	0.028	0.0025	0.0E+00	0.0E+00
Surface Water - Lower Ninemile - Older Child Recreational	0.034	0.0030	0.0E+00	0.0E+00
Surface Water - Lower Ninemile - Construction Worker	0.001	0.0004	0.0E+00	0.0E+00

Notes: Hazard indices (HI) and cancer risks in **bold** exceed specified levels (HI > 1, cancer risk > 10^{-6})
CT = central tendency
RME = reasonable maximum exposure
Cancer risk of '0.0E+00' indicates no quantifiable risk (no carcinogenic COPCs detected)

Table 7-4. Summary of COPCs Contributing to Cancer Risks

Pathway	RME Cancer Risk	Principal Chemicals Contributing to Risk [1]
Fish Ingestion - Adult Angler	**9.3E-05**	PCDD/PCDFs; PCBs (total)
Fish Ingestion - Young Child	**2.9E-05**	PCDD/PCDFs; PCBs (total)
Fish Ingestion - Older Child	**4.1E-05**	PCDD/PCDFs; PCBs (total)
Surface Sediments - Upper Geddes - Adult Recreational	**2.6E-05**	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Geddes - Older Child Recreational	**7.8E-05**	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Geddes - Construction Worker	**1.2E-06**	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Upper Geddes - Construction Worker	**1.2E-06**	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Adult Recreational	**5.3E-06**	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Older Child Recreational	**1.9E-05**	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Construction Worker	2.5E-07	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Lower Geddes - Construction Worker	**1.0E-06**	Hexachlorobenzene; PCBs (total)
Surface Sediments - Upper Ninemile - Adult Recreational	**1.5E-06**	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Ninemile - Older Child Recreational	**4.0E-06**	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Ninemile - Construction Worker	7.0E-08	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Upper Ninemile - Construction Worker	7.0E-08	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Ninemile - Adult Recreational	**3.9E-06**	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface Sediments - Lower Ninemile - Older Child Recreational	**1.3E-05**	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface Sediments - Lower Ninemile - Construction Worker	1.8E-07	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface and Subsurface Sediments - Lower Ninemile - Construction Worker	2.1E-07	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface Soils - Lower Geddes - Adult Recreational	**1.5E-05**	Benzo(a)pyrene
Surface Soils - Lower Geddes - Older Child Recreational	**5.7E-05**	Benzo(a)pyrene
Surface Soils - Lower Geddes - Construction Worker	6.9E-07	Benzo(a)pyrene
Surface and Subsurface Soils - Lower Geddes - Construction Worker	5.2E-07	Benzo(a)pyrene; arsenic
Surface Soils - Lower Ninemile - Adult Recreational	**5.6E-06**	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Soils - Lower Ninemile - Older Child Recreational	**2.0E-05**	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Soils - Lower Ninemile - Construction Worker	2.7E-07	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface and Subsurface Soils - Lower Ninemile - Construction Worker	2.9E-07	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Water - Upper Geddes - Adult Recreational	**9.1E-05**	PCDD/PCDFs
Surface Water - Upper Geddes - Older Child Recreational	**4.3E-05**	PCDD/PCDFs
Surface Water - Upper Geddes - Construction Worker	2.7E-07	PCDD/PCDFs
Surface Water - Lower Geddes - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Geddes - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Geddes - Construction Worker	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Construction Worker	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Construction Worker	0.0E+00	No quantifiable risk

Notes: COPC – chemical of potential concern
RME – reasonable maximum exposure
Cancer risk of '0.0E+00' indicates no quantifiable risk (no carcinogenic COPCs detected)
(1) Principal chemicals contributing to risk are those accounting for 10 percent or more of risk.

Table 7-4. (cont.)

Pathway	CT Cancer Risk	Principal Chemicals Contributing to Risk [1]
Fish Ingestion - Adult Angler	**1.2E-06**	PCDD/PCDFs; PCBs (total); dieldrin
Fish Ingestion - Young Child	**1.3E-06**	PCDD/PCDFs; PCBs (total); dieldrin
Fish Ingestion - Older Child	**1.3E-06**	PCDD/PCDFs; PCBs (total); dieldrin
Surface Sediments - Upper Geddes - Adult Recreational	8.7E-07	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Geddes - Older Child Recreational	**1.6E-06**	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Geddes - Construction Worker	3.9E-07	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Upper Geddes - Construction Worker	3.9E-07	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Adult Recreational	1.8E-07	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Older Child Recreational	3.4E-07	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Geddes - Construction Worker	6.9E-08	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Lower Geddes - Construction Worker	2.2E-07	Arsenic; hexachlorobenzene; PCBs (total)
Surface Sediments - Upper Ninemile - Adult Recreational	4.9E-08	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Ninemile - Older Child Recreational	9.0E-08	Arsenic; benzo(a)pyrene
Surface Sediments - Upper Ninemile - Construction Worker	2.4E-08	Arsenic; benzo(a)pyrene
Surface and Subsurface Sediments - Upper Ninemile - Construction Worker	2.4E-08	Arsenic; benzo(a)pyrene
Surface Sediments - Lower Ninemile - Adult Recreational	1.3E-07	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface Sediments - Lower Ninemile - Older Child Recreational	2.4E-07	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface Sediments - Lower Ninemile - Construction Worker	5.3E-08	Arsenic; benzo(a)pyrene; hexachlorobenzene
Surface and Subsurface Sediments - Lower Ninemile - Construction Worker	6.7E-08	Arsenic; hexachlorobenzene; PCDD/PCDFs
Surface Soils - Lower Geddes - Adult Recreational	5.0E-07	Benzo(a)pyrene
Surface Soils - Lower Geddes - Older Child Recreational	9.5E-07	Benzo(a)pyrene
Surface Soils - Lower Geddes - Construction Worker	1.8E-07	Arsenic; benzo(a)pyrene
Surface and Subsurface Soils - Lower Geddes - Construction Worker	1.3E-07	Arsenic; benzo(a)pyrene
Surface Soils - Lower Ninemile - Adult Recreational	1.9E-07	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Soils - Lower Ninemile - Older Child Recreational	3.6E-07	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Soils - Lower Ninemile - Construction Worker	7.4E-08	Arsenic; benzo(a)pyrene
Surface and Subsurface Soils - Lower Ninemile - Construction Worker	7.8E-08	Arsenic; benzo(a)pyrene; dibenz(a,h)anthracene
Surface Water - Upper Geddes - Adult Recreational	**3.8E-06**	PCDD/PCDFs
Surface Water - Upper Geddes - Older Child Recreational	**4.5E-06**	PCDD/PCDFs
Surface Water - Upper Geddes - Construction Worker	9.5E-08	PCDD/PCDFs
Surface Water - Lower Geddes - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Geddes - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Geddes - Construction Worker	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Upper Ninemile - Construction Worker	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Adult Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Older Child Recreational	0.0E+00	No quantifiable risk
Surface Water - Lower Ninemile - Construction Worker	0.0E+00	No quantifiable risk

Notes: COPC – chemical of potential concern
CT – central tendency
Cancer risk of '0.0E+00' indicates no quantifiable risk (no carcinogenic COPCs detected)
(1) Principal chemicals contributing to risk are those accounting for 10 percent or more of CT risk.

Table 7-5. Summary of COPCs Contributing to Non-Cancer Hazards

Pathway	RME HI	Principal Chemicals Contributing to Hazard [(1)]
Fish Ingestion - Adult Angler	**4.1**	Highly chlorinated PCBs, mercury (as methylmercury)
Fish Ingestion - Young Child	**6.4**	Highly chlorinated PCBs, mercury (as methylmercury)
Fish Ingestion - Older Child	**4.5**	Highly chlorinated PCBs, mercury (as methylmercury)
Surface Sediments - Upper Geddes - Adult Recreational	0.180	Arsenic; thallium
Surface Sediments - Upper Geddes - Older Child Recreational	0.610	Arsenic; thallium
Surface Sediments - Upper Geddes - Construction Worker	0.133	Arsenic; thallium
Subsurface Sediments - Upper Geddes - Construction Worker	0.134	Arsenic; thallium
Surface Sediments - Lower Geddes - Adult Recreational	0.030	Arsenic; iron; manganese
Surface Sediments - Lower Geddes - Older Child Recreational	0.106	Highly chlorinated PCBs; arsenic
Surface Sediments - Lower Geddes - Construction Worker	0.023	Arsenic; iron; manganese
Subsurface Sediments - Lower Geddes - Construction Worker	0.213	Highly chlorinated PCBs
Surface Sediments - Upper Ninemile - Adult Recreational	0.024	Arsenic; iron; manganese
Surface Sediments - Upper Ninemile - Older Child Recreational	0.061	Arsenic; iron; manganese
Surface Sediments - Upper Ninemile - Construction Worker	0.018	Arsenic; iron; manganese
Subsurface Sediments - Upper Ninemile - Construction Worker	0.017	Arsenic; iron; manganese
Surface Sediments - Lower Ninemile - Adult Recreational	0.035	Highly chlorinated PCBs; mercury; hexachlorobenzene; arsenic
Surface Sediments - Lower Ninemile - Older Child Recreational	0.132	Highly chlorinated PCBs; hexachlorobenzene; arsenic
Surface Sediments - Lower Ninemile - Construction Worker	0.026	Highly chlorinated PCBs; mercury; hexachlorobenzene; arsenic
Subsurface Sediments - Lower Ninemile - Construction Worker	0.032	Highly chlorinated PCBs; mercury; hexachlorobenzene; arsenic
Surface Soils - Lower Geddes - Adult Recreational	0.038	Highly chlorinated PCBs; mercury; arsenic; iron
Surface Soils - Lower Geddes - Older Child Recreational	0.155	Highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Geddes - Construction Worker	0.028	Highly chlorinated PCBs; mercury; arsenic; iron
Subsurface Soils - Lower Geddes - Construction Worker	0.037	Highly chlorinated PCBs; mercury; arsenic; iron
Surface Soils - Lower Ninemile - Adult Recreational	0.031	Highly chlorinated PCBs; arsenic; iron; manganese
Surface Soils - Lower Ninemile - Older Child Recreational	0.118	Highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Ninemile - Construction Worker	0.023	Highly chlorinated PCBs; arsenic; iron; manganese
Subsurface Soils - Lower Ninemile - Construction Worker	0.022	Arsenic; iron
Surface Water - Upper Geddes - Adult Recreational	0.003	Antimony; manganese
Surface Water - Upper Geddes - Older Child Recreational	0.004	Antimony; manganese
Surface Water - Upper Geddes - Construction Worker	0.0001	Antimony; manganese
Surface Water - Lower Geddes - Adult Recreational	0.048	Chromium; thallium
Surface Water - Lower Geddes - Older Child Recreational	0.068	Chromium; thallium
Surface Water - Lower Geddes - Construction Worker	0.0011	Chromium; thallium
Surface Water - Upper Ninemile - Adult Recreational	0.056	Cadmium; chromium
Surface Water - Upper Ninemile - Older Child Recreational	0.068	Cadmium; chromium
Surface Water - Upper Ninemile - Construction Worker	0.002	Cadmium; chromium
Surface Water - Lower Ninemile - Adult Recreational	0.028	Antimony; cadmium; chromium
Surface Water - Lower Ninemile - Older Child Recreational	0.034	Antimony; cadmium; chromium
Surface Water - Lower Ninemile - Construction Worker	0.0008	Antimony; cadmium; chromium

Notes: COPC – chemical of potential concern
RME – reasonable maximum exposure
HI – hazard index
(1) Principal chemicals contributing to risk are those accounting for 10 percent or more of hazard.

Table 7-5. (cont.)

Pathway	CT HI	Principal Chemicals Contributing to Hazard [(1)]
Fish Ingestion - Adult Angler	0.33	Highly chlorinated PCBs, mercury (as methylmercury)
Fish Ingestion - Young Child	0.52	Highly chlorinated PCBs, mercury (as methylmercury)
Fish Ingestion - Older Child	0.36	Highly chlorinated PCBs, mercury (as methylmercury)
Surface Sediments - Upper Geddes - Adult Recreational	0.020	Arsenic; thallium
Surface Sediments - Upper Geddes - Older Child Recreational	0.035	Arsenic; thallium
Surface Sediments - Upper Geddes - Construction Worker	0.120	Arsenic; thallium
Subsurface Sediments - Upper Geddes - Construction Worker	0.120	Arsenic; thallium
Surface Sediments - Lower Geddes - Adult Recreational	0.003	Arsenic; iron; manganese
Surface Sediments - Lower Geddes - Older Child Recreational	0.006	Highly chlorinated PCBs; arsenic; iron; manganese
Surface Sediments - Lower Geddes - Construction Worker	0.020	Arsenic; iron; manganese
Subsurface Sediments - Lower Geddes - Construction Worker	0.111	Highly chlorinated PCBs
Surface Sediments - Upper Ninemile - Adult Recreational	0.003	Arsenic; iron; manganese
Surface Sediments - Upper Ninemile - Older Child Recreational	0.005	Arsenic; iron; manganese
Surface Sediments - Upper Ninemile - Construction Worker	0.017	Arsenic; iron; manganese
Subsurface Sediments - Upper Ninemile - Construction Worker	0.016	Arsenic; iron; manganese
Surface Sediments - Lower Ninemile - Adult Recreational	0.004	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Sediments - Lower Ninemile - Older Child Recreational	0.007	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Sediments - Lower Ninemile - Construction Worker	0.023	Mercury; arsenic; iron; manganese
Subsurface Sediments - Lower Ninemile - Construction Worker	0.028	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Geddes - Adult Recreational	0.004	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Geddes - Older Child Recreational	0.007	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Geddes - Construction Worker	0.024	Mercury; arsenic; iron
Subsurface Soils - Lower Geddes - Construction Worker	0.031	Mercury; highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Ninemile - Adult Recreational	0.004	Highly chlorinated PCBs; arsenic; iron; manganese
Surface Soils - Lower Ninemile - Older Child Recreational	0.006	Highly chlorinated PCBs; arsenic; iron
Surface Soils - Lower Ninemile - Construction Worker	0.020	Highly chlorinated PCBs; arsenic; iron; manganese
Subsurface Soils - Lower Ninemile - Construction Worker	0.020	Arsenic; iron; manganese
Surface Water - Upper Geddes - Adult Recreational	0.0003	Antimony; manganese
Surface Water - Upper Geddes - Older Child Recreational	0.0004	Antimony; manganese
Surface Water - Upper Geddes - Construction Worker	0.00004	Antimony; manganese
Surface Water - Lower Geddes - Adult Recreational	0.004	Chromium; Thallium
Surface Water - Lower Geddes - Older Child Recreational	0.006	Chromium; Thallium
Surface Water - Lower Geddes - Construction Worker	0.0006	Chromium; Thallium
Surface Water - Upper Ninemile - Adult Recreational	0.005	Cadmium; chromium
Surface Water - Upper Ninemile - Older Child Recreational	0.006	Cadmium; chromium
Surface Water - Upper Ninemile - Construction Worker	0.0008	Cadmium; chromium
Surface Water - Lower Ninemile - Adult Recreational	0.0025	Antimony; cadmium; chromium
Surface Water - Lower Ninemile - Older Child Recreational	0.003	Antimony; cadmium; chromium
Surface Water - Lower Ninemile - Construction Worker	0.0004	Antimony; cadmium; chromium

Notes: COPC – chemical of potential concern
CT – central tendency
HI – hazard index
(1) Principal chemicals contributing to risk are those accounting for 10 percent or more of CT hazard.

Table 7-6. Summary of Cancer Risks and Non-Cancer Hazards Exceeding Specified Levels

	Non-Cancer Hazard		Cancer Risk					
	HI > 1		Risk > 10^{-4}		Risk > 10^{-5}		Risk > 10^{-6}	
Pathway	**RME**	**CT**	**RME**	**CT**	**RME**	**CT**	**RME**	**CT**
Fish Ingestion - Adult Angler	**X**	--	--	--	**X**	--	**X**	**X**
Fish Ingestion - Young Child	**X**	--	--	--	**X**	--	**X**	**X**
Fish Ingestion - Older Child	**X**	--	--	--	**X**	--	**X**	**X**
Surface Sediments - Upper Geddes - Adult Recreational	--	--	--	--	**X**	--	**X**	--
Surface Sediments - Upper Geddes - Older Child Recreational	--	--	--	--	**X**	--	**X**	**X**
Surface Sediments - Upper Geddes - Construction Worker	--	--	--	--	--	--	**X**	--
Surface and Subsurface Sediments - Upper Geddes - Construction Worker	--	--	--	--	--	--	**X**	--
Surface Sediments - Lower Geddes - Adult Recreational	--	--	--	--	--	--	**X**	--
Surface Sediments - Lower Geddes - Older Child Recreational	--	--	--	--	**X**	--	**X**	--
Surface Sediments - Lower Geddes - Construction Worker	--	--	--	--	--	--	--	--
Surface and Subsurface Sediments - Lower Geddes - Construction Worker	--	--	--	--	--	--	**X**	--
Surface Sediments - Upper Ninemile - Adult Recreational	--	--	--	--	--	--	**X**	--
Surface Sediments - Upper Ninemile - Older Child Recreational	--	--	--	--	--	--	**X**	--
Surface Sediments - Upper Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface and Subsurface Sediments - Upper Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface Sediments - Lower Ninemile - Adult Recreational	--	--	--	--	--	--	**X**	--
Surface Sediments - Lower Ninemile - Older Child Recreational	--	--	--	--	**X**	--	**X**	--
Surface Sediments - Lower Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface and Subsurface Sediments - Lower Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface Soils - Lower Geddes - Adult Recreational	--	--	--	--	**X**	--	**X**	--
Surface Soils - Lower Geddes - Older Child Recreational	--	--	--	--	**X**	--	**X**	--
Surface Soils - Lower Geddes - Construction Worker	--	--	--	--	--	--	--	--
Surface and Subsurface Soils - Lower Geddes - Construction Worker	--	--	--	--	--	--	--	--
Surface Soils - Lower Ninemile - Adult Recreational	--	--	--	--	--	--	**X**	--
Surface Soils - Lower Ninemile - Older Child Recreational	--	--	--	--	**X**	--	**X**	--
Surface Soils - Lower Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface and Subsurface Soils - Lower Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface Water - Upper Geddes - Adult Recreational	--	--	--	--	**X**	--	**X**	**X**
Surface Water - Upper Geddes - Older Child Recreational	--	--	--	--	**X**	--	**X**	**X**
Surface Water - Upper Geddes - Construction Worker	--	--	--	--	--	--	--	--
Surface Water - Lower Geddes - Adult Recreational	--	--	--	--	--	--	--	--
Surface Water - Lower Geddes - Older Child Recreational	--	--	--	--	--	--	--	--
Surface Water - Lower Geddes - Construction Worker	--	--	--	--	--	--	--	--
Surface Water - Upper Ninemile - Adult Recreational	--	--	--	--	--	--	--	--
Surface Water - Upper Ninemile - Older Child Recreational	--	--	--	--	--	--	--	--
Surface Water - Upper Ninemile - Construction Worker	--	--	--	--	--	--	--	--
Surface Water - Lower Ninemile - Adult Recreational	--	--	--	--	--	--	--	--
Surface Water - Lower Ninemile - Older Child Recreational	--	--	--	--	--	--	--	--
Surface Water - Lower Ninemile - Construction Worker	--	--	--	--	--	--	--	--

Notes: X - Hazard indices (HI) and cancer risks exceed specified levels
-- - Hazard indices (HI) and cancer risks below specified levels
CT - central tendency
RME - reasonable maximum exposure

8. BASELINE ECOLOGICAL RISK ASSESSMENT

This chapter presents a summary of the baseline ecological risk assessment (BERA) report (TAMS, 2003a) for the remedial investigation and feasibility study (RI/FS) for the Geddes Brook/Ninemile Creek site. The objective of the BERA is to evaluate the potential for adverse ecological effects associated with current exposures to chemicals and stressors present in the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those contaminants (i.e., under the no action alternative).

For the purposes of the BERA, the Geddes Brook/Ninemile Creek site includes the following:

- Geddes Brook sediment and surface water from approximately 2,500 feet (ft) (760 meters [m]) upstream from its intersection with Gerelock Road to the point of discharge into Ninemile Creek and associated floodplain soil from its intersection with the West Flume to the point of discharge into Ninemile Creek.

- Ninemile Creek sediment and surface water from Amboy Dam to the point of discharge into Onondaga Lake and associated floodplain soil from its intersection with Geddes Brook to the point of discharge into Onondaga Lake.

- State and federal wetlands associated with the Geddes Brook/Ninemile Creek site (i.e., Wetland SYW-18 and Wetland SYW-10 east of Interstate 690 [I-690]). Wetland SYW-10 west of I-690 is being evaluated as part of the Maestri 2 site.

The BERA was structured to follow the USEPA Superfund risk assessment process as well as NYSDEC's Fish and Wildlife Impact Analysis (FWIA) guidance and consists of the following chapters and appendices:

- Chapter 1, Introduction – Discusses the general framework and format of the document.

- Chapter 2, Summary of Honeywell and Other Industrial Facilities and Environmental Investigations – Describes Honeywell facilities and related areas and other sites near Geddes Brook and Ninemile Creek, and environmental studies conducted at those areas.

- Chapter 3, Site Description (FWIA Step I) – Presents information about fish and wildlife resources in and near the Geddes Brook/Ninemile Creek site, describes fish and wildlife resource values, and identifies applicable fish and wildlife criteria.

- Chapter 4, Screening-Level Problem Formulation and Ecological Effects Evaluation (ERAGS Step 1) – Presents the initial screening-level steps of the ecological risk assessment, including the development of a preliminary site conceptual model and preliminary identification of chemicals of potential concern (COPCs) and stressors of potential concern (SOPCs), ecological receptors, and assessment and measurement endpoints.

- Chapter 5, Screening-Level Exposure Estimate and Risk Calculation (ERAGS Step 2) – Presents the results of screening-level risk calculations used to refine the list of COPCs/SOPCs carried forward in the risk assessment.

- Chapter 6, Baseline Risk Assessment Problem Formulation (ERAGS Step 3) – Presents the baseline risk assessment problem formulation; selects chemicals of concern (COCs) and stressors of concern (SOCs); characterizes ecological effects of contaminants; reviews information on contaminant fate and transport, complete exposure pathways, and ecosystems potentially at risk; selects assessment endpoints and measurement endpoints; and develops a conceptual model.

- Chapter 7, Study Design (ERAGS Steps 4 and 5) – Describes the study design by summarizing major components of the Geddes Brook/Ninemile Creek work plan and sampling, the 1998, 2001, and 2002 field investigations, and other sources of information.

- Chapter 8, Analysis of Ecological Exposures (ERAGS Step 6) – Characterizes chemicals and stressors in Geddes Brook/Ninemile Creek site media and presents an exposure characterization for ecological receptors.

- Chapter 9, Analysis of Ecological Effects (ERAGS Step 6) – Presents information on effects characterization. Site-specific field investigations and observations are discussed, evidence of existing impacts based on toxicity testing and benthic community analysis are presented, and toxicity reference values (TRVs) are selected for fish and wildlife receptors.

- Chapter 10, Risk Characterization (ERAGS Step 7) – Integrates information on exposure and effects to estimate potential risks. Each assessment endpoint is evaluated in regard to associated measurement endpoints.

- Chapter 11, Uncertainty Analysis (ERAGS Step 7) – Evaluates various sources of uncertainty in the risk assessment.

- Chapter 12, Conclusions – Summarizes the major findings of the ecological risk assessment.

- Chapter 13, References – Presents references for all documents and personal communications cited in the main body of the report.

- Appendix A – Review of Honeywell Sites and Other External Sources and Potential Source Areas.

- Appendix B – Ecological Assessment Checklist.

- Appendix C – New York Natural Heritage Program and US Fish and Wildlife Service Letters.

- Appendix D – Characteristics of Covertypes in the Geddes Brook/Ninemile Creek Area.

- Appendix E – Wetlands Delineation Report.

- Appendix F – Fish Spawning Habitat Survey.

- Appendix G – Screening Ecological Risk Assessment Tables.

- Appendix H – Exposure Concentration and Food-Web Model Calculations.

- Appendix I – Sampling Photo Logs (1998, 2001, and 2002).

- Appendix J – Exceedances of NYSDEC Sediment Quality Values.

- Appendix K – Calculation of Contaminant Group Sums.

The implementation of the BERA follows the Superfund risk assessment process specified by USEPA (1997a) to evaluate the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more contaminants or stressors (see text box below). The specifications of NYSDEC's Fish and Wildlife Impact Analysis (1994), particularly those specifications that are not identified by USEPA (1997a, 1998b), have been incorporated into the BERA, so that the relevant New York State guidance was accommodated within the structure recommended by USEPA.

The first seven steps of the Superfund ecological risk assessment process were completed from 1990 through the present, inclusive of the BERA (TAMS, 2003a), and the final step will be performed by NYSDEC and USEPA, with the assistance of NYSDOH, during the FS and Record of Decision (ROD) process.

The Eight Steps of the Superfund Ecological Risk Assessment Process

1.) Screening-level problem formulation and ecological effects evaluation.

2.) Screening-level preliminary exposure estimate and risk calculation.

3.) Baseline risk assessment problem formulation.

4.) Study design and data quality objectives.

5.) Field verification of sampling design.

6.) Site investigation and analysis of exposure and effects.

7.) Risk characterization.

8.) Risk management.

8.1 Site History and Description

Chapters 2 and 3 of the BERA summarize the history of the Honeywell facilities and associated disposal areas in the vicinity of the Geddes Brook/Ninemile Creek site as well as physical attributes of the site and adjoining areas. This information is presented in greater detail in Chapters 1 through 4 of this RI.

8.2 Screening-Level Problem Formulation and Screening

Problem formulation specific to the Geddes Brook/Ninemile Creek site was performed in the revised RI/FS work plan (NYSDEC, 2000a), based on a review of existing information. As part of the work plan, a conceptual site model was developed, preliminary COPCs and potential groups of representative ecological receptors were identified, potential assessment and measurement endpoints were discussed, and a sampling design was developed to collect the additional data needed to satisfy the BERA objectives. Several elements of the screening-level problem formulation have been refined since that time, based on information collected during the 1998, 2001, 2002, and other Honeywell field investigations, or by using information collected by other parties, such as NYSDEC. The field investigations conducted by Honeywell from 1990 to 2002 and by NYSDEC in 2002 address the site investigation portions of Steps 4 to 6 of the USEPA Superfund ecological risk assessment process.

The preliminary conceptual site model for the Geddes Brook/Ninemile Creek BERA, which was retained as the site conceptual model for the BERA, is presented in Figure 8-1 and identifies the following:

- Primary and secondary sources.
- Potential pathways.
- Major chemical/stressor groups.
- Potential exposure routes and receptors.
- Effects to be initially evaluated as part of the BERA.

Animals and plants are directly exposed to chemicals and stressors primarily from contaminated sediments, soils, and water of the Geddes Brook/Ninemile Creek site, and animals are indirectly exposed through ingestion of food (e.g., prey) containing contaminants.

8.3 Chemicals/Stressors of Concern

Numerous potentially toxic chemicals, including mercury, lead, manganese, zinc, hexachlorobenzene, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs), were detected at elevated concentrations in various Geddes Brook/Ninemile Creek site media. For each complete exposure pathway, a chemical-specific screening ecotoxicity value was selected to establish contaminant exposure levels that represent conservative thresholds for adverse ecological effects. COCs selected for water, surface sediment, surface soil, plants, fish, and wildlife receptors are presented in Tables 8-1 to 8-3. Geddes Brook/Ninemile Creek site soils were divided into four areas (i.e., Wetland SYW-10, Wetland SYW-18, three Ninemile Creek islands, and other area [i.e., floodplain] soils) for the BERA (Table 8-2). In addition, combined (all) soils were evaluated.

The BERA focuses on hazardous substances (i.e., metals and organic compounds) identified under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). For purposes of the BERA, these CERCLA-related substances (stressor chemicals) are referred to as COCs, whereas stressors, such as calcite, are referred to as SOCs.

8.4 Assessment Endpoints

Assessment endpoints are explicit expressions of the actual environmental values that are to be protected and focus a risk assessment on particular components of the ecosystem that could be adversely affected due to contaminants and stressors at the site. Assessment endpoints are often expressed in terms of populations or communities. Because mercury and some of the other COCs, such as PCBs, at the Geddes Brook/Ninemile Creek site are known to bioaccumulate, an emphasis was also placed on indirect exposure at various levels of the food chain to address COC-related risks at higher trophic levels. In addition, assessment endpoints were also selected for communities that may have been affected by stressors. The nine assessment endpoints that were selected for the Geddes Brook/Ninemile Creek BERA are:

- Sustainability (i.e., survival, growth, and reproduction) of a terrestrial plant community that can serve as a shelter and food source for local invertebrates and wildlife.

- Sustainability (i.e., survival, growth, and reproduction) of a benthic invertebrate community that can serve as a food source for local fish and wildlife.

- Sustainability (i.e., survival, growth, and reproduction) of local fish populations.

- Sustainability (i.e., survival, growth, and reproduction) of local amphibian and reptile populations.

- Sustainability (i.e., survival, growth, and reproduction) of local insectivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local piscivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local carnivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local insectivorous (aquatic and terrestrial insect phases) mammal populations.

- Sustainability (i.e., survival, growth, and reproduction) of local semi-piscivorous and piscivorous mammal populations.

8.5 Measurement Endpoints

Measurement endpoints provide the actual values used to evaluate each assessment endpoint. Measurement endpoints generally include measured or modeled concentrations of chemicals and stressors in water, sediment, fish, birds, and/or mammals, laboratory toxicity studies, and field observations. Measurement endpoints in relation to their respective assessment endpoints were phrased in relation to respective risk questions contained in the BERA. Each assessment endpoint in the BERA had at least two measurement endpoints that were used as lines of evidence. Measurement endpoints identified for the Geddes Brook/Ninemile Creek BERA include:

- Community structure (fish, amphibians, and reptiles) as compared to reference or historic communities.

- Laboratory toxicity studies measuring benthic invertebrate growth and survival.

- Benthic community indices, such as richness, abundance, diversity, and biomass.

- Fish spawning habitat survey.

- Observed fish abnormalities.

- Measured total COC body burdens in fish to determine exceedance of effect-level thresholds based on TRVs.

- Modeled total COC body burdens in wildlife receptors to determine exceedance of effect-level thresholds based on TRVs.

- Exceedance of water quality standards, criteria, and guidance for concentrations of COCs and SOCs in Geddes Brook/Ninemile Creek surface water that are protective of aquatic organisms, fish, and wildlife (see Section 3.5 of BERA Chapter 3, Site Description [FWIA Step I]).

- Exceedance of sediment criteria and guidance for concentrations of COCs in Geddes Brook/Ninemile Creek surface sediments that are protective of aquatic life (see BERA Chapter 3, Section 3.5).

- Exceedance of sediment and soil criteria and guidance for concentrations of COCs in sediments/soils that are protective of plant life, microbes, and invertebrates living in or on sediments and soils (see BERA Chapter 3, Section 3.5).

- Field observations.

8.6 Ecological Receptors

The risks to the environment were evaluated for receptors that were selected to be representative of various communities, feeding preferences, predatory levels, and aquatic and wetland habitats. Individual assessment endpoints were evaluated with a minimum of one "model" (receptor) species. The following receptors were selected for the Geddes Brook/Ninemile Creek BERA:

- Terrestrial plant community.

- Benthic invertebrate community.

- Fish: bluegill (*Lepomis macrochirus*); brook trout (*Salvelinus fontinalis)*; smallmouth bass (*Micropterus dolomieui*); and white sucker (*Catostomus commersoni*).

- Amphibian and reptile communities.

- Insectivorous birds: tree swallow (*Tachycineta bicolor*).

- Piscivorous birds: belted kingfisher (*Ceryle alcyon*) and great blue heron (*Ardea herodias*).

- Carnivorous birds: red-tailed hawk (*Buteo jamaicensis*).

- Insectivorous mammals: little brown bat (*Myotis lucifugus*) – aquatic invertebrates; short-tailed shrew (*Blarina brevicauda*) – terrestrial invertebrates.

- Semi-piscivorous and piscivorous mammals: mink (*Mustela vison*) and river otter (*Lutra canadensis*).

8.7 Exposure Assessment

The exposure assessment describes complete exposure pathways and exposure parameters. The contaminants and ecological components within the Geddes Brook/Ninemile Creek site were temporally and spatially characterized to obtain an exposure profile. The distribution of chemicals and stressors in each medium (i.e., surface water, surface [0 to 15 cm] sediments, surface [0 to 15 cm] soils, and fish) to which ecological receptors may be exposed was examined and exposure point concentrations (EPCs) were calculated. The 0 to 15 cm zone of surficial sediment and soil is considered to be the primary layer of exposure. However, deeper sediments and soils may be exposed by bioturbation as some invertebrates and small mammals are found at depth and where former depositional areas are eroding. Biota uptake and food-web exposure models were developed to calculate receptor exposure.

Receptor parameters, such as body weight, prey ingestion rate, home range, etc., were used in the food-web models to calculate COC dietary doses for wildlife. Exposure parameters were obtained from USEPA references and the scientific literature. The resulting exposure profiles for each receptor quantified the spatial and temporal patterns of exposure as they relate to the assessment endpoints and risk questions.

8.8 Effects Assessment

The effects assessment describes the methods used to characterize effects on aquatic and terrestrial organisms due to exposure to chemicals and stressors. Chemical exposure was evaluated using measures of toxicological effects (i.e., TRVs) that provide a basis for estimating whether the chemical exposure at a site is likely to result in adverse ecological effects. Exposure to stressors was evaluated using available literature and field observations.

For chemical exposure, TRVs were selected based on lowest observed adverse effects levels (LOAELs) and/or no observed adverse effects levels (NOAELs) from laboratory and/or field-based studies reported in the scientific literature. These TRVs examine the effects of COCs on the survival, growth, and reproduction of fish and wildlife species in the Geddes Brook/Ninemile Creek site. Reproductive effects (e.g., egg maturation, egg hatchability, and survival of juveniles) were generally the most sensitive exposure endpoints and were selected when available and appropriate.

8.9 Risk Characterization

Risk characterization integrates the exposure and effects assessments and examines the likelihood of adverse ecological effects occurring as a result of exposure to chemicals and/or stressors. The Geddes Brook/Ninemile Creek BERA employs a strength-of-evidence approach, using at least two lines of evidence to evaluate each assessment endpoint.

Toxicological risks were estimated by comparing the results of the exposure assessment (measured or modeled concentrations of chemicals in receptors of concern) to the TRVs developed in the effects assessment, resulting in a ratio of these two numbers, called a hazard quotient (HQ). HQs equal to or greater than 1.0 ($HQ \geq 1$) are typically considered to indicate potential risk (e.g., reduced or impaired reproduction or recruitment) to ecological receptors, while HQs less than 1.0 indicate that ecological risk is unlikely. The HQs provide insight into the potential for adverse effects upon individual animals in the local population resulting from chemical exposure. If an HQ suggests that effects are not expected to occur for the average individual, then they are probably insignificant at the population level. However, if an HQ suggests that risks are present for the average individual, then risks may be present for the local population.

Other measurement endpoints, such as field observations and toxicity studies, were evaluated in conjunction with toxicological risks on a receptor-specific basis. Use of at least two lines of evidence resulted in the following risk characterizations for each assessment endpoint.

8.9.1 Sustainability (i.e., Survival, Growth, and Reproduction) of a Terrestrial Plant Community That Can Serve as a Shelter and Food Source for Local Invertebrates and Wildlife

Sustainability of a terrestrial plant community that can serve as a shelter and food source for local invertebrates and wildlife was assessed using two lines of evidence. The first was field observations of the Geddes Brook/Ninemile Creek terrestrial plant community. Only obvious effects, such as the sparse vegetation found on the wastebeds and reduced wetlands near wastebeds around Ninemile Creek, can be directly attributed to activities at Honeywell facilities (i.e., disposal of Solvay and other industrial wastes).

The second was to compare surface soil concentrations to plant toxicity values. Comparisons of soil chemical concentrations to plant toxicity values indicate that high levels of contaminants, and mercury in particular, may adversely affect the plant community and, subsequently, local invertebrates and wildlife that live or forage in local habitats. These results suggest the potential for adverse effects on plants via exposure to COCs in soils at all four areas examined (i.e., Wetlands SYW-10 and SYW-18, Ninemile Creek islands, and other area soils) and combined soils.

8.9.2 Sustainability (i.e., Survival, Growth, and Reproduction) of a Benthic Invertebrate Community That Can Serve as a Food Source for Local Fish and Wildlife

The potential effect of COCs and SOCs on the benthic community in Geddes Brook and Ninemile Creek was evaluated using the following four lines of evidence: exceedance of water quality standards, criteria, and guidance; benthic community metrics analysis; sediment toxicity testing; and exceedance of sediment quality guidelines.

Concentrations of some chemicals in Geddes Brook and Ninemile Creek water were found to exceed surface water standards, criteria, and guidance in parts of the site. Chloride (an SOC) water quality standards were exceeded in the West Flume, Geddes Brook below the confluence with the West Flume, Ninemile Creek below Wastebed 11, and the unnamed tributary. The very high concentrations of Honeywell's ionic wastes in the Geddes Brook/Ninemile Creek site result in contravention of several of the New York State narrative water quality standards (6 NYCRR Part 703.2), including the prohibitions for turbidity and for suspended, colloidal, or settleable solids. These contraventions are evidenced by recent observations, including a substantial visible contrast over background, the ease of resuspension of the sediments, the large white plumes that result from minimal disturbances (e.g., normal stream flow, animals walking through the stream), and the calcite crust that has formed in several sections of the stream. The large quantities of ionic waste constituents that have entered Geddes Brook and Ninemile Creek may have adversely impacted both aquatic benthic invertebrate and aquatic macrophyte habitat in these water bodies.

The benthic invertebrate community metrics analyzed in the BERA included taxa richness, dominance, abundance of indicator species, species diversity, and percent model affinity (PMA). The analysis of these metrics showed that many of the benthic invertebrate communities living in Geddes Brook and Ninemile Creek in 1998 were impaired to some degree. NYSDEC's analysis of the benthic communities in 1989 and 1990 also found that stations in Geddes Brook and Ninemile Creek were impaired. Overall, the results of the benthic community analysis indicate that the Geddes Brook/Ninemile Creek site downstream from the wastebeds is impaired.

Based on the 1998 toxicity tests, amphipod toxicity was confined to the farthest downstream location in Geddes Brook and the farthest downstream section of Ninemile Creek. Chironomid toxicity was found at all sampling stations, except at one station in upper Ninemile Creek upstream of Amboy Dam. These results indicate that Geddes Brook/Ninemile Creek site sediments, particularly in the lower reaches of the two water bodies, are toxic to benthic invertebrates.

COCs in sediments exceeded NYSDEC sediment criteria throughout lower Geddes Brook (downstream of the confluence with the West Flume) and lower Ninemile Creek (downstream of the confluence with Geddes Brook). Concentrations of mercury and lead in Geddes Brook/Ninemile Creek site sediments exceeded both lowest effect level (LEL) and severe effect level (SEL) concentrations. Arsenic, copper, manganese, nickel, and zinc generally exceeded LELs, but not SELs. Sediment criteria for organic COCs were also exceeded throughout lower Geddes Brook and lower Ninemile Creek.

All four lines of evidence suggest an adverse effect from COCs and SOCs on the benthic invertebrate populations in the Geddes Brook/Ninemile Creek site, particularly in lower Geddes Brook and lower Ninemile Creek. Based on these analyses, it can be concluded that local fish and wildlife populations using the benthic invertebrate community as a food source are also likely to be impacted.

8.9.3 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Fish Populations

The sustainability of local fish populations was assessed using six lines of evidence. The first was to examine the fish community structure as compared to historical accounts of Geddes Brook and Ninemile Creek in relation to the health of local fish populations. The second was to look for potential effects of chemicals/stressors on fish spawning habitat. The third was to observe possible visual abnormalities (e.g., tumors, lesions) in Geddes Brook/Ninemile Creek site fish. The fourth was to compare measured water column concentrations to water quality criteria for the protection of aquatic life. The fifth was to compare measured sediment concentrations to criteria for the protection of aquatic life for benthic-dwelling species of fish. The sixth and final line of evidence was to compare measured concentrations of chemicals in fish representing various feeding strategies and trophic levels to TRVs.

Risks to fish from chemicals were evaluated on a species-specific basis using measured body burdens for four fish species representing the Geddes Brook/Ninemile Creek fish community (Table 8-4). HQs greater than 1.0 were calculated for the following chemicals (by species):

- **Bluegill** – arsenic, methylmercury, selenium, and zinc.
- **Brook trout** – methylmercury, selenium, and zinc.
- **Smallmouth bass** – arsenic, methylmercury, PCDD/PCDFs, selenium, and zinc.
- **White sucker** – arsenic, methylmercury, PCDD/PCDFs, and selenium.

Contaminant levels in Geddes Brook/Ninemile Creek site fish were greater than those in background fish. All COCs in fish are considered to be site-related.

The very high concentrations of Honeywell's ionic wastes in the Geddes Brook/Ninemile Creek site result in contravention of several of the New York State narrative water quality standards, including the prohibitions for turbidity and for suspended, colloidal, or settleable solids. Historical studies have shown that the massive quantities of ionic wastes discharged to the Geddes Brook/Ninemile Creek site precluded fish survival in the past. Current effects of ionic waste constituents on fish populations are likely to be limited to a reduction of foraging and spawning habitat.

Five of the six lines of evidence (historical accounts, fish spawning habitat survey, measured surface water concentrations, measured sediment concentrations, and measured concentrations of chemicals in fish) suggest adverse effects of COCs on the Geddes Brook/Ninemile Creek site fish community. The remaining line of evidence, incidence of visual abnormalities, was inconclusive. This strength-of-evidence approach suggests that local fish populations are adversely affected by the contaminants and stressors present in the Geddes Brook/Ninemile Creek site.

8.9.4 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Amphibian and Reptile Populations

Sustainability of local amphibian and reptile populations was assessed using two lines of evidence. The first was to conduct a field survey of local amphibian and reptile populations around Onondaga Lake, including lower Ninemile Creek. The second was to compare measured surface water concentrations to water quality criteria for the protection of aquatic life.

The two lines of evidence, based partially on Onondaga Lake studies, indicate that amphibian and reptile populations have been adversely affected by contaminants and/or stressors found in Onondaga Lake water. As many of the same chemicals and stressors are found in Onondaga Lake and Geddes Brook/Ninemile Creek site water, the Onondaga Lake lines of evidence, in combination with measured Geddes Brook/Ninemile Creek site surface water concentrations, indicate that amphibian and reptile populations may have been adversely affected by contaminants and/or stressors found in Geddes Brook/Ninemile Creek site water.

8.9.5 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Insectivorous Bird Populations

Sustainability of local insectivorous bird populations was assessed using three lines of evidence. The first was modeling dietary doses of chemicals in an insectivorous bird (tree swallow). The second was to compare measured surface water concentrations to water quality standards, criteria, and guidance for the protection of wildlife. The third line of evidence was field-based observation.

The first line of evidence indicates that insectivorous birds may be adversely affected by contaminants found in the Geddes Brook/Ninemile Creek site and taken up by aquatic invertebrates (Table 8-5). In particular, mercury HQs were greater than 1.0 for the full point estimate range of risk (i.e., based on exceedances of both NOAELs and LOAELs using both 95 percent upper confidence limit [UCL] and mean concentrations). The second and third lines of evidence, comparisons of water concentrations to standards, criteria, and guidance and field observations, are inconclusive, primarily because of lack of water quality bioaccumulation values and field data.

8.9.6 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Piscivorous Bird Populations

Sustainability of local piscivorous bird populations was assessed using three lines of evidence. The first was modeling dietary doses of chemicals for two piscivorous species with different feeding methods and preferences (belted kingfisher and great blue heron). The second was to compare measured water column concentrations to water quality standards, criteria, and guidance for the protection of wildlife. The third line of evidence was field-based observation.

The first line of evidence indicates that piscivorous birds may be adversely affected by contaminants found in the Geddes Brook/Ninemile Creek site, and in particular by mercury, for which HQs were greater than 1.0 for the full point estimate range of risk and were over an order-of-magnitude greater than the NOAELs (Table 8-5). The second and third lines of evidence, comparisons of water concentrations to standards, criteria, and guidance and field observations, are inconclusive, primarily because of lack of water quality bioaccumulation values and field data.

8.9.7 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Carnivorous Bird Populations

Sustainability of local carnivorous bird populations was assessed using two lines of evidence. The first was modeling dietary doses of chemicals in a carnivorous bird (red-tailed hawk) and the second was field-based observation. Modeled methylmercury exceeded the NOAEL at both 95 percent UCL and mean concentrations (Table 8-5). Total PAH exposure dose concentrations exceeded the NOAEL at both 95 percent UCL and mean concentrations and exceeded the LOAEL at the 95 percent UCL, but concentrations of total PAHs were similar to those detected in reference areas. These results indicate that carnivorous birds may be adversely affected via exposure to methylmercury at the Geddes Brook/Ninemile Creek site. Risks from PAHs are similar to risks present at reference locations. The second line of evidence, field observations, is inconclusive primarily because of lack of field data.

8.9.8 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Insectivorous (Aquatic and Terrestrial Insect Phases) Mammal Populations

Sustainability of local insectivorous mammal populations was assessed using three lines of evidence. The first was modeling dietary doses of chemicals in two insectivorous mammals (little brown bat and short-tailed shrew). The second was to compare measured surface water concentrations to water quality criteria for the protection of wildlife. The third line of evidence was field-based observation.

Modeled dose concentrations of hexachlorobenzene for the little brown bat exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure concentrations (i.e., across the entire range of exposure) (Table 8-6). These results suggest the potential for adverse effects on insectivorous mammals, via exposure to hexachlorobenzene, through consumption of invertebrate prey with an aquatic life phase.

Insectivorous mammals feeding on terrestrial invertebrates in Wetlands SYW-10 and SYW-18, Ninemile Creek islands, and other area soils in the floodplain may also be adversely affected by chemicals found in the Geddes Brook/Ninemile Creek site. Risks for the short-tailed shrew varied by wetland area, with Wetland SYW-10 (at the mouth of Ninemile Creek) having the greatest number of COCs with HQs above 1.0 (Table 8-7). In all four areas, risks from exposure to methylmercury, hexachlorobenzene, and total PAHs were greater than 1.0 for the full point estimate range of risk. Concentrations of total PAHs were similar to those found at reference locations. The second and third lines of evidence, comparisons of water concentrations to standards, criteria, and guidance and field observations, are inconclusive primarily because of lack of water quality bioaccumulation values and field data.

8.9.9 Sustainability (i.e., Survival, Growth, and Reproduction) of Local Semi-piscivorous and Piscivorous Mammal Populations

The sustainability of local semi-piscivorous and piscivorous mammal populations was assessed using three lines of evidence. The first was modeling dietary doses of chemicals in semi-piscivorous and piscivorous mammals (mink and river otter, respectively). The second was to compare measured surface water concentrations to water quality criteria for the protection of wildlife. The third line of evidence was field-based observation.

The first line of evidence indicates that semi-piscivorous and piscivorous mammals feeding around Geddes Brook and Ninemile Creek may be adversely affected by contaminants found in the Geddes Brook/Ninemile Creek site, and in particular by methylmercury, hexachlorobenzene, and total PCBs (Table 8-6). The second and third lines of evidence, comparisons of water concentrations to standards, criteria, and guidance and field observations, are inconclusive primarily because of lack of water quality bioaccumulation values and field data.

8.10 Uncertainties

To integrate the various components of the BERA, the results of the risk characterization and associated uncertainties were evaluated to assess the risk of adverse effects to Geddes Brook/Ninemile Creek site receptors as a result of exposure to chemicals and stressors originating in the Geddes Brook/Ninemile Creek watershed. Uncertainty exists because of data limitations (e.g., extrapolating between species for TRVs) and natural variability (e.g., fish tissue concentrations, ingestion rates).

Uncertainty is an inherent component of risk assessments. Elements of uncertainty in the BERA were identified in BERA Chapter 11 and efforts were made to minimize them. For components in which a moderate degree of uncertainty was unavoidable (e.g., sampling data), efforts were made to minimize any systematic bias associated with the data. Small mammal uptake factors for methylmercury and other COCs may have been underestimated due to the lack of chemical data on uptake by insectivorous receptors, thereby underestimating risks to receptors feeding on small mammals (e.g., red-tailed hawk, mink). The Geddes Brook/Ninemile Creek BERA uses various point estimates of exposure and response to develop a range of point estimates of risk (i.e., 95 percent UCL, mean, NOAEL, and LOAEL) to aid in judging the ecological significance of risks and to evaluate potential uncertainties inherent in the BERA.

8.11 Conclusions

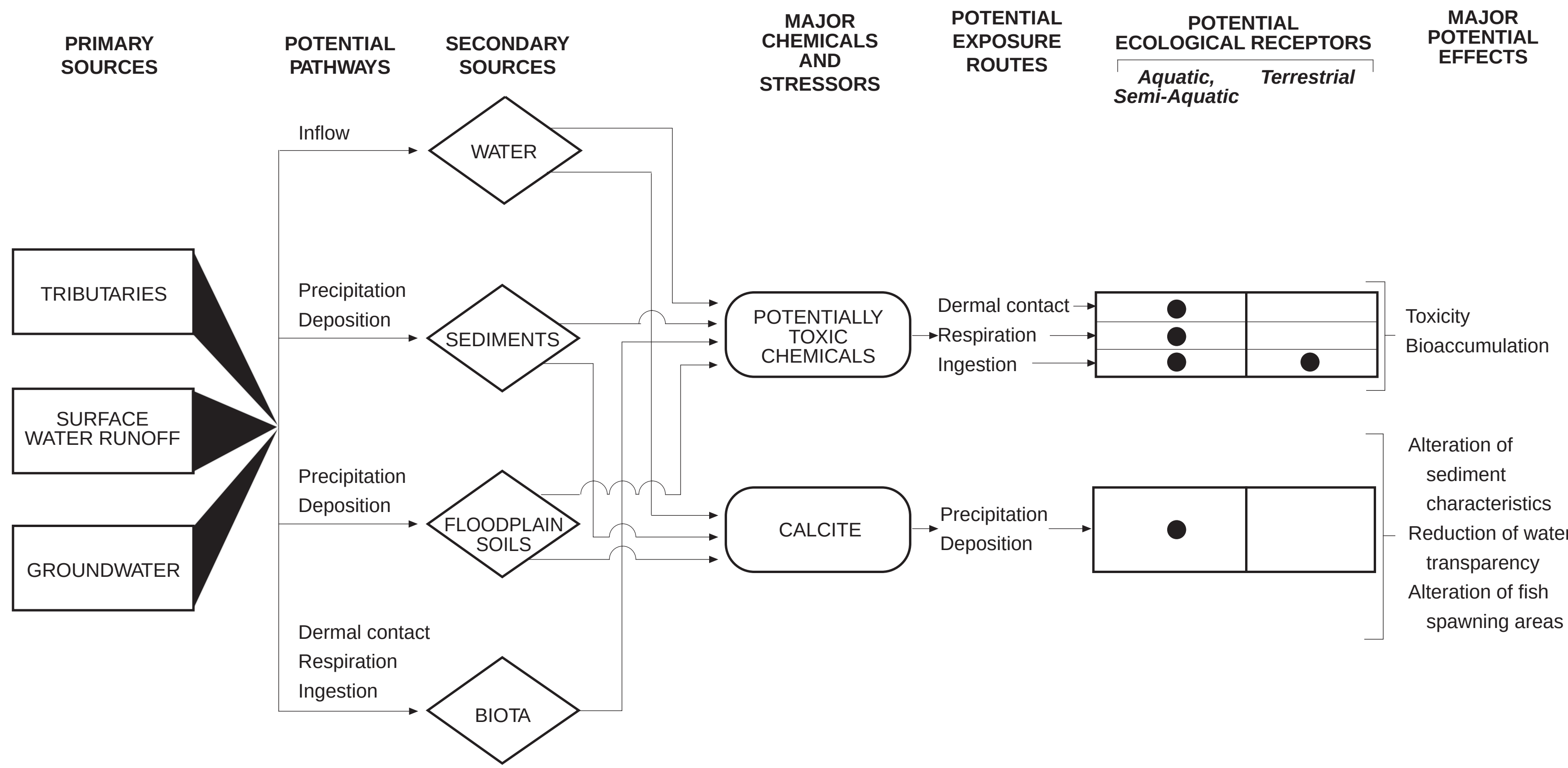
Multiple lines of evidence were used to evaluate major components of the Geddes Brook/Ninemile Creek site ecosystem to determine if site contamination has adversely affected plants and animals in and around Geddes Brook and Ninemile Creek. Many of the lines of evidence indicate that the Honeywell-related contaminants in the Geddes Brook/Ninemile Creek site have produced adverse ecological effects at all trophic levels examined. Honeywell's ionic wastes have also impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the streams for feeding or spawning.

Exceedances of water quality standards, criteria, and guidance (including narrative water quality standards), sediment criteria, and the results of benthic invertebrate toxicity tests and community analyses suggest that adverse effects to benthic invertebrates will frequently occur in lower Geddes Brook and lower Ninemile Creek.

There has been bioaccumulation of mercury and possibly other chemicals (e.g., hexachlorobenzene, total PCBs) in many organisms serving as a food source, such as fish, and, most likely in lower trophic-level organisms (e.g., aquatic and terrestrial invertebrates). Concentrations of these bioaccumulative chemicals tend to increase in higher trophic-level animals, exposing them to the contaminants at levels greater than seen in individual media.

Comparisons of measured tissue concentrations and modeled doses (i.e., intake) of chemicals to TRVs show exceedances of HQs for site-related chemicals throughout the range of the point estimates of risk. Many of the contaminants in the Geddes Brook/Ninemile Creek site are persistent and, therefore, the ecological risks associated with these contaminants are unlikely to decrease significantly in the short term in the absence of remediation. The various field studies performed on site indicate that contaminant levels have not decreased substantially in some of the site media (i.e., sediments, soils, fish) over the last 15 years.

On the basis of these comparisons, it has been determined through the BERA that all receptors evaluated are at risk due to contamination at the Geddes Brook/Ninemile Creek site. These receptors, representing various trophic levels and feeding preferences, indicate either impacts or potential impacts to most of the Geddes Brook and Ninemile Creek ecological community.



Source: Modified from Exponent, 2001a

Figure 8-1. Conceptual Site Model for the Baseline Ecological Risk Assessment for Geddes Brook and Ninemile Creek

Table 8-1. Chemicals and Stressors of Concern Selected in the BERA for Geddes Brook/Ninemile Creek Media

Chemical	Water	Sediment	Plants	Fish
Metals				
Arsenic		•	•	•
Barium	•			
Chromium			•	
Copper		•		
Lead	•	•	•	
Manganese	•	•		
Mercury/Methylmercury	•	•	•	•
Nickel		•		
Selenium			•	•
Thallium			•	
Vanadium			•	
Zinc		•	•	•
Volatile Organic Compounds				
Dichlorobenzenes (Sum)		•		
Carbon disulfide		•		
Methylene chloride		•		
Semivolatile Organic Compounds				
Bis(2-ethylhexyl)phthalate		•		
Hexachlorobenzene		•		
2-Methylphenol		•		
Phenol		•		
Polycyclic aromatic hydrocarbons (total)		•		
Pesticides/Polychlorinated Biphenyls				
Chlordane isomers		•		
DDT and metabolites		•		•
Endosulfans (sum)		•		
Heptachlor and heptachlor epoxide		•		
Polychlorinated biphenyls (total)		•		•
Dioxins/Furans				
PCDD/PCDFs (total)				•
Other Substances/Stressors				
Calcite		•		
Chloride	•			
Sodium	•			
Total dissolved solids	•			

Notes: • – Chemicals and stressors of concern assessed in the BERA for the specific media listed. Other substances were qualitatively evaluated as stressors of concern.

Table 8-2. Chemicals of Concern Selected in the BERA for Geddes Brook/Ninemile Creek Soils

Chemical	Combined Soils	Wetland SYW-18	Wetland SYW-10	Island Soils	Other Areas
Metals					
Arsenic	•	•	•		•
Cadmium	•				•
Chromium	•	•	•	•	•
Copper	•	•	•	•	•
Iron	•	•	•	•	•
Lead	•	•	•		•
Manganese	•	•	•	•	•
Mercury/Methylmercury	•	•	•	•	•
Nickel	•	•	•		
Selenium	•	•	•		•
Thallium	•	•	•		•
Vanadium	•	•	•	•	•
Zinc	•	•	•	•	•
Semivolatile Organic Compounds					
Hexachlorobenzene	•	•	•	•	•
Phenol	•	•			•
Polycyclic aromatic hydrocarbon (total)	•	•	•	•	•
Pesticides/Polychlorinated Biphenyls					
Chlordane isomers	•				•
DDT and metabolites	•	•	•	•	•
Dieldrin	•	•			•
Endrin	•				•
Heptachlor and heptachlor epoxide	•	•		•	
Polychlorinated biphenyls (total)	•	•	•	•	•
Dioxins/Furans					
PCDD/PCDFs (TEQ)	•	•	•		•

Notes: • – Chemicals of concern assessed in the BERA for the specific media listed.
Combined soils include all wetland, island, and other area soils.
TEQ – toxicity equivalent

Table 8-3. Chemicals of Concern for Wildlife Species Evaluated for the Geddes Brook/Ninemile Creek BERA

Chemical	Tree Swallow	Belted Kingfisher	Great Blue Heron	Red-Tailed Hawk	Little Brown Bat	Short-Tailed Shrew	Mink	River Otter
Metals								
Arsenic	•				•	•	•	•
Barium	•				•	•		
Cadmium						•		
Chromium	•				•	•		
Cobalt					•			
Copper	•				•			
Lead	•			•	•	•		
Mercury/Methylmercury	•	•	•	•	•	•	•	•
Nickel	•				•			
Selenium	•	•			•	•	•	•
Thallium	•	•			•	•	•	•
Vanadium					•	•	•	
Zinc	•	•	•		•			
Semivolatile Organic Compounds								
Hexachlorobenzene	•			•	•	•	•	
Polycyclic aromatic hydrocarbon (total)	•			•	•	•	•	
Pesticides/Polychlorinated Biphenyls								
Chlordanes						•	•	
DDT and metabolites		•	•	•				
Dieldrin				•		•	•	
Endrin				•		•		
Polychlorinated biphenyls (total)	•	•	•	•	•	•	•	•
Dioxins/Furans								
PCDD/PCDFs (TEQ)	•	•		•	•	•	•	•

Notes:

• – Chemicals of concern assessed in the BERA for the specific receptor listed.

TEQ – toxicity equivalent

Table 8-4. Hazard Quotients for Measured Geddes Brook/Ninemile Creek Fish Concentrations

COC	Bluegill 95%UCL HQ NOAEL	Bluegill 95%UCL HQ LOAEL	Bluegill Mean HQ (NOAEL)	Bluegill Mean HQ (LOAEL)	Brook Trout 95%UCL HQ (NOAEL)	Brook Trout 95%UCL HQ (LOAEL)	Brook Trout Mean HQ (NOAEL)	Brook Trout Mean HQ (LOAEL)
Metals								
Arsenic	**1.2**	0.5	**1.4**	0.5	ND	ND	ND	ND
Mercury	**1.9**	0.6	**1.6**	0.5	**2.1**	0.7	**1.5**	0.5
Methylmercury	**4.5**	**1.5**	**2.5**	0.8	**4.2**	**1.4**	**1.5**	0.5
Selenium	**12**	**1.2**	**7.3**	0.7	**11**	**1.1**	**9.0**	**9.0**
Zinc	**4.0**	**3.4**	**1.3**	**1.1**	**1.2**	**1.0**	0.8	0.8
Pesticides/Polychlorinated Biphenyls								
DDT and metabolites	2.2E-02	4.6E-03	2.0E-02	4.1E-03	2.3E-02	4.8E-03	1.2E-02	1.2E-02
PCBs (Sum)	0.2	3.1E-02	0.1	2.9E-02	0.2	3.2E-02	0.1	6.3E-02
Dioxin/Furans								
PCDD/PCDFs (TEQ) Fish	0.8	0.4	0.6	0.3	0.4	0.2	0.2	0.2

Table 8-4. (cont.)

COC	Smallmouth Bass 95%UCL HQ NOAEL	Smallmouth Bass 95%UCL HQ LOAEL	Smallmouth Bass Mean HQ NOAEL	Smallmouth Bass Mean HQ LOAEL	White Sucker 95%UCL HQ (NOAEL)	White Sucker 95%UCL HQ (LOAEL)	White Sucker Mean HQ (NOAEL)	White Sucker Mean HQ (LOAEL)
Metals								
Arsenic	**2.2**	0.8	0.9	0.3	**1.3**	0.5	0.6	0.2
Mercury	**7.5**	**2.5**	**7.5**	**2.5**	**7.5**	**2.5**	**7.5**	**2.5**
Methylmercury	**28**	**9.4**	**16**	**5.2**	**4.4**	**1.5**	**3.2**	**1.1**
Selenium	**17**	**1.7**	**10**	**1.0**	**12**	**1.2**	**7.7**	0.8
Zinc	**1.2**	0.99	0.5	0.4	0.5	0.5	0.5	0.4
Pesticides/Polychlorinated Biphenyls								
DDT and metabolites	0.1	2.6E-02	4.4E-02	9.1E-03	1.6E-02	3.4E-03	7.3E-03	1.5E-03
PCBs (Sum)	0.3	0.1	0.2	0.0	0.2	4.4E-02	0.1	1.2E-02
Dioxin/Furans								
PCDD/PCDFs (TEQ) Fish	**1.2**	0.6	0.7	0.3	**4.1**	**2.0**	0.6	0.3

Notes: NA = Not Available; NS = Not selected as a COC for this receptor.
Hazard quotients equal to or greater than one are outlined and bolded.
TEQ – toxicity equivalent

Table 8-5. Hazard Quotients for Modeled Avian Exposure

COC	Tree Swallow				Belted Kingfisher				Great Blue Heron				Red-Tailed Hawk			
	95% UCL HQ NOAEL/LOAEL		Mean HQ NOAEL/LOAEL		95% UCL HQ NOAEL/LOAEL		Mean HQ NOAEL/LOAEL		95% UCL HQ NOAEL/LOAEL		Mean HQ NOAEL/LOAEL		95% UCL HQ NOAEL/LOAEL		Mean HQ NOAEL/LOAEL	
Total Metals																
Arsenic	7.2E-04	2.4E-04	0.1	4.2E-02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Barium	1.6E-02	8.0E-03	1.6E-02	7.8E-03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chromium	0.2	3.5E-02	0.2	3.4E-02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Copper	3.5E-02	2.7E-02	3.4E-02	2.6E-02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lead	0.6	6.4E-02	0.5	5.2E-02	NS	NS	NS	NS	NS	NS	NS	NS	0.3	2.8E-02	0.3	2.7E-02
Methylmercury	0.2	2.0E-02	0.2	1.7E-02	**70**	**7.0**	**21**	**2.1**	**38**	**3.8**	**17**	**1.7**	**1.6**	0.2	**1.1**	0.1
Mercury	**6.2**	**3.1**	**2.9**	**1.4**	0.5	0.2	0.3	0.1	0.2	0.1	0.2	0.1	0.7	0.3	0.5	0.3
Nickel	3.3E-03	2.4E-03	3.3E-03	2.4E-03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Selenium	0.2	0.1	0.3	0.1	**1.2**	0.6	0.98	0.5	NS	NS	NS	NS	NS	NS	NS	NS
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NS	NS	NS	NS	NS	NS	NS	NS
Zinc	0.1	1.3E-02	0.1	1.3E-02	**2.6**	0.3	**2.0**	0.2	0.5	0.1	0.4	0.0	NS	NS	NS	NS
Semivolatile Organic Compounds																
Hexachlorobenzene	**8.8**	0.9	**3.2**	0.3	NS	NS	NS	NS	NS	NS	NS	NS	0.2	1.5E-02	0.1	7.1E-03
Polycyclic aromatic hydrocarbons	**33**	**3.3**	**7.8**	0.8	NS	NS	NS	NS	NS	NS	NS	NS	**10**	**1.0**	**7.8**	0.8
Pesticides/Polychlorinated Biphenyls																
DDT and metabolites	NS	NS	NS	NS	**3.0**	0.3	**2.6**	0.3	**9.1**	0.9	**11**	**1.1**	0.1	8.8E-03	0.1	7.4E-03
Dieldrin	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.2E-03	2.2E-04	2.1E-03	2.1E-04
Endrin	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9E-02	2.9E-03	2.5E-02	2.5E-03
Polychlorinated biphenyls (PCBs)	0.6	5.7E-02	0.6	5.6E-02	0.99	0.1	0.9	0.1	0.7	6.8E-02	0.8	7.6E-02	4.1E-02	4.1E-03	3.6E-02	3.6E-03
Dioxins/Furans																
PCDD/PCDFs (TEQ) avian	0.8	7.6E-02	0.3	2.7E-02	0.3	2.7E-02	0.2	2.1E-02	NS	NS	NS	NS	0.1	6.7E-03	4.5E-02	4.5E-03

Notes: NA = Not Available; NS = Not selected as a COC for this receptor.

Hazard quotients equal to or greater than one are outlined and bolded.

TEQ – toxicity equivalent

Table 8-6. Hazard Quotients for Modeled Mammalian Exposure

	Little Brown Bat				Mink				River Otter			
	95% UCL HQ		Mean HQ		95% UCL HQ		Mean HQ		95% UCL HQ		Mean HQ	
COC	NOAEL/LOAEL		NOAEL/LOAEL		NOAEL/LOAEL		NOAEL/LOAEL		NOAEL/LOAEL		NOAEL/LOAEL	
Total Metals												
Arsenic	**1.0**	0.1	0.95	0.1	0.7	0.1	0.6	0.1	0.7	6.9E-02	0.6	6.1E-02
Barium	3.1E-03	1.9E-03	3.0E-03	1.8E-03	NS	NS	NS	NS	NS	NS	NS	NS
Chromium	2.0E-02	5.1E-03	2.0E-02	5.0E-03	NS	NS	NS	NS	NS	NS	NS	NS
Cobalt	0.2	0.1	0.2	0.1	NS	NS	NS	NS	NS	NS	NS	NS
Copper	1.4E-02	1.1E-02	1.4E-02	1.0E-02	NS	NS	NS	NS	NS	NS	NS	NS
Lead	3.6E-02	3.6E-03	3.0E-02	3.0E-03	NS	NS	NS	NS	NS	NS	NS	NS
Methylmercury	0.2	2.0E-02	0.2	1.7E-02	**32**	**3.2**	**11**	**1.1**	**87**	**8.7**	**39**	**3.9**
Mercury	**1.1**	0.1	0.5	0.1	0.3	3.3E-02	0.2	2.2E-02	0.1	1.3E-02	0.1	8.7E-03
Nickel	2.4E-03	1.2E-03	2.5E-03	1.2E-03	NS	NS	NS	NS	NS	NS	NS	NS
Selenium	0.2	0.1	0.2	0.1	0.5	0.3	0.4	0.3	0.8	0.5	0.7	0.4
Thallium	0.2	1.5E-02	0.2	2.0E-02	0.4	3.7E-02	0.4	3.7E-02	1.9E-02	1.9E-03	2.4E-02	2.4E-03
Vanadium	0.8	0.1	0.7	0.1	0.4	3.8E-02	0.3	2.7E-02	NS	NS	NS	NS
Zinc	1.5E-03	7.3E-04	1.4E-03	7.2E-04	NS	NS	NS	NS	NS	NS	NS	NS
Semivolatile Organic Compounds												
Hexachlorobenzene	**55**	**5.5**	**20**	**2.0**	**6.9**	0.7	**4.7**	0.5	NS	NS	NS	NS
Polycyclic aromatic hydrocarbons	**1.8**	0.2	0.4	4.3E-02	**1.1**	0.1	0.8	0.1	NS	NS	NS	NS
Polychlorinated Biphenyls												
Chlordanes (sum)	NS	NS	NS	NS	7.2E-03	1.4E-03	1.4E-02	2.8E-03	NS	NS	NS	NS
Dieldrin	NS	NS	NS	NS	0.2	0.1	0.2	0.1	NS	NS	NS	NS
Polychlorinated biphenyls (PCBs)	0.1	2.5E-02	0.1	2.4E-02	0.5	0.5	0.5	0.4	**1.6**	**1.4**	**1.8**	**1.5**
Dioxins/Furans												
PCDD/PCDFs (TEQ) mammalian	0.6	0.1	0.3	3.4E-02	0.7	0.1	0.5	0.1	0.9	0.1	0.6	0.1

Notes: NA = Not Available; NS = Not selected as a COC for this receptor.
Hazard quotients equal to or greater than one are outlined and bolded.
TEQ – toxicity equivalent

Table 8-7. Hazard Quotients for Modeled Short-Tailed Shrew Exposure

COC	SYW-10 95% UCL HQ NOAEL	SYW-10 95% UCL HQ LOAEL	SYW-10 Mean HQ NOAEL	SYW-10 Mean HQ LOAEL	SYW-18 95% UCL HQ NOAEL	SYW-18 95% UCL HQ LOAEL	SYW-18 Mean HQ NOAEL	SYW-18 Mean HQ LOAEL	NMC Island 95% UCL HQ NOAEL	NMC Island 95% UCL HQ LOAEL	NMC Island Mean HQ NOAEL	NMC Island Mean HQ LOAEL	Other Areas 95% UCL HQ NOAEL	Other Areas 95% UCL HQ LOAEL	Other Areas Mean HQ NOAEL	Other Areas Mean HQ LOAEL
Total Metals																
Arsenic	**5.3**	0.5	**2.3**	0.2	**2.1**	0.2	**2.0**	0.2	**2.0**	0.2	**2.0**	0.2	**2.6**	0.3	**2.1**	0.2
Barium	0.1	0.1	0.1	4.9E-02	0.1	3.4E-02	0.1	3.0E-02	0.1	4.2E-02	0.1	3.9E-02	0.1	3.2E-02	0.05	2.9E-02
Cadmium	**1.2**	0.1	0.7	0.1	0.5	0.1	0.3	3.2E-02	2.0E-04	2.0E-05	1.8E-04	1.8E-05	0.4	0.04	0.4	0.04
Chromium	0.3	0.1	0.2	4.3E-02	0.1	3.4E-02	0.1	3.2E-02	0.2	4.7E-02	0.2	4.3E-02	0.2	4.1E-02	0.1	3.5E-02
Lead	**1.0**	0.1	0.6	0.1	0.4	4.4E-02	0.4	3.8E-02	0.4	4.3E-02	0.4	3.7E-02	**1.3**	0.1	0.7	0.1
Methylmercury	**30**	**3.0**	**25**	**2.5**	**24**	**2.4**	**19**	**1.9**	**15**	**1.5**	**13**	**1.3**	**18**	**1.8**	**15**	**1.5**
Mercury	0.5	5.2E-02	0.4	4.0E-02	0.4	4.0E-02	0.3	3.1E-02	0.2	2.0E-02	0.2	1.7E-02	0.2	2.4E-02	0.2	2.0E-02
Selenium	**1.3**	0.8	0.7	0.4	0.7	0.4	0.6	0.4	**1.1**	0.7	0.98	0.6	0.95	0.6	0.8	0.5
Thallium	**4.3**	0.4	**2.8**	0.3	1.0	0.1	0.9	0.1	**1.5**	0.1	0.8	0.1	**1.1**	0.1	0.9	0.1
Vanadium	**3.9**	0.4	**2.0**	0.2	**2.1**	0.2	**2.0**	0.2	**2.3**	0.2	**2.1**	0.2	**2.7**	0.3	**2.3**	0.2
Semivolatile Organic Compounds																
Hexachlorobenzene	**25**	**2.5**	**17**	**1.7**	**84**	**8.4**	**34**	**3.4**	**272**	**27**	**32**	**3.2**	**336**	**34**	**71**	**7.1**
Polycyclic aromatic hydrocarbons	**155**	**16**	**27**	**2.7**	**66**	**6.6**	**48**	**4.8**	**28**	**2.8**	**20**	**2.0**	**354**	**35**	**98**	**10**
Pesticides/Polychlorinated Biphenyls																
Chlordane isomers	8.0E-05	1.6E-05	6.8E-05	1.4E-05	1.7E-02	3.5E-03	1.5E-02	3.0E-03	2.2E-02	4.4E-03	1.5E-02	3.0E-03	1.7E-02	3.4E-03	1.5E-02	2.9E-03
Dieldrin	ND	ND	ND	ND	0.6	0.3	0.5	0.3	ND	ND	ND	ND	0.1	0.1	0.5	0.2
Endrin	ND	ND	ND	ND	0.1	8.5E-03	0.1	7.5E-03	ND	ND	ND	ND	0.2	2.4E-02	0.1	1.4E-02
Polychlorinated biphenyls (PCBs)	0.1	3.5E-02	5.9E-02	1.5E-02	0.1	1.9E-02	0.1	1.4E-02	0.1	1.4E-02	3.0E-02	7.4E-03	5.4E-02	1.3E-02	3.8E-02	9.4E-03
Dioxins/Furans																
PCDD/PCDFs (TEQ) mammalian	**18**	**1.8**	**8.6**	0.9	**6.4**	0.6	**4.2**	0.4	**2.4**	0.2	**1.2**	0.1	**5.8**	0.6	**3.2**	0.3

Notes:

Hazard quotients equal to or greater than one are outlined and bolded.

ND = Not detected

TEQ – toxicity equivalent

9. CONCLUSIONS

9.1 Summary of Major Conclusions

Chapters 1 (Introduction) and 2 (Field and Laboratory Investigations) of this Geddes Brook/Ninemile Creek Remedial Investigation (RI) report present information on the site's remedial history and a summary of field and laboratory investigations performed within the Geddes Brook/Ninemile Creek site.

Chapter 3, Site History and Physical Characteristics, provides a detailed discussion of the history and physical characteristics of the Geddes Brook/Ninemile Creek site. The key findings of Chapter 3 include:

- Geddes Brook and Ninemile Creek have undergone extensive changes to their natural state as a result of anthropomorphic activities. Of particular interest to the RI with respect to the chemical parameters of interest (CPOIs) are impacts due to dredging/rerouting of the stream beds and the disposal of industrial wastes.

- The most downstream reach of Ninemile Creek (i.e., Reach AB; see Chapter 2, Figure 2-2) was rerouted in 1926, thus moving the mouth from Lakeview Point to the present location. Lakeview Point is the current location of Wastebeds 1 to 8. Reach AB extends from the mouth of Ninemile Creek to the large bend near Interstate 690 (I-690). Reach AB appears to have been dredged and channelized in the late 1960s.

- The next reach of Ninemile Creek (Reach BC; see Chapter 2, Figure 2-2) extends from just north of I-690 to the large bend south of New York State Route 695 (Route 695). Reach BC was rerouted and channelized during the construction of I-690 and Route 695 in the 1950s and the late 1960s, respectively. It is not known how sediments in the original channel may have been disturbed and/or disposed as a result of the rerouting.

- The next upstream reach in Ninemile Creek (Reach CD; see Chapter 2, Figure 2-2) extends from the large bend south of Route 695 to the confluence with Geddes Brook. This reach does not appear to have undergone any significant physical modifications since at least the 1930s.

- A large portion of Ninemile Creek upstream of the confluence with Geddes Brook was rerouted in 1944 to accommodate Honeywell's Wastebeds 9 to 11.

- A small segment of Geddes Brook upstream of its confluence with the West Flume was rerouted during construction of Route 695 in the late 1960s.

Chapter 4, Sources and Potential Sources of Chemical Parameters of Interest, provides information on past and present Honeywell sources and potential sources of CPOIs, as well as potential sources from locations not identified as Honeywell sites. The key findings of Chapter 4 include:

- Honeywell disposed of industrial waste into the Geddes Brook/Ninemile Creek watershed primarily via the West Flume and Wastebeds 1 to 15, and, to a lesser extent, through disposal to the currently inactive Mathews Avenue Landfill. Accordingly, the site has been divided (in this report) into upper and lower Geddes Brook (upstream and downstream of the confluence with the West Flume) and upper and lower Ninemile Creek (upstream and downstream of the confluence with Geddes Brook). Note that while Transect TN-16 in Ninemile Creek is just upstream of the confluence with Geddes Brook, it is included as part of lower Ninemile Creek, as it has apparently been impacted by Geddes Brook.

- CPOIs associated with Honeywell operations include mercury; lead; chlorinated benzenes; benzene, toluene, ethylbenzene, and xylenes (BTEX); polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); and polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs).

- Other potential sources of CPOIs (PAHs and metals) include urban runoff and the disposal by other parties in other landfills.

- Honeywell's historical direct discharges into the West Flume and overflow from the wastebeds into Geddes Brook and Ninemile Creek were of such magnitude that the annual mean flow in lower Ninemile Creek during Honeywell's operations was almost twice the current flow. This increased flow due to Honeywell discharges likely caused the boundaries of the creek to be larger in lower Geddes Brook and lower Ninemile Creek than they are now, with more of the current floodplain frequently underwater at that time.

- The Honeywell operations also caused the total suspended solids (TSS) and total dissolved solids (TDS) loads to be more than twice as great as they are now. These operations had the effect of causing large deposits of Solvay waste (i.e., solids that settled out from the Solvay Wastebeds overflow) to accumulate in the stream beds and floodplains of Geddes Brook and Ninemile Creek that were below the discharge points, primarily in the reaches downstream of the West Flume. Such deposits may be referred to herein as "depositional" sediments.

- Ongoing releases from Honeywell sites continue to impact the levels of CPOIs at the Geddes Brook/Ninemile Creek site.

Chapter 5, Nature and Extent of Contamination, documents the distribution of CPOIs in sediments, floodplain soils, wetland and island soils, surface water, and fish at the Geddes Brook/Ninemile Creek site. The RI data collected by Honeywell and NYSDEC between 1998 and 2002, along with data collected independently of this RI, provide a comprehensive basis for understanding the current nature and extent of CPOIs within the Geddes Brook/Ninemile Creek site. The key findings of this chapter include:

Sediments

- Mercury concentrations in sediment and floodplain soils reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek as well as the stream channel geomorphology and historical changes to the stream channel. Concentrations of total mercury were relatively high (greater than 10 mg/kg) at stations located on the right side of Ninemile Creek facing downstream between Transects TN-15 and TN-10 (within Reach CD). These high concentrations of mercury are also found at deeper intervals in this area. The stretch along the right bank between these transects is a relatively quiescent (i.e., depositional) region within Reach CD, where water entering Ninemile Creek from Geddes Brook appears to hug the shoreline and does not readily mix across the entire Ninemile Creek cross section due to the presence of the islands. The sediments from this area of high mercury concentration were noted as containing Solvay waste materials in the 2001 BBL sediment probing survey.

- Higher concentrations of other metals (i.e., arsenic, nickel, and zinc) at depth were most prevalent at Transects TN-5 and TN-6 in Reach BC of Ninemile Creek and, to a lesser extent, Transects TG-3 and TG-4 in Geddes Brook, with contamination extending to a depth of approximately 10 ft (3 m) in some cases.

- For organic CPOIs in sediments, the highest concentrations were found in lower Ninemile Creek and lower Geddes Brook. There were several elevated concentrations (greater than 1,000 µg/kg) of hexachlorobenzene in lower Geddes Brook and in Reach CD of Ninemile Creek. Concentrations of hexachlorobenzene exceeding 10,000 µg/kg occurred in Geddes Brook just below the discharge point of the West Flume to a depth of about 4 ft (1.28 m). Elevated levels (greater than 1,000 µg/kg) of Aroclors 1254 and 1268 were also detected at some stations in lower Geddes Brook and lower Ninemile Creek. Unlike Aroclor 1254, elevated concentrations of Aroclor 1268 occurred in the deeper sediments (greater than 1 m depth) in Reach CD of Ninemile Creek and in surface sediments (0 to 0.15 m) in Reach AB of Ninemile Creek. The highest concentrations of PCDD/PCDFs (TEQs) were found in Geddes Brook immediately below the confluence with the West Flume.

Floodplain Soils

- Mercury concentrations in soils from floodplain and wetland areas along Ninemile Creek showed a distinct distribution pattern, with concentrations exceeding 10 mg/kg in samples collected near the mouth of the creek and along Reach CD. Floodplain soils collected at depth intervals ranging from 0.3 to 0.9 m during the 2002 supplemental floodplain sampling program in Ninemile Creek (Chapter 5, Figure 5-15) showed elevated levels of mercury as high as 76.9 mg/kg (on the right side, facing downstream, of the mouth of Ninemile Creek in a low-lying wetland area [i.e., Reach AB]) and 43.1 mg/kg (1.5 m from the water's edge on the right bank facing downstream between the two southern islands in Ninemile Creek [i.e., Reach CD]).

  It should be noted that the elevated concentrations of mercury at deeper intervals are localized in areas where Ninemile Creek is characterized as strongly depositional at base flow. These elevated mercury concentrations at depth occur in the low-lying wetland area at the mouth of Ninemile Creek that has historically been exposed to flooding and in Reach CD where the elevated mercury concentrations in floodplain soil are adjacent to the sediments with elevated mercury concentrations at depth.

- Many of the sediments/soils from these areas of high mercury concentrations were identified as containing Solvay waste materials.

- Hexachlorobenzene, PAHs, PCBs, and PCDD/PCDFs were detected at elevated concentrations in floodplain soils, mainly along lower Geddes Brook and along Reach CD of Ninemile Creek.

Surface Water

- Total mercury concentrations in surface water reflect the input of mercury from the West Flume to Geddes Brook and from Geddes Brook to Ninemile Creek. Total mercury concentrations were higher in the lower reaches of both Geddes Brook and Ninemile Creek than in the upper reaches.

- Total mercury concentrations in the West Flume, lower Geddes Brook, and lower Ninemile Creek have declined since 1990, with concentrations in 1998 at least 77 percent lower than 1990 values in these areas of the system.

- Concentrations of the other inorganics and ionic waste constituents (e.g., chloride, calcium, sodium, and TDS) in surface water clearly indicate the continued impact of Wastebeds 9 to 15 on the Geddes Brook/Ninemile Creek site.

Fish

- The maximum mercury concentration in adult fish from the 1998 data (1,534 µg/kg wet weight in fillets) was detected in lower Ninemile Creek just downstream of the confluence with Geddes Brook.

- The maximum mercury concentration (850 µg/kg) in young-of-year (YOY) fish reported in the 2002 NYSDEC/TAMS data, which were obtained from lower Ninemile Creek samples collected downstream of the mercury source, is nearly 20 times greater than the maximum concentration (46.8 µg/kg) from the 1998 Honeywell/Exponent data, which were obtained from Ninemile Creek YOY fish samples upstream of the source (i.e., upstream of the confluence with Geddes Brook).

Chapter 6, Transport and Fate of Chemical Parameters of Interest, describes these processes and focuses on the following major groups: mercury, inorganics other than mercury, organic compounds, and ionic waste constituents. The key findings of this chapter include:

- Wastes from Honeywell's Syracuse Works were discharged into Geddes Brook and Ninemile Creek via the West Flume and overflow from the Solvay Wastebeds, starting at the time that the wastebeds were first constructed (1926 for Wastebeds 1 to 8 and 1944 for Wastebeds 9 to 15) and with the construction of the LCP Bridge Street Plant (1953). These wastes contained primarily Solvay waste, but included other waste streams as well, and settled into depositional areas downstream of these discharges.

- Mercury and other CPOIs (e.g., hexachlorobenzene, PCBs, PAHs, and PCDD/PCDFs) appear to be primarily associated with depositional zones containing Solvay waste materials downstream of the Honeywell LCP Bridge Street site and the West Flume.

- Some of the historical contaminated materials in Ninemile Creek were likely removed during various non-remedial construction operations such as channelization and rerouting of the stream beds.

- The changes in the hydraulic regime of Geddes Brook and Ninemile Creek, caused by the cessation of Honeywell discharges in 1980, have resulted in some of these historically depositional areas becoming more erosional.

- Reach CD contains the highest concentrations of CPOIs in Ninemile Creek, and the reach as a whole is the most erosional in lower Ninemile Creek. The right-hand channel of Reach CD (facing downstream) is depositional at base flow and erosional at high flow.

- Normalization of surface sediment mercury concentrations to iron (normalizing to iron helps to remove variability in concentrations due to changes in factors such as grain size, etc.) indicates that there may be localized areas with uniquely high concentrations of mercury within lower Ninemile Creek.

- Based on load analysis, the sediments of lower Geddes Brook and lower Ninemile Creek are major sources of mercury to the water column and biota of Geddes Brook, Ninemile Creek, and Onondaga Lake at base-flow conditions. However, the source of the mercury measured in lower Ninemile Creek at base flow appears to be heavily influenced by releases from the West Flume, which is the largest external source of mercury to the Geddes Brook/Ninemile Creek site.

- The transport of mercury in Geddes Brook and Ninemile Creek surface water has been measured to increase significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils to Onondaga Lake increases dramatically. Under these high-flow conditions, the sediments and floodplain soils of lower Ninemile Creek become the dominant source of mercury being transported to Onondaga Lake, and are a major component of the annual mercury load to the lake.

- An analysis of loads of TDS in surface water confirms that groundwater from Wastebeds 9 to 15 continues to be a source of ionic waste constituents, primarily in the forms of calcium chloride and sodium chloride, to Geddes Brook and Ninemile Creek.

- The transport of TSS and ionic waste constituents in Geddes Brook and Ninemile Creek surface water increases significantly (i.e., by two orders of magnitude) during storm-related high-flow events, and the relative importance of the loading from lower Ninemile Creek sediments and floodplain soils increases dramatically. Under these high-flow conditions, the sediments of lower Ninemile Creek become the dominant source of TSS being transported to Onondaga Lake, and are a major component of the annual TSS and ionic waste constituents load to the lake.

- CPOIs other than mercury (hexachlorobenzene, PCBs, PAHs, PCDD/PCDFs) that are primarily associated with the same sediments as mercury would be expected to have similar transport and fate as mercury. The sediments and floodplain soils containing these CPOIs would be expected to erode under high-flow conditions and ultimately transported to Onondaga Lake.

Chapters 7 and 8 summarize the Geddes Brook/Ninemile Creek Human Health Risk Assessment (HHRA) and Baseline Ecological Risk Assessment (BERA), respectively (TAMS, 2003b,a). The key findings of the risk assessments include:

Human Health Risk Assessment

The objective of the HHRA is to evaluate the potential for adverse human health effects associated with current and future exposures to chemicals present in the fish, sediment, soil, and surface water of the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those chemicals (i.e., under the no action alternative). For cancer risks, the acceptable risk levels, as specified by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR § 300.430[e][2][i][A][2]), range from an excess upper-bound lifetime cancer risk to an individual of 1×10^{-4} to 1×10^{-6}, with 1×10^{-6} as the point of departure for determination of remedial goals. For non-cancer hazards, the target hazard level is a hazard index (HI) of 1.0 or less, the level below which adverse health effects are considered to be unlikely. Key findings of the HHRA include:

- For the reasonable maximum exposure (RME) scenario for consumption of fish, the calculated non-cancer hazards (from 4.1 for adults to 6.4 for young children) exceeded the non-cancer target level (1.0) and the calculated cancer risks (from 2.9×10^{-5} for young children to 9.3×10^{-5} for adults) approached the upper end of the 10^{-6} to 10^{-4} risk range. For the RME scenario, the calculated total cancer risk to adults and older children across all pathways (ranging from 2.4×10^{-4} to 2.7×10^{-4}) exceeded the high end of the cancer risk range (10^{-4}), and exceeded the low end of the risk range (10^{-6}) by more than two orders of magnitude. The RME total non-cancer hazards across all pathways (ranging from 4.6 to 6.4) for all recreational receptors exceeded the target HI (1.0) by a factor of four or more.

- The calculated central tendency (CT) non-cancer HIs for all receptors were less than the target threshold (i.e., less than 1). CT total cancer risks for all receptors, ranging from 1×10^{-6} for construction workers to 9.4×10^{-6} for older child recreational receptors, were below the upper end of the 10^{-6} to 10^{-4} risk range.

- RME cancer risks for 17 of the 36 pathways other than fish ingestion equaled or exceeded the low end (1×10^{-6}) of the cancer risk range (10^{-6} to 10^{-4}), with the highest of these being 9.1×10^{-5} for adult exposure to Upper Geddes Brook surface water and 7.8×10^{-5} for older child exposure to Upper Geddes Brook sediments. For the CT cancer risk calculations, the low end of the cancer risk range was equaled or exceeded in three of the 36 pathways other than fish ingestion, with a maximum CT risk of about 4.5×10^{-6} for older child exposure to Upper Geddes Brook surface water.

Baseline Ecological Risk Assessment

The objective of the BERA is to evaluate the potential for adverse ecological effects associated with current exposures to chemicals and stressors present in the Geddes Brook/Ninemile Creek site in the absence of any action to control or mitigate those contaminants (i.e., under the no action alternative). Key findings of the BERA include:

- Honeywell-related contaminants within the Geddes Brook/Ninemile Creek site have produced adverse ecological effects at all trophic levels examined.

- Honeywell's ionic wastes have also impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the streams for feeding or spawning.

- Comparisons of measured tissue concentrations and modeled doses (i.e., intake) of chemicals to toxicity reference values (TRVs) show exceedances of hazard quotients (HQs) for site-related chemicals throughout the range of the point estimates of risk. Many of the contaminants in the Geddes Brook/Ninemile Creek site are persistent and, therefore, the ecological risks associated with these contaminants are unlikely to decrease significantly in the short term in the absence of remediation. The various field studies performed on site indicate that contaminant levels have not decreased substantially in some of the site media (i.e., sediments, soils, fish) over the last 15 years. On the basis of these comparisons, it has been determined in the BERA that all receptors examined are at risk due to contamination at the Geddes Brook/Ninemile Creek site. These receptors, representing various trophic levels and feeding preferences, indicate either impacts or potential impacts to most of the Geddes Brook and Ninemile Creek ecological community.

9.2 Preliminary Remedial Action Objectives

Pursuant to USEPA guidance, preliminary remedial action objectives (RAOs) for the Geddes Brook/Ninemile Creek site are derived from key conclusions of the RI, including the analysis of the nature and extent of contamination, transport and fate of contaminants, and the risk assessments. The key conclusions of the RI for purposes of developing RAOs are that:

- Elevated levels of metals and organic compounds result in adverse impacts (known or modeled) to all trophic levels of the Geddes Brook/Ninemile Creek site ecosystem examined.

- Honeywell's ionic wastes have impacted the Geddes Brook/Ninemile Creek site, reducing habitat value for aquatic macrophytes, benthic invertebrates, and fish that use the streams for feeding or spawning.

- There are potential non-cancer hazards for humans, based primarily on the consumption of fish. The potential total cancer risk from consumption of fish and exposure to sediment, soil, and surface water exceeds the upper end of USEPA's specified risk range.

- The major historical external sources of mercury at the Geddes Brook/Ninemile Creek site were the disposal of wastes containing CPOIs from the various Honeywell upland sites either directly, via the West Flume, or through migration from the Solvay Wastebeds into Geddes Brook and Ninemile Creek.

- Current groundwater releases from Honeywell's Wastebeds 1 to 15 do not appear to be a major source of mercury to Geddes Brook and Ninemile Creek.

- Groundwater releases from Honeywell's Wastebeds 9 to 15 have been, and continue to be, major external sources of ionic waste constituents to the Geddes Brook/Ninemile Creek site.

- The current major external source of mercury to the Geddes Brook/Ninemile Creek site is the Honeywell LCP Bridge site, via the West Flume. For the remedial actions at the Geddes Brook/Ninemile Creek site to be fully effective in reducing risks, this external source will need to be remediated under a separate program and is not included in the preliminary RAOs for the Geddes Brook/Ninemile Creek site specified below. The remedial design at Operable Unit 1 (OU-1) is underway at this site. An RI/feasibility study (FS) is underway at OU-2.

- The major internal sources of mercury are the sediments and floodplain soils of lower Geddes Brook and lower Ninemile Creek.

- Surface water is the major transport mechanism for sediment containing mercury and other CPOIs in Geddes Brook and Ninemile Creek.

- Mercury and other CPOIs in Geddes Brook and Ninemile Creek are transported to Onondaga Lake. The Onondaga Lake RI (TAMS, 2002c) established that CPOIs transported to the lake remain available to the environment.

The preliminary RAOs for the Geddes Brook/Ninemile Creek site, which will be addressed pursuant to the FS, are as follows:

- To eliminate or reduce, to the extent practicable, releases of mercury and other CPOIs from the sediments and floodplain soils of lower Geddes Brook and lower Ninemile Creek.

- To eliminate or reduce, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources, as well as potential risks to humans.

- To reduce, to the extent practicable, levels of mercury and other CPOIs in surface water in order to meet surface water quality standards.

10. REFERENCES

American Society for Testing and Materials (ASTM). 1995. Standard test methods for measuring the toxicity of sediment-associated contaminants with fresh water invertebrates. E1706-95b. American Society for Testing and Materials, West Conshohocken, PA.

Ayers, D., Data Manager, Cornell Institute for Resource Information Systems. 2002. Personal communication with R. Montione, TAMS Consultants, Inc., Latham, NY. Provision of copies of historical aerial photographs of Ninemile Creek, Syracuse, NY. Cornell Institute for Resource Information Systems, Cornell University, Ithaca, NY. January.

Bein, P.M., New York State Department of Law. 1998. Personal communication via letter to Manning Gasch of Hunton and Williams, Richmond, VA, regarding the Determination to Disapprove and Revise the Sampling and Analysis Plan of the Geddes Brook/Ninemile Creek Remedial Investigation Work Plan. June 30.

Berg, C.O. 1963. Middle Atlantic states. pp. 191–237. In: Limnology in North America. D.G. Frey (ed). University of Wisconsin Press, Madison, WI.

Blasland & Bouck. 1989. Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area. Volume 1 of 2. Prepared for AlliedSignal, Inc., Solvay, NY by Blasland & Bouck Engineers, P.C., Syracuse, NY. April.

Blasland & Bouck. 1990. Honeywell's Mathews Avenue Landfill Closure Investigation. Personal communication via letter to A.J. Labuz, Honeywell, Syracuse, New York, summarizing the results of the soil sampling at the Mathews Avenue Landfill. Blasland & Bouck Engineers, P.C., Syracuse, NY. July 26.

Blasland, Bouck & Lee, Inc. (BBL). 1990. Waste Bed Feasibility Study (Sections 1 to 4). Prepared for AlliedSignal, Inc., Solvay, NY by Blasland & Bouck Engineers, P.C., Syracuse, NY. February.

BBL. 1995. Summary Data Report for Allied Wastebeds 9 to 15 and Lower Ninemile Creek Valley. Prepared for AlliedSignal, Inc., Solvay, NY by Blasland & Bouck Engineers, P.C., Syracuse, NY. July.

BBL. 1999. Supplemental Site Investigation Report, Wastebeds 9 to 15, Onondaga County, New York. Prepared for AlliedSignal, Inc., Syracuse, NY by BB&L Engineers and Scientists, Syracuse, NY. August.

BBL. 2000. Ninemile Creek/Geddes Brook Sediment IRM Sampling Plan. Prepared for Honeywell, Inc., Syracuse, NY by Blasland, Bouck & Lee, Inc., Syracuse, NY. December.

BBL. 2001. Ninemile Creek/Geddes Brook Sediment IRM Investigation Report. Prepared for Honeywell, Inc., Syracuse, NY by Blasland, Bouck & Lee, Inc., Syracuse, NY. September.

Bode, R.W., M.A. Novak, and L.E. Abele. 1989. Biological Stream Assessment: Tributaries to Onondaga Lake. New York State Department of Environmental Conservation.

Burdick, R.L., Onondaga County Health Department. 2001. Personal communication by letter to A. Labuz of Honeywell, East Syracuse, NY, regarding water wells along Ninemile Creek and Geddes Brook. Onondaga County Health Department, Division of Environmental Health, Syracuse, NY. February 27. As cited in Exponent, 2001b.

C & S Engineers. 1995. Closure Investigation Report for the Village of Solvay Landfill. Prepared for the Village of Solvay by C&S Engineers, Liverpool, New York. March.

CDR Environmental Specialists (CDR). 1991. Environmental Assessment of Lower Reaches of Ninemile Creek and Geddes Brook, Oswego Watershed, New York. Prepared for AlliedSignal, Solvay, NY by CDR Environmental Specialists, Stow, MA. July.

City of Syracuse Department of Engineering (CSDE). 1948. Pollution survey of Onondaga Lake and tributaries. Syracuse, NY.

Clements, M., Region 3 New York State Department of Transportation. 2002. Personal communication with D. Scheuing, TAMS Consultants, Inc., Latham, NY. Provision of copies of historical aerial photographs of Ninemile Creek, Syracuse, NY. December.

Cooper, A.L., M.J. Tracy, and G.N. Neuderfer. 1974. A Macroinvertebrate Study of Ninemile Creek. New York State Department of Environmental Conservation.

Daskalakis, K.D. and T.P. O'Connor. 1995. Normalization and Elemental Sediment Contamination in the Coastal United States. Environ. Sci. Technol. 29: 470-477.

Dyrssen, D. and M. Wedborg. 1991. The sulphur-mercury (II) system in natural waters. Water, Air, & Soil Pollution (Water Air Soil Pollut.), 56:507-519.

Effler, S.W. and G. Harnett. 1996. Background. In: Limnological and Engineering Analysis of a Polluted Urban Lake, Prelude to Environmental Management of Onondaga Lake, New York. S.W. Effler (ed). pp. 1–31. Springer-Verlag, New York, NY.

Effler, S.W. and K.A. Whitehead. 1996. Tributaries and discharge. In: Limnological and Engineering Analysis of a Polluted Urban Lake, Prelude to Environmental Management of Onondaga Lake, New York. S. W. Effler (ed). pp. 97–199. Springer-Verlag, New York, NY.

Exponent. 2000a. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study Baseline Ecological Risk Assessment. Draft. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. August. (Document rewritten by TAMS for NYSDEC. See TAMS, 2003a.)

Exponent. 2000b. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study Human Health Risk Assessment. Draft. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. July. (Document rewritten by TAMS for NYSDEC. See TAMS, 2003b.)

Exponent. 2000c. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study Remedial Investigation Report. Draft. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. August. (Document rewritten by TAMS for NYSDEC, July 2003.)

Exponent. 2000d. Onondaga Lake RI/FS Supplemental Data Phase 2A Work Plan and Dredged Material Disposal Area Addendum. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. March.

Exponent. 2001a. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study, Baseline Ecological Risk Assessment. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. November. (Document rewritten by TAMS for NYSDEC. See TAMS, 2003a.)

Exponent. 2001b. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study, Human Health Risk Assessment. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. November. (Document rewritten by TAMS for NYSDEC. See TAMS, 2003b.)

Exponent. 2001c. Geddes Brook/Ninemile Creek Remedial Investigation/Feasibility Study, Remedial Investigation Report. Prepared for Honeywell, Inc., East Syracuse, NY by Exponent, Bellevue, WA. November. November. (Document rewritten by TAMS for NYSDEC, July 2003.)

Finger, T.R. 1982. Fish community – habitat relations in a Central New York stream. J. Freshwater Ecology. 1:343-352.

Gbondo-Tugbawa, S. 1997. Concentrations and fluxes of total and methyl mercury to Onondaga Lake, Syracuse, New York. Thesis. Syracuse University, Syracuse, NY.

Gradient and Parsons. 1999. Feasibility Study Report, LCP Bridge Street Facility, Solvay, New York. Prepared for AlliedSignal, Inc., Solvay, NY by Gradient Corporation, Cambridge, MA and Parsons Engineering-Science, Liverpool, NY.

Henry, E.A., Exponent. 1998. Personal communication via letter to T.J. Larson, New York State Department of Environmental Conservation, Albany, New York, regarding changes to Geddes Brook/Ninemile Creek work plan. Exponent, Bellevue, WA. July 16.

Hornlein, J., US Geological Survey. 2003. Personal communication via letter to R. Montione, TAMS Consultants, Inc., Latham, NY regarding data transmittal and gauging in Ninemile Creek. USGS, Ithaca, NY. January 21.

Hutton, Jr., F.Z. and E. Rice. 1977. Soil survey of Onondaga County, New York. USDA, Soil Conservation Service in cooperation with Cornell University Agric. Exp. Sta.

Kahn, L. 1986. Method for determination of total organic carbon in sediment. USEPA Region II.

Larson, T.J., NYSDEC. 2001a. Personal communication via letter to A.J. Labuz, Honeywell, East Syracuse, NY, regarding Geddes Brook/Ninemile HHRA reference locations and station groupings. New York State Department of Environmental Conservation, Division of Environmental Remediation, Albany, NY. July 31.

Larson, T.J., NYSDEC. 2001b. Personal communication via letter to A.J. Labuz, Honeywell, East Syracuse, NY, regarding approval of the Ninemile Creek/Geddes Brook remedial investigation/IRM sampling plan addendum. New York State Department of Environmental Conservation, Division of Environmental Remediation, Albany, NY. March 6.

Larson, T.J., NYSDEC. 2002a. Personal communication via letter to A.J. Labuz, Honeywell, East Syracuse, NY, regarding disapproval of the revised Geddes Brook/Ninemile Creek RI/FS reports. New York State Department of Environmental Conservation, Division of Environmental Remediation, Albany, NY. February 15.

Larson, T.J., NYSDEC. 2002b. Personal communication via letter to A.J. Labuz, Honeywell, East Syracuse, NY, regarding approval of the Ninemile Creek Supplemental Floodplain Sampling Report. New York State Department of Environmental Conservation, Division of Environmental Remediation, Albany, NY. August 28.

Larson, T.J. and P. Bein, NYSDEC. 2000. Personal communication via letter to A.J. Labuz, Honeywell, East Syracuse, NY, regarding disapproval of the Geddes Brook/Ninemile Creek RI/FS Draft Report. New York State Department of Environmental Conservation, Albany, NY. November 17.

Lincoln, D.F. 1982. Glaciation in the Finger Lake region of New York. Am. J. Sci. 144(26):290–301.

Luetze, W.P. 1964. The Salina Group, in Prucha, J.J., ed., New York State Geological Association guidebook for 36th annual meeting: Syracuse, New York, Syracuse University, 193 pp.

Marino, R., Chief, Site Control Section, Bureau of Hazardous Site Control, NYSDEC. 1994. Personal communication via letter to interested parties regarding site classification of State Fair Landfill. December 8.

McAuliffe, J.P., Honeywell. 2003. Data associated with personal communication via letter to T. Smith, NYSDEC, Albany, NY, regarding status report for the Geddes Brook IRM site. Honeywell, Inc., East Syracuse, NY. May 6.

Montgomery Watson Harza (MWH). 2002. Preliminary Site Assessment Work Plan – Mathews Avenue Site. Prepared for Honeywell, Inc., East Syracuse, NY by Montgomery Watson Harza, Utica, NY. September.

Murphy, C.B. 1978. Onondaga Lake. In: Lakes of Western New York State. J. Bloomfield (ed). Academic Press, New York, NY. pp. 223–365.

Murphy, K., Devorsetz, Stinziano, Gilberti, Heintz & Smith. 2002. Data associated with personal communication via letter to D.J. Hesler, NYSDEC, Albany, NY, regarding Ninemile Creek/Geddes Brook Remedial Investigation Report and 1999 to 2001 surface water data. Devorsetz, Stinziano, Gilberti, Heintz & Smith for Onondaga County, Syracuse, NY. January 16.

National Climatic Data Center (NCDC). 1995. Syracuse Hancock AP Onondaga County, New York USA average rainfall. Web site: http://www.worldclimate.com/cgi-bin/data.pl?ref=N43W076+2200+308383C. As accessed in 1995 by Exponent.

NCDC. 1998. http://www.ncdc.noaa.gov. As accessed in 1998 by Exponent.

National Oceanic and Atmospheric Administration (NOAA). 1998. Local climatological data annual summary with comparative data (1998), Hancock Airport, Syracuse, NY. National Oceanic and Atmospheric Administration, National Environmental Satellite Data and Information Office, National Climatic Data Center, Asheville, NC.

NOAA. 2001. Syracuse, New York climate data. Web site: http://www.nws.noaa.gov/er/bgm/cli/syrcli.htm. National Oceanic and Atmospheric Administration, National Weather Service. As accessed in 2001.

NOAA. 2003. Erie Canal, Three Mile Point to Lock 24 at Baldwinsville, Onondaga Lake and Syracuse Terminal. Image Archives of the Historical Map and Chart Collection. Web site: ftp://anchor.ncd.noaa.gov/views_pc/GIF/CHART/eriec14.gif. As accessed on February 26.

New York State Department of Environmental Conservation (NYSDEC). 1986. Phase I Investigation Report of Frazer & Jones Company, prepared by Wehran Engineering and NYSDEC, Albany, New York.

NYSDEC. 1989. Engineering Investigations at Inactive Hazardous Waste Sites: Phase II Investigation. New York State Department of Environmental Conservation, Division of Hazardous Waste Remediation, Albany, NY. August. As cited in PTI, 1991.

NYSDEC. 1992. Rotating Intensive Basin Studies, Water Quality Assessment Program 1989-1990. Allegheny River Basin, Lake Ontario Basin, Genessee River Basin, Seneca-Oneida-Oswego River Basin, Mohawk River Basin. New York State Department of Environmental Conservation, Albany, New York. January.

NYSDEC. 1994. Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA). New York State Department of Environmental Conservation, Division of Fish and Wildlife, Albany, NY.

NYSDEC. 1995. Analytical services protocol. October 1995 revisions. New York State Department of Environmental Conservation, Albany, New York.

NYSDEC. 1998. New York State's revision of the sampling and analysis portion of the Geddes Brook/Ninemile Creek remedial investigation work plan (including revised field sampling plan, quality assurance project plan, SOP 114 fish collection procedures, and SOP 115 fish processing procedures). Prepared by New York State Department of Environmental Conservation, Division of Environmental Remediation, Albany, NY.

NYSDEC. 1999. Technical Guidance for Screening Contaminated Sediments. New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources, Albany, NY.

NYSDEC. 2000a. New York State's Revision of the Geddes Brook/Ninemile Creek Remedial Investigation Work Plan. Original version (April 1998) prepared for AlliedSignal by Exponent. New York State Department of Environmental Conservation, Albany, NY. April.

NYSDEC. 2000b. Record of Decision. LCP Bridge Street Site. Sub-Site to the Onondaga Lake NPL Site, Village of Solvay, Onondaga County, Site Number 7-34-049. September.

NYSDEC. 2001. Registry of Inactive Hazardous Waste Disposal Sites in New York State. Volume 7. Prepared by New York State Department of Environmental Conservation, Division of Environmental Remediation and New York State Department of Health, Albany, NY.

NYSDEC. 2002. Order on Consent with Honeywell for the Geddes Brook IRM. Index No. D7-0003-01-09. April 16.

NYSDEC. 2003. Technical and administrative guidance memorandum #4046 – Recommended soil cleanup objectives for volatile organic contaminants, semi-volatile organic contaminants, organic pesticides/herbicides, PCBs, and heavy metals. Last revised 1994. Web site: www.dec.state.ny.us/website/der/tagms/prtg4046b.html. As accessed in June.

NYSDEC/TAMS Consultants, Inc. (NYSDEC/TAMS). 1998. New York State's Revision of the Remedial Investigation and Risk Assessment Reports, LCP Bridge Street Site, Solvay, New York. New York State Department of Environmental Conservation, Albany, NY, and TAMS Consultants, Inc., New York, NY.

New York State Department of Health (NYSDOH). 1951. The Onondaga Lake Drainage Basin, Recommended Classifications and Assignments of Standards of Quality and Purity for Designated Waters of New York State. Oswego River Drainage Basin Survey Series Report No. 1. Water Pollution Control Board. July.

NYSDOH. 2003. 2003-2004 Health Advisories – Chemicals in Sportfish and Game. May 27.

O’Brien & Gere. 1990. History of the Willis Avenue Plant, Petroleum Storage Facility, and Associated “Hot-Spots.” Prepared for AlliedSignal, Inc. Solvay, New York by O’Brien & Gere Engineers, Inc., Syracuse, NY. November.

O’Brien & Gere. 1999. Feasibility Study Revised Final Report, Semet Residue Ponds Site, Geddes, New York. Prepared for AlliedSignal, Inc., Syracuse, NY by O’Brien & Gere Engineers, Inc., Syracuse, NY.

O’Brien & Gere. 2002a. Floodplain Sampling and Analysis Work Plan: Ninemile Creek Supplemental Sampling Program. Geddes, NY. Prepared for Honeywell, Inc., Syracuse, New York by O’Brien & Gere Engineers, Inc., Syracuse, NY. August.

O’Brien & Gere. 2002b. Ninemile Creek Supplemental Sampling Program Data Validation Report. Geddes, NY. Prepared for Honeywell by O’Brien & Gere Engineers, Inc., Syracuse, NY. November 2002. August.

O’Brien & Gere. 2002c. Willis Avenue Chlorobenzene Site: Remedial Investigation, Geddes, New York. Under Review. Prepared for AlliedSignal, Inc., Solvay, NY by O’Brien & Gere, Syracuse, NY. October.

O’Brien & Gere. 2002d. DNAPL Recovery System Modifications – Completion Report. Willis Avenue Chlorobenzene Site. Report finalized April 2003. Prepared for Honeywell, Inc., Syracuse, NY by O’Brien & Gere Engineers, Inc., Syracuse, NY.

Onondaga County. 1971. Onondaga Lake Study. Prepared for US Environmental Protection Agency, Water Quality Office, Washington, DC by Onondaga County, Syracuse, NY.

Parsons. 2002a. Interim Remedial Measure Work Plan for the Geddes Brook Site. Geddes, NY. Prepared for Honeywell, Inc., Morristown, NJ by Parsons, Liverpool, NY. November.

Parsons. 2002b. Remedial Design Work Plan for the LCP Bridge Street Site. Solvay, NY. Prepared for Honeywell, Inc., Morristown, NJ by Parsons, Liverpool, NY. September.

Parsons Engineering Science, Inc. 2001. Work Plan for Remedial Investigation/Feasibility Study at the LCP Bridge Street Site, Operable Unit 2, Solvay, New York. Prepared for Honeywell, Syracuse, NY, by Parsons, Liverpool, NY. Revised May 2002.

Perkins, M.G. and E. Romanowicz. 1996. Hydrogeologic Setting. In: Limnological and Engineering Analysis of a Polluted Urban Lake, Prelude to Environmental Management of Onondaga Lake, New York. S.W. Effler (ed). pp.32–93. Springer-Verlag, New York, NY.

PTI Environmental Services, Inc. (PTI). 1991. Onondaga Lake RI/FS Work Plan. Prepared for AlliedSignal, Inc., Solvay, NY by PTI Environmental Services, Bellevue, WA. December.

PTI. 1992. Onondaga Lake RI/FS Site History Report. Prepared for AlliedSignal, Inc., Solvay, NY by PTI Environmental Services, Bellevue, WA. July.

PTI.1993. Onondaga Lake RI/FS Mercury and Calcite Mass Balance Investigation Data Report. Prepared for Allied Signal by PTI Environmental Services, Bellevue, WA.

PTI. 1996. Onondaga Lake RI/FS West Flume Mercury Investigation and Supplemental Sampling and Ninemile Creek Supplemental Sampling Data Report. Prepared for AlliedSignal, Inc, Syracuse, NY by PTI Environmental Services, Bellevue, WA.

Schuster, E. 1991. The behavior of mercury in the soil with special emphasis on complexation and adsorption processes – a review of the literature. Water Air Soil Pollut. 56:667–680.

Shindel, H.L. 1972. Map showing flood of June 1972 resulting from Tropical Storm Agnes, Onondaga Lake and Ley Creek at Syracuse, NY. US Geological Survey Open-File Report 72-346, 1 sheet.

Smith, T.A., NYSDEC. 2002. Personal communication via letter to J.P. McAuliffe, Honeywell, East Syracuse, NY, regarding conditional approval of IRM Work Plan for the Geddes Brook Site. November 27.

Smith, T.A., NYSDEC. 2003. Personal communication via letter to J.P. McAuliffe, Honeywell, East Syracuse, NY, regarding approval of IRM Work Plan for the Geddes Brook Site. April 24.

Staubitz, W.W. and T.S. Miller. 1987. Geology and hydrology of the Onondaga aquifer in eastern Erie County, New York, with an emphasis on groundwater level declines since 1982. Water Resources Investigations Report 86-4317. US Geological Survey.

Stearns & Wheler. 1987. Phase II Investigation, Town of Van Buren Landfill, Onondaga County, New York. Stearns & Wheler Engineers and Scientists, Cazenovia, NY.

Syracuse Herald Journal. 1967. Ceremonies Thursday Will Mark Onondaga Lake Park Dredging. Syracuse, NY. May 16.

TAMS Consultants, Inc. (TAMS). 1995. Wastebeds Investigation Report. Prepared for New York State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY. September.

TAMS. 2002a. Onondaga Lake Baseline Ecological Risk Assessment. Original document prepared for Honeywell, East Syracuse, NY by Exponent, Bellevue, WA. Revision prepared for New York State Department of Environmental Conservation, Albany, New York by TAMS Consultants, Inc., New York, NY and YEC, Valley Cottage, NY. December.

TAMS. 2002b. Onondaga Lake Human Health Risk Assessment Report. Original document prepared for Honeywell, East Syracuse, NY by Exponent, Bellevue, WA. Revision prepared for New York

State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY and YEC, Valley Cottage, NY. December.

TAMS. 2002c. Onondaga Lake Remedial Investigation Report. Original document prepared for Honeywell, East Syracuse, NY by Exponent, Bellevue, WA. Revision prepared for New York State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY and YEC, Valley Cottage, NY. December.

TAMS. 2002d. Work Plan for Young-of-Year Fish Collection in Ninemile Creek. Prepared for New York State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY. September.

TAMS. 2003a. Geddes Brook/Ninemile Creek Baseline Ecological Risk Assessment. Original document prepared for Honeywell, East Syracuse, NY by Exponent, Bellevue, WA. Revision prepared for New York State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY and YEC, Valley Cottage, NY. July.

TAMS. 2003b. Geddes Brook/Ninemile Creek Human Health Risk Assessment Report. Original document prepared for Honeywell, East Syracuse, NY by Exponent, Bellevue, WA. Revision prepared for New York State Department of Environmental Conservation, Albany, NY by TAMS Consultants, Inc., New York, NY and YEC, Valley Cottage, NY. July.

Thomas, G.M., Blasland, Bouck and Lee. 2000. Data associated with personal communication via letter to A.J. Labuz, AlliedSignal, Solvay, NY, dated December 21, 2000, regarding transmittal of the 34^{th} quarterly report for the ongoing monitoring program in the Ninemile Creek Valley. Blasland, Bouck and Lee, Syracuse, NY. As cited in Exponent, 2001c.

Trewartha, G.T. 1968. An Introduction to Climate. Fourth Edition. McGraw-Hill Book Co., New York, NY.

United States Army Corps of Engineers (USACE). 1987. United States Army Corps of Engineers wetlands delineation manual. Technical Report Y-87-1. USACE Waterways Experiment Station, Vicksburg, MS.

United States (US) Census Bureau. 2002. Table CO-EST2001-08-36 – New York Population Change for Counties Sorted in Alphabetical Order. Web site: http://eire.census.gov/popest/ data/ counties/ tables/ CO-EST2001-08/ CO-EST2001-08-36.php. US Census Bureau, Population Division. Release Date: April 29, 2002. As accessed in November 2002.

United States Environmental Protection Agency (USEPA). 1973. Report of Mercury Source Investigation, Onondaga Lake, New York and Allied Chemical Corporation, Solvay, New York. Prepared by National Field Investigations Center Cincinnati and USEPA Region II, New York. USEPA Office of Enforcement and General Counsel. April.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. United States Environmental Protection Agency, Office of Emergency and Remedial Response, Washington DC.

USEPA. 1990. National Oil and Hazardous Substances Pollution Contingency Plan. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC.

USEPA. 1992. Evaluation of metals data for the Contract Laboratory Program (CLP). SOP HW-2. United States Environmental Protection Agency, Region II.

USEPA. 1994a. USEPA contract laboratory program national functional guidelines for inorganic data review. WPA 540/R-94/013. February 1994. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1994b. USEPA contract laboratory program national functional guidelines for organic data review. EPA 540/R-94/012. February 1994. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1994c. SOP No. HW-19. Revision 1. October 1994. USEPA Region II data validation SOP for SW-846 Method 8290 polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by high resolution gas chromatography/high resolution mass spectrometry.

USEPA. 1994d. Considering Wetlands at CERCLA Sites. EPA540/R-94/019. US Environmental Protection Agency. May.

USEPA. 1995a. Contract laboratory program statement of work, inorganics analysis, multi -media, multi-concentration. Document ILM04.0. United States Environmental Protection Agency. Environmental Monitoring and Support Laboratory, Las Vegas, NV.

USEPA. 1995b. New Policy on Evaluating Health Risks to Children. Memorandum from C. Browner, USEPA Administrator, and F. Hansen, Deputy Administrator, to Regional Administrators. October 20. Includes attached “Policy on Evaluating Health Risks to Children,” USEPA Science Policy Council.

USEPA. 1995c. Land Use in the CERCLA Remedy Selection Process. Memorandum from E. Laws, Assistant Administrator to Regional Waste Management Directors. OSWER Directive 9355.7-04. May 25.

USEPA. 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA 540-R-97-0C5. US Environmental Protection Agency, Solid Waste and Emergency Response, Washington, DC.

USEPA. 1997b. Exposure Factors Handbook. EPA/600/P-95/002F. US Environmental Protection Agency, Office of Research and Development, Washington, DC.

USEPA. 1998a. Method 1630: Methylmercury in water by distillation, aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry. US Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division, Washington, DC.

USEPA.1998b. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC. EPA/630/R-95/002F. April.

USEPA. 1999. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. Washington, DC.

USEPA. 2000. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD) and Related Compounds, Part III: Integrated Risk Summary and Risk Characterization for 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD) and Related Compounds. EPA/600/P-00/001Bg, September 2000 – Preliminary Review Draft.

USEPA. 2001a. RAGS Volume I: Human Health Evaluation Manual, Part E – Supplemental Guidance for Dermal Risk Assessment for Public Comment. Interim Draft. USEPA Office of Emergency and Remedial Response. EPA/540/R/99/005. September.

USEPA. 2001b. Risk Assessment Guidance for Superfund (RAGS) 3, Part A – Process for Conducting Probabilistic Risk Assessment. Exhibit 3-2, Definitions for Chapter 3. December 31.

USEPA. 2001c. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, March 2001, Peer Review Draft; OSWER 9355.4-24.

USEPA. 2001d. RAGS Volume I – Human Health Evaluation Manual, Part D – Standardized Planning, Reporting and Review of Superfund Risk Assessments. Final. December.

USEPA. 2002. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA 540/R-01-008. Washington, DC.

United States Geological Survey (USGS). 1999. Water resources data, New York, water year 1998, western New York. US Geological Survey, Water Resources Division, Ithaca, NY.

USGS. 2003. Annual Stream Flow Statistics for Ninemile Creek. Station 04240300. Web site: http://waterdata.usgs.gov/nwis/annual/calendar_year/?site_no=04240300. As accessed in May.

URS Consultants, Inc. (URS). 1991. Preliminary Site Assessment of the State Fair Landfill. Prepared for New York State Department of Environmental Conservation, Albany, NY by URS, Buffalo, NY. October.

Van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F.

Waern, and T. Zacharewski.1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ. Health Perspect. 106(12):775–792.

Wakeman, A., New York State Department of Health. 1994. Personal communication via letter to E. Barcomb, New York Department of Environmental Conservation, regarding concurrence of Site Classification Decision on State Fair Landfill. July 20.

Winkley, S.J. 1989. The Hydrogeology of Onondaga County, New York. Prepared for Onondaga County Water Quality Management, Onondaga County Health Department, and Onondaga County Environmental Management Council. Syracuse University, Department of Geology, Syracuse, NY.

Wolman, M.G. and L.B. Leopold. 1957. River flood plains: some observations on their formation. US Geological Survey Professional Paper 282-C. US Government Printing Office, Washington, DC.

Zingarow, N., New York State Department of Transportation, Region 3. 2002. Personal communication with D. Scheuing, TAMS Consultants, Inc., Latham, NY. Provision of copies of historical construction drawings of Ninemile Creek, Syracuse, NY. December.