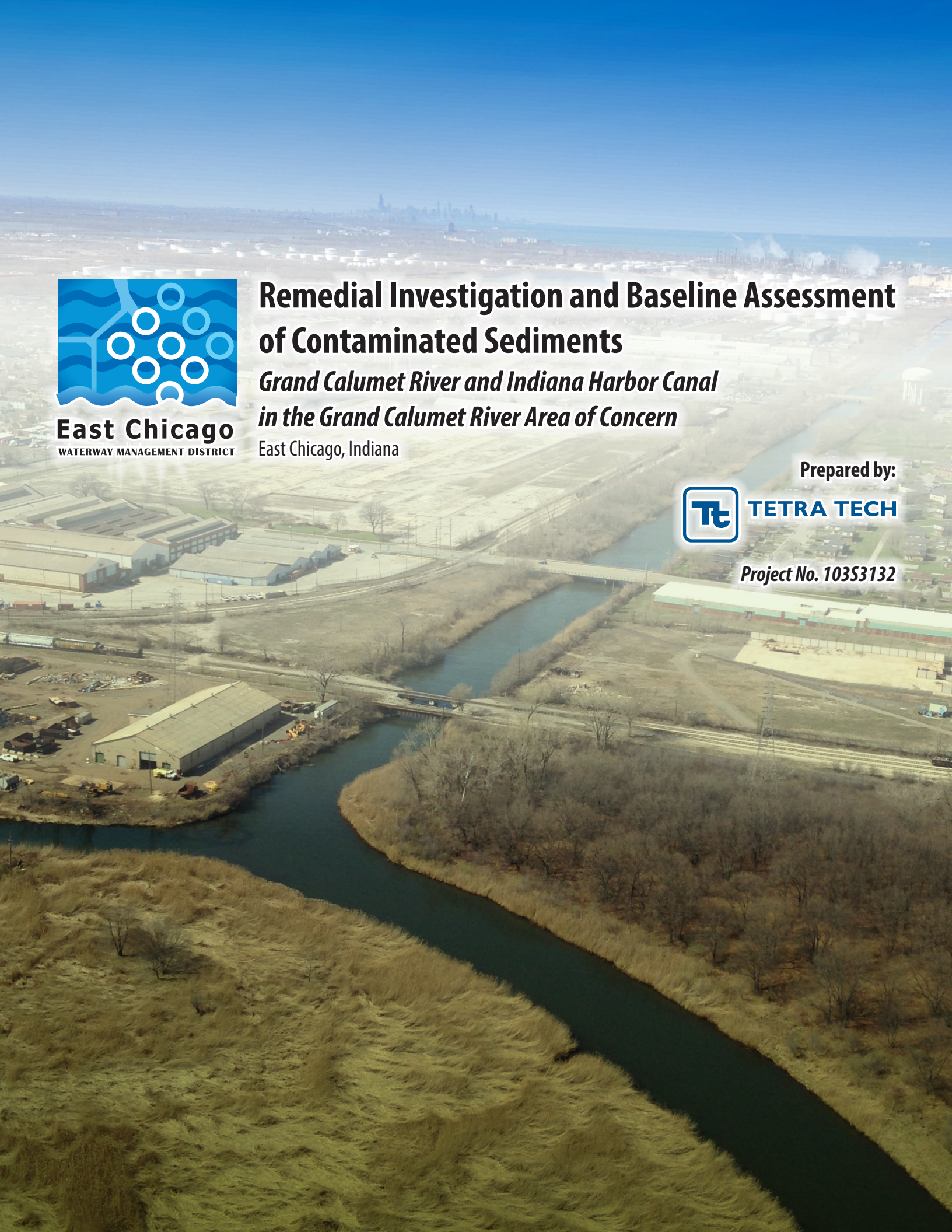

East Chicago
WATERWAY MANAGEMENT DISTRICT

Remedial Investigation and Baseline Assessment of Contaminated Sediments

Grand Calumet River and Indiana Harbor Canal in the Grand Calumet River Area of Concern

East Chicago, Indiana

Prepared by:

TETRA TECH

Project No. 103S3132

REMEDIAL INVESTIGATION AND BASELINE ASSESSMENT OF CONTAMINATED SEDIMENTS OF THE GRAND CALUMET RIVER AND INDIANA HARBOR CANAL IN THE GRAND CALUMET RIVER AREA OF CONCERN

Submitted to
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March 27, 2015

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ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
AVS	Acid Volatile Sulfide
DRO	Diesel Range Organic
DQO	Data Quality Objective
ECWMD	East Chicago Waterway Management District
EOX	Extractable Organic Halogen
EPA	Environmental Protection Agency
ft	feet
GCR	Grand Calumet River
GLNPO	Great Lakes National Program Office
GPS	Global Positioning System
GRO	Gasoline Range Organic
IHC	Indiana Harbor Canal
IJC	International Joint Commission
Khz	Kilohertz
lb	pound
LGC	Lake George Canal
µg/L	Microgram per Liter
MDL	Minimum Detection Limit
mg/kg	Milligram per Kilogram
mg/L	Milligram per Liter
NGVD29	National Geodetic Vertical Datum of 1929
OC	Organic Carbon
PAH	Polyaromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RTK	Real Time Kinematic
SEM	Simultaneously Extracted Metals
SOW	Scope of Work
SVOC	Semivolatile Organic Compound
TCLP	Toxic Characteristic Leachate Procedure
TSCA	Toxic Substance Control Act
USACE	United States Army Corps of Engineers

1.0 INTRODUCTION

This remedial investigation and baseline assessment report, funded by the East Chicago Waterway Management District (ECWMD), presents results of field and laboratory activities for chemical, physical, and topographic data from portions of the Grand Calumet River (GCR), Indiana Harbor Canal (IHC), and Lake George Canal (LGC) in East Chicago, Indiana. The data will be used to evaluate the nature and extent of contamination in these water bodies. The data will also support a subsequent feasibility study to evaluate options for removing and disposing of, or isolating, contaminated sediment. Tetra Tech, Inc. (Tetra Tech) completed a portion of the remedial investigation field activities under the direction of the U.S. Army Corps of Engineers (USACE) Chicago District and the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO).

Additional field and laboratory activities are planned for April 2015. The final scope of activities is contingent on access to various privately owned parcels within the project area. The results of these additional activities will be compiled as an addendum to this document. Once the additional sampling is completed the addendum will provide additional information including spatial representation of the analytical results.

In 1987, both the GCR and IHC were identified as areas of concern (AOC) by the International Joint Commission (IJC). The site was classified as an AOC because it was found to have impairments for each of the 14 beneficial uses evaluated by the IJC.

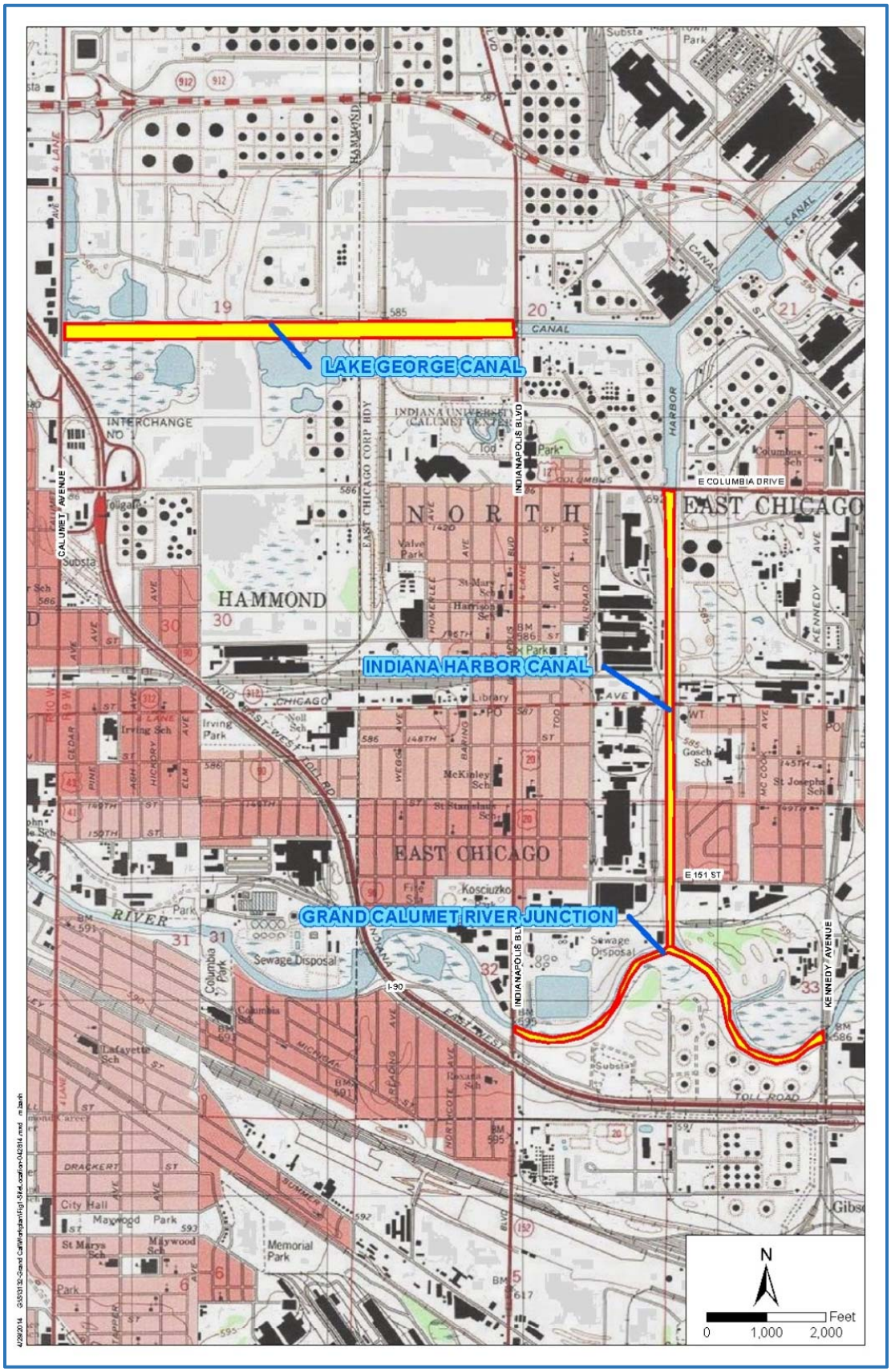
Figure 1 shows the location of the three investigation areas (GCR, IHC, and LGC); the interconnection of these water bodies is further described below.

The GCR is composed of two east-west oriented branches that meet at the southern end of the IHC. The East Branch of the GCR originates at the Grand Calumet River lagoons, located east of the U.S. Steel facility in Gary, Indiana. From the headwaters, the East Branch flows west for about 10 miles to reach its confluence with the IHC and the West Branch of the GCR. The West Branch extends 6 miles from the IHC to the confluence with the Little Calumet River in northeastern Illinois. The GCR system is connected to Lake Michigan by the IHC and Indiana Harbor. The IHC extends a distance of approximately 4 miles north from the confluence of the East and West branches of the GCR to Indiana Harbor. The LGC is a 2-mile branch that extends east-west from Calumet Avenue in Hammond, Indiana, to its junction with the IHC.

The study area for the remedial investigation includes portions of the GCR, IHC, and LGC and is defined as follows:

- GCR Junction: A 1.3-mile section of the GCR from Kennedy Avenue (east) to Indianapolis Boulevard (west)
- IHC: A 1.5-mile non-navigable section of the IHC from the junction with the GCR north to Columbus Drive (U.S. Route 12)
- LGC: A 1.5-mile section of the LGC from Calumet Avenue (west) to Indianapolis Boulevard (east)

FIGURE 1-1: SITE LOCATION MAP



Past sampling of sediment in the GCR and IHC identified elevated concentrations of metals, polychlorinated biphenyls (PCB), semivolatile organic compounds (SVOC), and pesticides (USACE, 2010). The land surrounding these water bodies is primarily industrial and commercial, interspersed with residential areas. The area contains heavy manufacturing facilities associated with the steel industry, petroleum-related operations, packaging operations, chemical processing plants, and other industrial land uses. Removal and remediation of contaminated sediment in the GCR and IHC will aid in restoring many of the impaired beneficial uses (USACE, 2010).

Prior studies indicate that the water level in the GCR and IHC typically varies from 576 to 581 feet relative to National Geodetic Vertical Datum of 1929 (NGVD29), and the water elevation is strongly influenced by Lake Michigan (USACE, 2010). Water depth in the West Branch GCR is 1 to 3 feet and the East Branch is 4 to 7 feet deep. The water depth in the IHC varies from 7 to over 25 feet. The GCR width ranges from 75 to 125 feet wide. The IHC width ranges from 100 to 200 feet, with the widest section in the LGC. Several utilities run under the river and canal. Most of these are located along bridges, although there are a few locations where petroleum pipe lines cross through other rights-of-way. These utilities are typically marked with signs or placards on both sides of the water channel.

1.1 PROBLEM DEFINITION AND BACKGROUND

This section provides project-specific background information on the scope of the GCR, IHC, and LGC remedial investigation (RI). This section also describes the environmental problems associated with contaminated sediment in these areas.

1.2 PROJECT AND TASK DESCRIPTIONS

The remedial investigation for the GCR, IHC, and LGC is based on scopes of work (SOW) issued by the ECWMD (ECWMD 2013) and the USACE Chicago District (USACE 2014). The SOW outlines the following requirements for the remedial investigation:

1. Characterization of sediment in the GCR, IHC, and LGC. The characterization will include both chemical contamination and geophysical characteristics.
2. Pore water sampling and groundwater flow measurements. This part of the investigation will evaluate chemical contamination in sediment pore water as well as hydraulic gradients at the bottom of each water body.
3. Soil characterization of upland areas. The characterization will include both chemical contamination and classification of soils following the Unified Soil Classification System (USCS) in upland areas that may be considered as support or staging areas during future remedial actions. The areas under consideration include an area southwest of the junction of the East and West Branches of the GCR and an area south of the LGC and immediately west of Indianapolis Boulevard.

4. Examination of ongoing sources of contamination in the project area. Storm water outfalls that may contribute to the contaminant loading in the project area will be sampled during storm events.

Completion of Items 3 and 4 above including hydraulic gradient measurements in the sediment pore water and collection of the upland soil samples and storm water samples will be completed as part of ongoing investigation activities scheduled for April 2015. Results of these field activities will be documented in an addendum to this report.

1.3 APPROACH

The overall approach for establishing the sampling plan for GCR and IHC was to follow U.S. EPA's Data Quality Objective (DQO) process, which is documented at the following Web site (http://www.epa.gov/quality/qs-docs/g4-final.pdf). This is a systematic planning tool that first targets one or more management decisions which need to be made for the site, and then considers the quantitative information needed to support those decisions, the risk (consequences and probabilities) of making incorrect decisions, and the type and quantity of data required to support the decisions and adequately control the risks.

For the GCR and IHC, the sampling has two primary components of sampling to detect overall changes in contamination levels in: (1) in the top 6 inches of sediment across the entire site; and (2) in subsurface sediment between 1 and 10 feet across the entire site. Piezometer installation was based on the approach taken during remediation of previous sections of the GCR, including the Roxana section on the West Branch immediately west of the project area, and the Du Pont section on the East Branch immediately east of the project area.

2.0 SITE ASSESSMENT ACTIVITIES SUMMARY

The site assessment activities were conducted as two separate field events. Field Event 1 consisted of a bathymetric survey and Field Event 2 consisted of surface and subsurface sediment collection, piezometer installation, and sediment pore water collection.

Each task was performed in accordance to the sampling design, described in Tetra Tech's approved *Quality Assurance Project Plan for Remedial Investigation of the Grand Calumet River & Indiana Harbor Canal East Chicago, Indiana*, hereafter referred to as the QAPP (Tetra Tech, 2014). The project subtasks were performed as a means of collecting data to accomplish the primary project objectives, which is detailed in the QAPP. The objectives of this program are summarized in Section 1.2 and the methods used to achieve these objectives are detailed below.

2.1 BATHYMETRIC SURVEY

The bathymetric survey was performed by White Lake Dock & Dredge (White Lake). The survey began July 28, 2014, and was completed August 1, 2014. Barges used for a dredging project prevented collection of data in a small area of the LGC in front of the USACE Confined Disposal Facility. USACE provided survey information from 2013 to fill in this data gap. Since no dredging occurred in the area after 2013, the information is assumed to be relatively accurate.

The bathymetric survey was accomplished using several different-sized vessels because of the varying site conditions across the project area. Cross lines were run at 25- to 50-foot intervals (i.e. bank to bank) using a combination of depth sounder and conventional sounding pole techniques. Specialized equipment used for the survey is summarized below:

- Trimble MS 750 RTK GPS and Trimble 5600 robotic total station: These systems utilize local correction signals real time and are sub-centimeter accurate for horizontal and sub 2 centimeter accurate for vertical.
- Imagenex 330/800 Khz dual frequency digital side scan sonar: The side-scan sonar was either pole-mounted or supported by a float when working in shallow water. This system is interlaced with the Trimble positioning system.

The bathymetric survey also included utility and infrastructure measurements to aid the remedial design. White Lake coordinated with Buckeye Partners to locate two petroleum pipe lines that run under the GCR. Two points were located on the top of a 10-inch pipe line in the West Branch. White Lake could not find a 16-inch line in the East Branch because the overlying material was too stiff to penetrate with a probe. White Lake also recorded bridge elevations on the bridges crossing the IHC.

2.2 SURFACE SEDIMENT COLLECTION

A total of 43 surficial grab sediment samples were collected from 43 locations and analyzed for chemical parameters and 11 surficial composite sediment samples were tested for physical parameters. Table 2-1 provides the global positioning system (GPS) coordinates and date collected. Table 2-2 provides the source samples for the physical parameter composite samples. Sample locations are shown on Figures 2-1 through 2-3. Sediment sample collection was performed by White Lake using a Duracraft 24-foot commercial workboat as the sampling platform for most of the samples. A 14-foot John boat was used to collect four samples on the IHC (IHC-02-SED-0-111014 to IHC-05-SED-0-111014) because the bridge heights would not allow access for the Duracraft vessel. Actual sediment sample location coordinates were obtained by White Lake using a Trimble total station.

Most surficial sediment samples were collected with a Ponar grab sampler in order to accumulate sufficient volume for the chemical and geotechnical analyses. Seven of the surficial sediment samples in the IHC (all except IHC-1-SE-0-1103014 and IHC-06-SED-0-110514) and four of the surficial samples in the LGC (LGC-04-SED-0-110514 to LGC-07-SED-0-110514) were taken from the top 6 inches of the sediment in the Vibracore sampler, which was also used for collection of the subsurface sediment samples.

At two locations, GCR 10 and LGC 16, two surface samples were collected at each planned sampling point. The second sample at each location is designated A (Alternate) on the lab results. The additional Alternate sample was collected because the Vibratore equipment could not collect a subsurface sample at the original surficial sample location. At the initial location for both of these sample points, the subsurface was too stiff for the vibratory equipment to penetrate. The sampling vessel off set a short distance to find a more suitable location for sample collection. The second surficial sample was collected from the top 6 inches of the sediment in the Vibracore sampler, which was used for collection of the subsurface sediment samples.

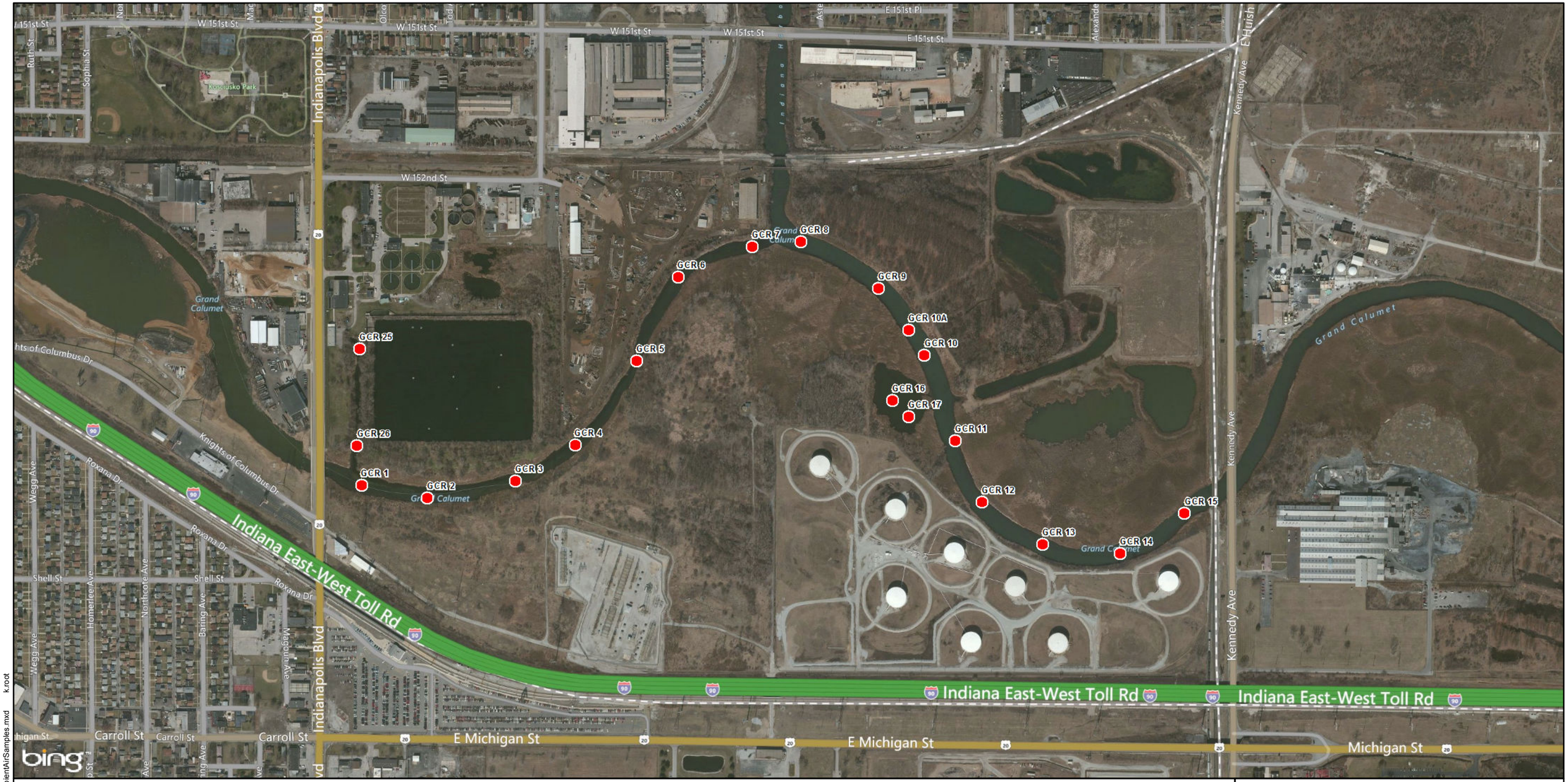
Upon sample collection, the homogenized surficial sediment was distributed into the appropriate certified-clean sample containers. Each sample was labeled with a unique identification number and logged into the chain-of-custody record. Once contained, the samples were packaged for shipment via overnight delivery to the appropriate laboratories for analysis as specified in the QAPP.

Table 2-1. Surficial Sediment Sample Locations

Sample Point	Latitude North	Longitude West	Date
GCR 1	41.61406373	-87.47981752	10/29/2014
GCR 2	41.61386377	-87.47842316	10/29/2014
GCR 3	41.61413905	-87.47657041	10/29/2014
GCR 4	41.6147151	-87.47532671	10/29/2014
GCR 5	41.61603962	-87.474031	10/29/2014
GCR 6	41.6173706	-87.4731763	10/29/2014
GCR 7	41.61784983	-87.47161824	10/29/2014
GCR 8	41.61793797	-87.47058806	10/29/2014
GCR 9	41.61720746	-87.46895554	10/29/2014
GCR 10	41.61615147	-87.46797942	10/29/2014
GCR 10A	41.61655393	-87.46830927	11/7/2014
GCR 11	41.61480402	-87.46733165	10/29/2014
GCR 12	41.61383507	-87.46675812	10/30/2014
GCR 13	41.61317313	-87.46547689	10/30/2014
GCR 14	41.61303446	-87.46384676	10/30/2014
GCR 15	41.6136785	-87.4624972	10/30/2014
GCR 16	41.61543753	-87.46865638	10/31/2014
GCR 17	41.61518578	-87.46831339	10/31/2014
GCR 25	41.61465246	-87.47991632	12/17/2014
GCR 26	41.61468621	-87.47991528	10/30/2014
IHC 1	41.61861337	-87.47105803	10/30/2014
IHC 2	41.61994543	-87.47109081	11/7/2014
IHC 3	41.6225343	-87.47115231	11/7/2014
IHC 4	41.62494502	-87.47108283	11/7/2014
IHC 5	41.62874449	-87.47114342	11/7/2014
IHC 6	41.63126965	-87.4711658	11/5/2014
IHC 7	41.63429771	-87.4712149	11/5/2014
IHC 8	41.63621845	-87.47123442	11/5/2014
IHC 9	41.63810085	-87.47123013	11/5/2014
LGC 1	41.64657019	-87.50695285	11/6/2014
LGC 2	41.64675328	-87.5050472	11/6/2014
LGC 3	41.64671751	-87.50176903	11/6/2014
LGC 4	41.64684876	-87.49590279	11/4/2014
LGC 5	41.64650455	-87.49596817	11/4/2014
LGC 6	41.64693678	-87.49197446	11/4/2014
LGC 7	41.64656812	-87.49271634	11/4/2014
LGC 12	41.64692425	-87.48680484	11/3/2014
LGC 13	41.64690755	-87.48505356	11/3/2014
LGC 14	41.64679266	-87.48339839	11/3/2014
LGC 15	41.64654142	-87.48662152	11/3/2014
LGC 16	41.64642279	-87.48477717	11/3/2014
LGC 16A	41.64659721	-87.48744394	11/4/2014
LGC 17	41.64637632	-87.48355289	11/3/2014

Table 2-2. Physical Parameter Composite Sample Composition

Composite Sample	Source Samples
GCR-1/3-SE-GEO	GCR-01-SE-0-102914 GCR-02-SE-0-102914 GCR-03-SE-0-102914
GCR-4/7/SE-GEO	GCR-04-SE-0-102914 GCR-05-SE-0-102914 GCR-06-SE-0-102914 GCR-07-SE-0-102914
GCR-8/11-SE-GEO	GCR-08-SE-0-102914 GCR-09-SE-0-102914 GCR-10-SE-0-102914 GCR-11-SE-0-102914
GCR-12/15-SE-GEO	GCR-12-SE-0-103014 GCR-13-SE-0-103014 GCR-14-SE-0-103014 GCR-15-SE-0-103014
GCR -16/17-SE-GEO	GCR-16-SE-0-110314 GRC-17-SE-0-110314
IHC-1/5-SE-GEO	IHC-1-SE-0-1103014 IHC-02-SED-0-111014 IHC-03-SED-0-111014 IHC-04-SED-0-111014 IHC-05-SED-0-111014
IHC-6/9-SE-GEO	IHC-06-SED-0-110514 IHC-07-SED-0-110514 IHC-08-SED-0-110514 IHC-09-SED-0-110514
LGC-1/3-SE-GEO	LGC-01-SED-0-110614 LGC-02-SED-0-110614 LGC-03-SED-0-110614
LGC-4/7-SE-GEO	LGC-04-SED-0-110514 LGC-05-SED-0-110514 LGC-06-SED-0-110514 LGC-07-SED-0-110514
LGC-12/14-SE-GEO	LGC-12-SE-0-110414 LGC-13-SE-0-110414 LGC-14-SE-0-110414
LGC-15/17-SE-GEO	LGC-15-SE-0-110414 LGC-16-SE-0-110414 LGC-17-SE-0-110414



LEGEND

● Surface Sediment Sample Location

N

0 500 1,000 Feet

FIGURE 2-1
SURFACE SEDIMENT SAMPLES
GRAND CALUMET RIVER

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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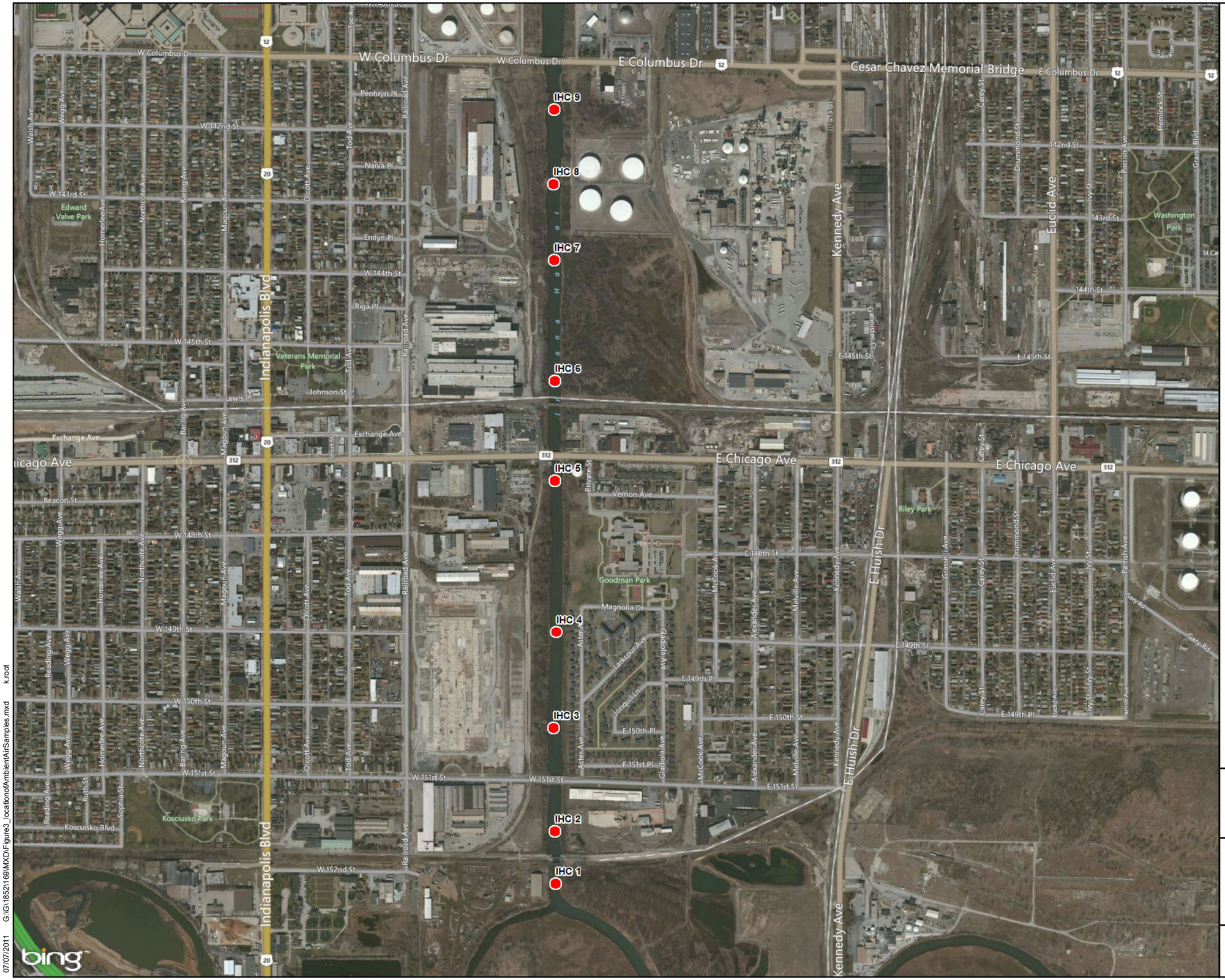

LEGEND

● Surface Sediment Sample Location

N

0 1,000 2,000 Feet

FIGURE 2-2
SURFACE SEDIMENT SAMPLES
INDIANA HARBOR CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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LEGEND

● Surface Sediment Sample Location

N

0 500 1,000 Feet

FIGURE 2-3
SURFACE SEDIMENT SAMPLES
LAKE GEORGE CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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Surficial sediment samples were analyzed for the following chemical parameters:

- Total organic carbon
- Polyaromatic hydrocarbons (PAH)
- PCB Aroclors
- Oil and grease
- Gasoline-range organics (GRO)
- Diesel-range organics (DRO)
- Total extractable organic halogen
- Total phenol
- Total metals
- Cyanide
- Acid volatile sulfides/simultaneously extracted metals (AVS/SEM)
- Toxicity Characterization Leaching Procedure (TCLP)

Surficial sediment samples were also analyzed for the following physical parameters:

- Moisture content
- Bulk density
- Grain size distribution

Atterberg Limit tests were not performed on any of the samples because the clay content in all of the samples was too low.

2.3 SUBSURFACE SEDIMENT COLLECTION

Subsurface sediment samples were collected at 40 locations to 10 feet below the sediment surface or refusal. A total of 80 samples were submitted for laboratory analyses. Table 2-3 provides the global positioning system (GPS) coordinates and date collected. Locations for the subsurface samples are shown in Figures 2-4 through 2-6; these locations vary somewhat from the surficial sampling locations based on the different sampling method for subsurface sampling. Sediment sample collection was performed by White Lake. A Duracraft 24-foot commercial workboat was used as the sampling platform for most of the samples. A 14-foot John boat was used to collect eight samples on the IHC (sample points IHC-02 to IHC-05) because the bridge heights would not allow access for the Duracraft vessel. Actual sediment sample locations coordinates were obtained by White Lake using a Trimble total station.

The Duracraft commercial workboat was affixed with a rugged 20-foot A-frame securely pinned to adaptors on the rear of the work platform and was cable stayed to the forward part of the boat. White Lake used a Vibracore unit with polycarbonate 3-inch diameter sample tubes of 10 feet in length. An electric winch with remote control provided vertical lift for the vibratory coring unit. The cable was marked with length indicators to document sediment depths and penetrations during Vibracore sampling. Subsurface samples collected from the John boat used a custom designed 3-inch piston sampler. A piston inside the core tube provided the required suction to overcome surface friction when driving the coring device and retrieving the sample.

Upon retrieval, the sediment samples were inspected for acceptability. If the sediment surface within the core barrel appeared disturbed, then the sample was considered unacceptable and the sample was discarded and a new sediment core was collected. After identifying a suitable core, excess water was drained from the core and the top and bottom capped and sealed with tape. The core was placed upright in a storage rack on the vessel and maintained in that position until removed from the vessel for sample collection.

Sample cores were placed in the horizontal position and the cores split down each side to expose the sediment. Tetra Tech examined the sediment core, recorded the length, and took photographs. A log was completed on each core with the soil classification and soil description for each unique interval in the sediment core. After a review of the entire core, Tetra Tech identified two 6 to12-inch intervals below the top 12 inches of sediment for sample collection.

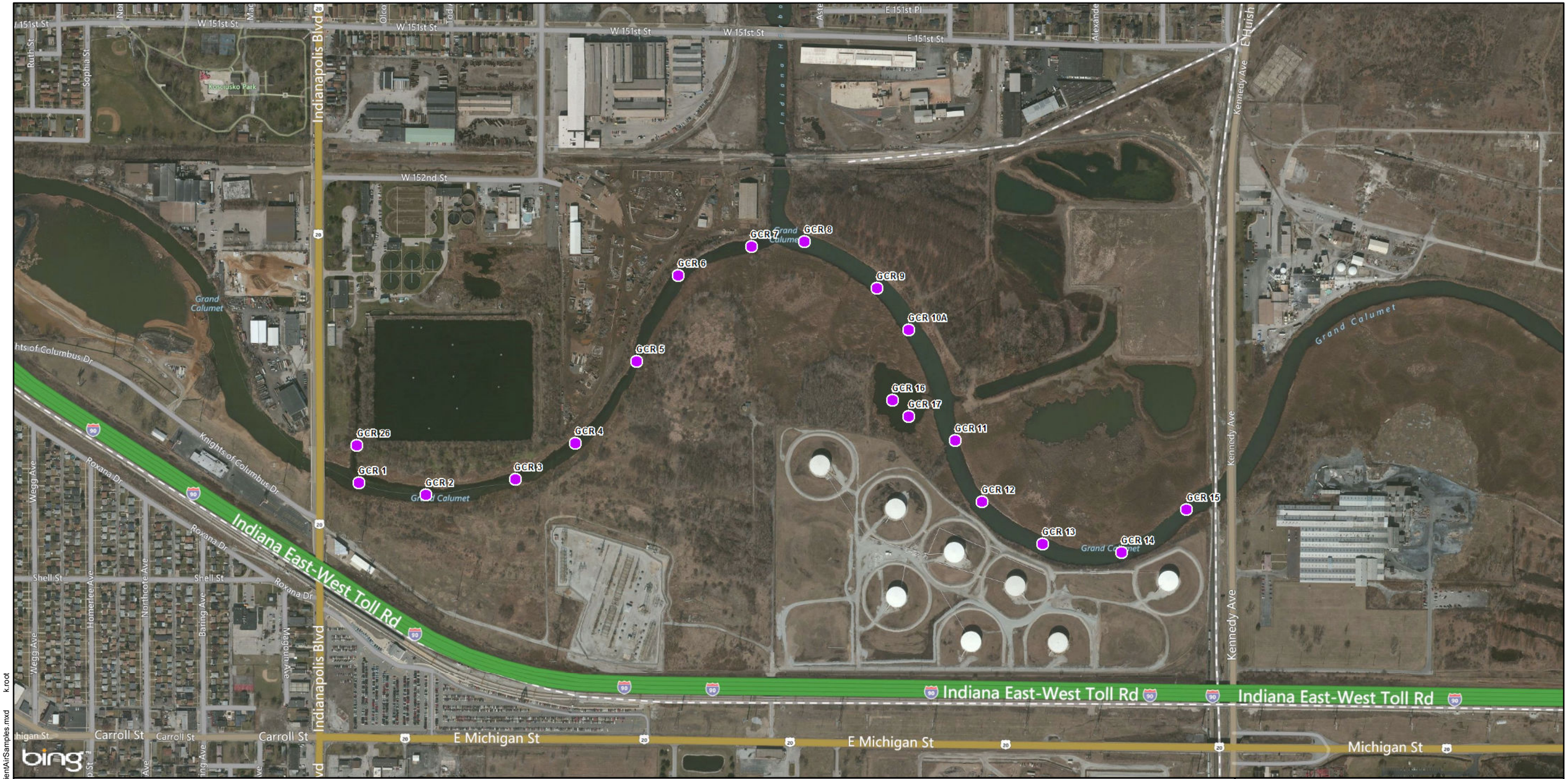
Upon sample collection, the homogenized subsurface sediment was distributed into the appropriate certified-clean sample containers. Each sample was labeled with a unique identification number and logged into the chain-of-custody record. Once contained, the samples were packaged for shipment via overnight delivery to the approved laboratories for analysis, as specified in the QAPP.

Subsurface sediment samples were analyzed for the following chemical parameters:

- Total organic carbon
- Polyaromatic hydrocarbons (PAH)
- PCB Aroclors
- Oil and grease
- Gasoline-range organics
- Diesel-range organics
- Total metals

Table 2-3. Subsurface Sediment Sample Locations

Sample Point	Latitude North	Longitude West	Date
GCR 1	41.61409725	-87.47986442	10/31/2014
GCR 2	41.61391534	-87.47846253	10/31/2014
GCR 3	41.61416544	-87.47658278	10/31/2014
GCR 4	41.61473967	-87.47532426	10/31/2014
GCR 5	41.61603196	-87.4740338	11/7/2014
GCR 6	41.61739387	-87.47316923	10/30/2014
GCR 7	41.61785704	-87.47163749	10/30/2014
GCR 8	41.6179398	-87.47051701	11/7/2014
GCR 9	41.61720954	-87.46898328	11/7/2014
GCR 10A	41.61655393	-87.46830927	11/7/2014
GCR 11	41.61480402	-87.46733165	11/6/2014
GCR 12	41.61383507	-87.46675812	11/6/2014
GCR 13	41.61317313	-87.46547689	11/6/2014
GCR 14	41.61305168	-87.46381735	11/6/2014
GCR 15	41.61373119	-87.46244924	11/6/2014
GCR 16	41.61543753	-87.46865638	10/31/2014
GCR 17	41.61518578	-87.46831339	10/31/2014
GCR 26	41.61475132	-87.4799042	10/31/2014
IHC 1	41.61861337	-87.47105803	11/7/2014
IHC 2	41.61994543	-87.47109081	11/7/2014
IHC 3	41.6225343	-87.47115231	11/7/2014
IHC 4	41.62494502	-87.47108283	11/7/2014
IHC 5	41.62874449	-87.47114342	11/7/2014
IHC 6	41.63126965	-87.4711658	11/5/2014
IHC 7	41.63429771	-87.4712149	11/5/2014
IHC 8	41.63621845	-87.47123442	11/5/2014
IHC 9	41.63810085	-87.47123013	11/5/2014
LGC 1	41.64657019	-87.50695285	11/6/2014
LGC 2	41.64675328	-87.5050472	11/6/2014
LGC 3	41.64671751	-87.50176903	11/6/2014
LGC 4	41.64684876	-87.49590279	11/4/2014
LGC 5	41.64650455	-87.49596817	11/4/2014
LGC 6	41.64693678	-87.49197446	11/4/2014
LGC 7	41.64656812	-87.49271634	11/4/2014
LGC 12	41.64692425	-87.48680484	11/3/2014
LGC 13	41.64690755	-87.48505356	11/3/2014
LGC 14	41.64679266	-87.48339839	11/3/2014
LGC 15	41.64654142	-87.48662152	11/3/2014
LGC 16A	41.64659721	-87.48744394	11/4/2014
LGC 17	41.64637632	-87.48355289	11/4/2014



LEGEND

● Subsurface Sediment Sample Location

N

0 500 1,000 Feet

FIGURE 2-4
SUBSURFACE SEDIMENT SAMPLES
GRAND CALUMET RIVER

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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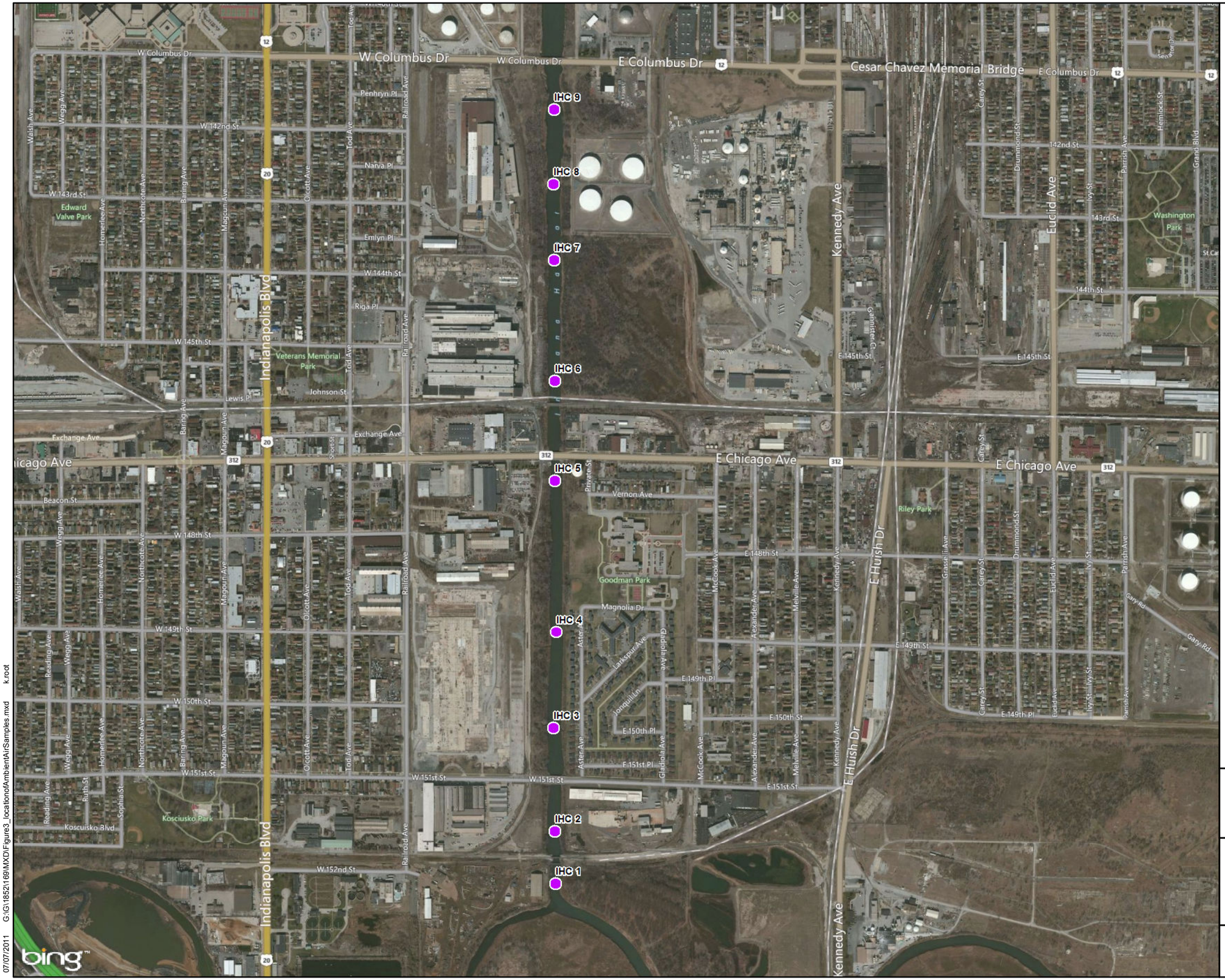

LEGEND

- Subsurface Sediment Sample Location

N

0 1,000 2,000 Feet

FIGURE 2-5
SUBSURFACE SEDIMENT SAMPLES
INDIANA HARBOR CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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LEGEND

● Subsurface Sediment Sample Location

N

0 500 1,000 Feet

FIGURE 2-6
SUBSURFACE SEDIMENT SAMPLES
LAKE GEORGE CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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2.4 PORE WATER COLLECTION

Sediment pore water was collected at 11 locations in the GCR, IHC, and LGC and submitted for laboratory analyses. Table 2-4 provides the global positioning system (GPS) coordinates and date collected. Locations for the samples are shown in Figures 2-7 through 2-9. Eight of the pore water samples were collected concurrently with the surface sediment sampling. Surficial sediment for pore water analysis was collected using a Ponar grab sampler. Sufficient grab sample volumes were collected at each surface location to fill a 5- gallon bucket.

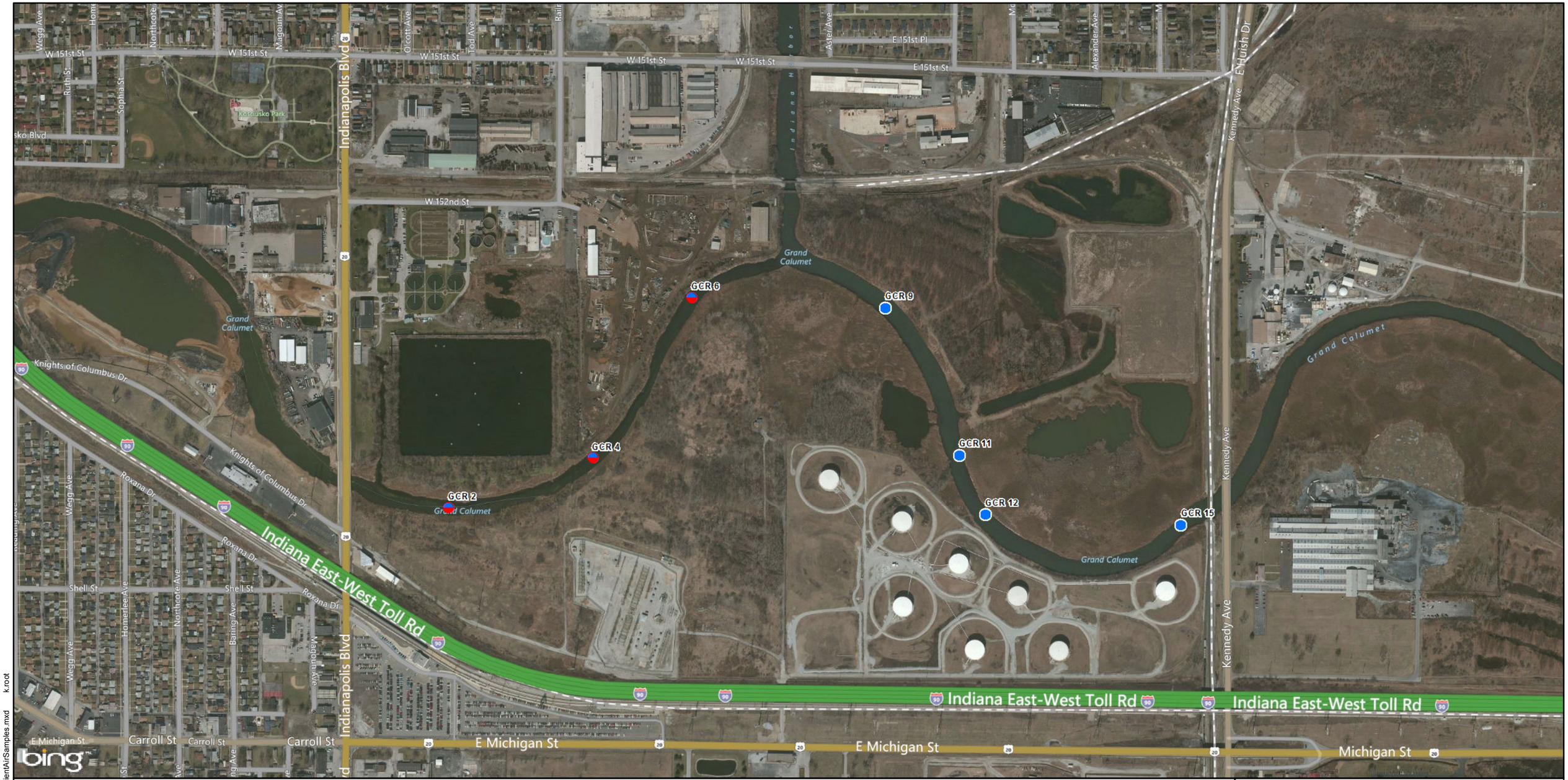
Subsurface sediment pore water was collected from shallow piezometers installed at three locations on the West Branch of the GCR. The piezometers were constructed using 1. 5-inch Schedule 40 polyvinyl chloride with a 12-inch long screen approximately 4 feet below the sediment surface. Each piezometer was installed using a manual slide hammer. Following installation, each piezometer was developed using a low-flow peristaltic pump to remove sediment fines and clear the piezometer screen. Subsurface pore water samples were collected one week after development using a low-flow peristaltic pump.

Table 2-4. Pore Water Sample Locations

Sample Point	Sample Depth	Latitude North	Longitude West	Date
GCR 2	4 Feet Below Surface	41.61391534	-87.47846253	12/04/2014
GCR 4	4 Feet Below Surface	41.61473967	-87.47532426	12/04/2014
GCR 6	4 Feet Below Surface	41.6173706	-87.4731763	12/04/2014
GCR 9	Surface	41.61720746	-87.46895554	10/30/2014
GCR 11	Surface	41.61480402	-87.46733165	10/29/2014
GCR 12	Surface	41.61383507	-87.46675812	10/30/2014
GCR 15	Surface	41.6136785	-87.4624972	10/30/2014
IHC 2	Surface	41.61994543	-87.47109081	11/7/2014
IHC 9	Surface	41.63810085	-87.47123013	11/5/2014
LGC 4	Surface	41.64684876	-87.49590279	11/4/2014
LGC 6	Surface	41.64693678	-87.49197446	11/4/2014

Sediment pore water samples were analyzed for the following chemical parameters:

- PCB Aroclors
- Polyaromatic hydrocarbons (PAH)
- Pesticides
- Total organic carbon
- Dissolved organic carbon
- Total metals
- Dissolved metals



LEGEND

- Piezometer and Pore Water Sample Location
- Pore Water Sample Location

N

0 500 1,000 Feet

FIGURE 2-7
PORE WATER SAMPLES
GRAND CALUMET RIVER

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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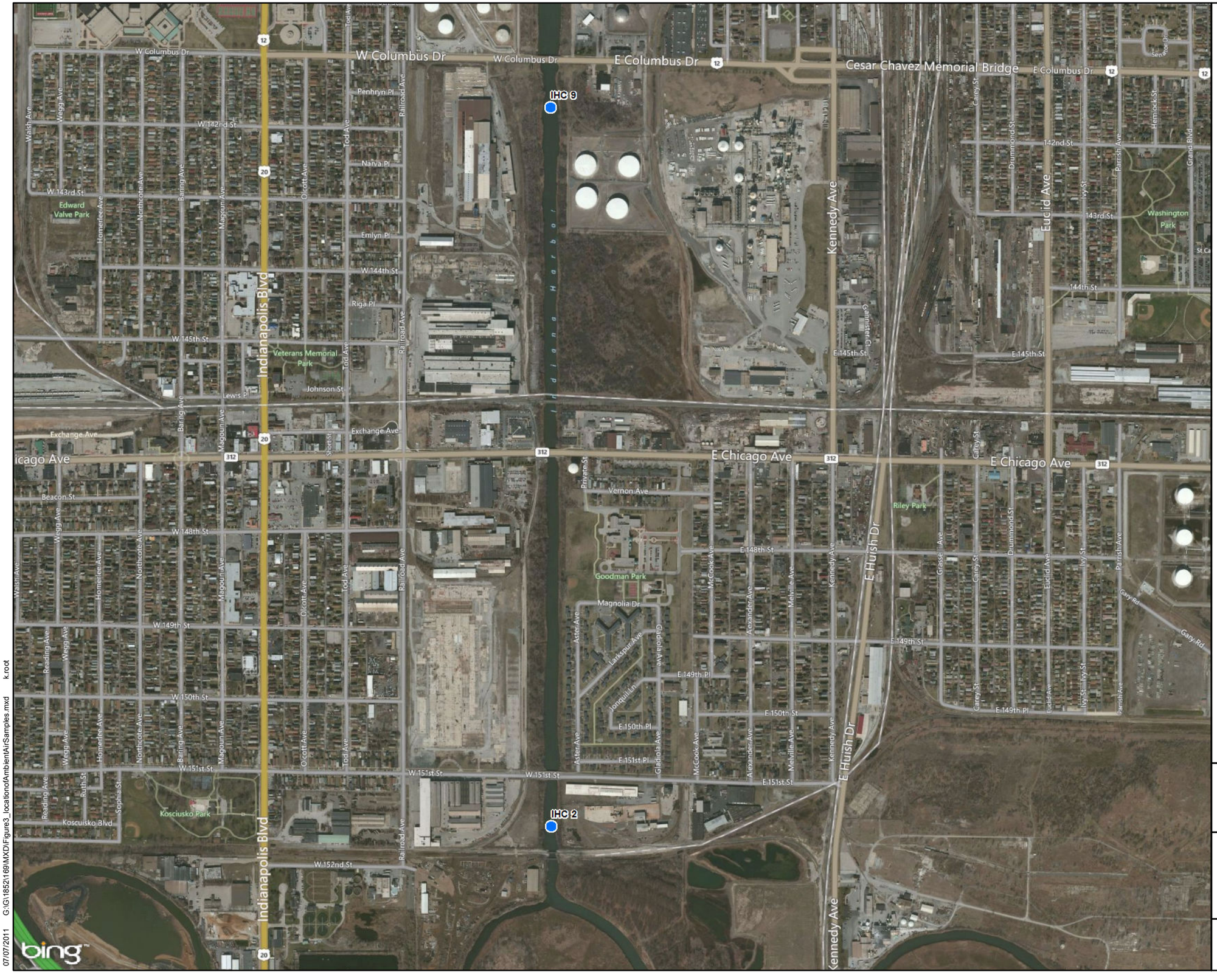

LEGEND

● Pore Water Sample Location

N

0 1,000 2,000 Feet

FIGURE 2-8
PORE WATER SAMPLES
INDIANA HARBOR CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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LEGEND

- Pore Water Sample Location

N

0 500 1,000 Feet

FIGURE 2-9
PORE WATER SAMPLES
LAKE GEORGE CANAL

GCR JUNCTION REACH
ECWMD GRAND CALUMET RIVER AND
INDIAN HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

TETRA TECH

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3.0 CHARACTERIZATION RESULTS

A summary of the surveying and sampling results for the remedial investigation effort is presented in this section. Tables in this section summarize the laboratory results for select parameters of the sediment and pore water samples. Table 3-1 identifies the various laboratories used for analyses. Complete laboratory data packages including quality assurance/quality control (QA/QC) sample results are provided in appendices to this report as follows:

Appendix A - Bathymetry results
Appendix B –Chemical parameter results
Appendix C – Physical parameter results
Appendix D – Core logs
Appendix E – Photo log of cores

For the calculation of total PCBs and Total PAHs, parameters with non-detect results were assigned a value of one-half (½) the MDL.

Table 3-1. Summary of Laboratories Performing Analyses

Analytical Laboratory/Shipping Address
Eurofins Lancaster Laboratories Environmental, LLC 2425 New Holland Pike , Lancaster, PA 17601
ALS Environmental 34 Dogwood Lane, Middletown, PA 17057
K&S Engineers, Inc. 9715 Kennedy Avenue, Highland, IN 46322

3.1 BATHYMETRY RESULTS

The bathymetric survey results are consistent with the expected sediment surface in the project area. Average sediment elevation in the West Branch of the GCR is approximately 578 feet and the East Branch is 575 feet, although the surface rises in the middle of this section east of the 16-inch pipe line. Sediment elevation in the IHC is approximately 573 feet, although deeper scour holes are present downstream of the 151st Street and Chicago Avenue bridges. The LGC east of the land bridge varies between 560 feet and 570 feet. The deeper sections are on the north side of the canal immediately south of the USACE Confined Disposal Facility, which is part of the navigation channel, and under the railroad bridge. The LGC west of the land bridge varies between 560 feet and 570 feet.

Several utilities cross over and under all sections of the project area, and most underground utilities are well marked on the banks. A 10-inch petroleum pipe line (owned by Buckeye Partners) crosses the West Branch of the GCR in a north-south orientation immediately east of the East Chicago Sanitary District. The top of the pipe line is approximately 1 to 2 feet below the top of the sediment and appears higher near the south bank. Additional information on utilities in the project area will be provided in a separate technical memorandum.

Debris (consistent with the long period of industrial use, such as wood pilings and metal posts) was found along the edge of the river and canal. No significant debris was found within the center of the water bodies; however, small objects such as a bicycle and shopping cart were noted.

Results are provided in Appendix A.

3.2 SURFICIAL SEDIMENT RESULTS

A total of 43 surficial grab sediment samples were analyzed for chemical parameters and 11 surficial composite sediment samples were tested for physical parameters. As discussed in the Introduction, additional sampling for sections of the project area is planned in April 2015. Figures showing the spatial distribution of the organic parameters will be prepared after the April sampling and included in the addendum to this report.

Chemical Parameter Results. All surficial sediment samples were analyzed for the chemical parameters discussed in Section 2.2. Total PAHs were calculated as the sum of the 16 priority PAHs. A summary of the chemical organic concentrations in presented in Table 3-2. Aroclor 1248 and Aroclor 1254 were the principal Aroclors detected, with Aroclor 1260 also appearing in a few samples. One location, IHC-3, contained PCBs detected in the surficial sediment at a concentration of 81 mg/kg, exceeding 50 mg/kg, which is the threshold at which material would be considered a Toxic Substances Control Act (TSCA) waste if removed during remediation. Additional sampling is planned in April 2015 to further delineate the PCB impacts and extent of potential TSCA material in the IHC.

The spatial distribution of the organic parameters varies within subunits in the project area. For, example, PCBs are higher in the East Branch of the GCR, the IHC, and part of the LGC. Oil and grease and DRO products are generally more pronounced in the LGC than the GCR.

Table 3-2. Surficial Sediment: Organic Chemical Concentrations

Sample Point	TOC %	Total PAH (16) mg/kg	Total PCB mg/kg	Oil & Grease mg kg	GRO mg/kg	DRO mg/kg	EOX mg/kg	Phenol mg/kg
GRC-1	1.3	4.7	1.11	2610	8.3	440	ND	3.2
GRC-2	2	4.84	0.69	4170	4.6	1400	ND	2.1
GCR-3	2.87	10.5	0.81	9140	12	4200	ND	1.7
GCR 4	2.88	3.02	0.54	4100	6	730	ND	1.6
GCR-5	3.53	39.44	1.02	21600	140	15000	ND	1.8
GCR-6	4.11	10.08	0.47	4650	40	4200	ND	1.9
GCR-7	2.55	11.09	0.78	6760	35	3200	ND	2.0
GCR-8	3.66	3.33	3.1	5780	3.3	1100	ND	2.1
GCR-9	6.75	3.73	3.43	2490	6	1000	ND	2.9
GCR-10	4.91	20.29	1.66	7280	8.2	4400	ND	1.7
GCR-10A	7.5	27.04	5.48	87600	79	3500	ND	See Note
GCR-11	8.58	5.48	6.89	15300	10	1700	ND	2.6
GCR-12	9.37	6.94	6.01	8300	6	1500	ND	3.4
GCR-13	6.65	6.4	4.35	14600	5.8	1700	ND	2.6
GCR-14	2.17	3.8	1.89	4040	2.9	610	ND	6.1
GCR-15	4.31	4.23	4.77	6050	3.5	1500	ND	2.1
GCR-16	7.73	9.18	2.62	3640	19	2200	ND	7.3
GCR-17	13	9.48	3.53	5200	18	3300	ND	10.2
GCR 25	8.02	80.2	1.69	2440	110	2000	22.2	5.2
GCR 26	2.38	1.35	0.61	1560	3.3	160	ND	4.8
IHC 1	6.63	9.26	3.39	1650	3.4	2000	ND	5.2
IHC 2	1.19	13	0.06	3070	6.7	3500	ND	1.8
IHC 3	2.98	40.28	81.15	19300	13	6900	ND	2.6
IHC 4	0.64	11.71	3.87	3930	5.1	2300	ND	1.6
IHC 5	1.33	4.21	1.63	1820	4.1	1600	ND	1.6
IHC 6	0.58	7.63	1.81	4910	1.3	2600	ND	1.3
IHC 7	1.26	2.99	1.3	3490	2.7	1300	ND	1.8
IHC 8	3.22	7.46	1.99	2150	2.3	2700	ND	1.6
IHC 9	10.7	42.33	23.02	77200	9.8	26000	ND	5.3
LGC 1	14.8	61.7	0.17	12500	220	11000	ND	11.1
LGC 2	36.7	60.7	0.33	3900	26	10000	ND	10.0
LGC 3	9.78	52.7	0.2	8500	25	9000	ND	10.3
LGC 4	27.6	13.53	1.3	90100	32	9500	ND	5.1
LGC 5	16.8	16.33	1.16	86900	19	9200	ND	7.8
LGC 6	11.7	58.42	1.61	72600	200	29000	ND	2.6
LGC 7	11	24.46	1.06	73800	10	9200	ND	4.8
LGC 12	1.88	39.38	0.66	7350	610	9000	ND	1.4
LGC 13	11.4	211.2	5.96	18700	280	2100	ND	3.5
LGC 14	8.9	147.2	6.84	10400	520	1600	ND	3.4
LGC 15	1.44	17.01	1.03	3030	220	47000	7.6	1.4
LGC 16	4.35	158	3.57	6510	430	15000	ND	2.0
LGC 16A	10.1	46.07	3.26	20000	380	56000	ND	2.0
LGC 17	1.89	29.75	1.12	4830	110	8100	ND	1.5

Note: Sample Point 10A was not analyzed for total phenol

Table 3-3 shows the surficial sediment total metals concentrations for arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury as well as cyanide.

Table 3-3. Surficial Sediment: Inorganic Chemical Concentrations

Sample Point	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Nickel mg/kg	Zinc mg/kg	Mercury mg/kg	Cyanide mg/kg
GRC-1	19.7	6.01	141	143	352	45.4	1090	0.85	4.7
GRC-2	15.2	3.55	81.1	77.3	210	24.5	584	0.55	2.1
GCR-3	18.4	5.25	102	120	369	30.7	844	0.73	2.2
GCR 4	9.73	4.08	88.6	88.9	200	20.4	700	0.78	2.5
GCR-5	27	4.12	86.3	119	8090	23.1	705	0.73	2.5
GCR-6	37.9	5.42	161	132	509	40.3	1090	0.54	2.9
GCR-7	42.8	3.35	214	143	647	35.7	1260	0.52	4.7
GCR-8	73	3.99	129	92.3	289	31.8	1120	0.43	1.3
GCR-9	76.6	6.97	211	163	512	49.1	2010	0.75	2.6
GCR-10	79.8	6.08	105	90.1	290	37.5	1170	0.58	1.9
GCR-10A	165	9.71	42	106	349	3.85	1050	1.47	See Note
GCR-11	64	5.81	284	201	619	102	2320	1.1	3.6
GCR-12	86.6	9.11	238	180	631	71.7	2190	1.36	3.5
GCR-13	76.7	7.3	196	137	516	54.4	1750	1.15	2.0
GCR-14	24.9	2.75	58.3	63.5	173	19	675	0.31	1.3
GCR-15	24.5	3.06	62.7	61.4	187	18.3	685	0.33	1.5
GCR-16	32.6	12.5	211	157	742	52.5	1990	1.09	1.1
GCR-17	53.4	19.7	294	212	848	65.4	3020	1.09	4.4
GCR 25	32.2	7.45	144	196	242	10.5	1950	2.03	18.0
GCR 26	21.7	2.13	60.8	69.5	115	9.4	426	0.65	8.9
IHC 1	56.9	5.16	165	174	687	38.2	1180	0.74	2.6
IHC 2	38.9	3.73	12.1	33.5	211	6.84	2190	0.33	1.4
IHC 3	27.1	4.88	143	82.6	636	34.8	1200	0.35	2.7
IHC 4	13.8	1.29	93	45.4	171	21.8	769	0.18	2.8
IHC 5	18.1	5.48	42.5	50.9	236	11	706	0.45	3.1
IHC 6	20	3.59	64.8	33	118	13.7	1380	0.32	1.3
IHC 7	9.07	0.63	82.1	35.1	83.9	85	488	0.22	1.2
IHC 8	15.3	0.75	89.6	67.3	185	31.7	787	0.49	1.1
IHC 9	74.5	4.08	437	311	878	99.5	3100	1.77	2.5
LGC 1	41.5	2.91	77.6	131	566	32.6	844	0.508	1.7
LGC 2	34.7	2.12	93.5	224	699	46.1	833	1.66	1.5
LGC 3	22.6	1.49	55.5	107	365	28.6	536	0.898	1.5
LGC 4	44.2	4.44	464	135	849	38.9	1420	0.614	2.8
LGC 5	59	3.78	652	196	789	51	1610	0.84	4.5
LGC 6	19.3	1.33	118	45	404	15.9	440	0.263	0.7
LGC 7	43.4	2.95	286	101	671	28	1070	0.522	4.5
LGC 12	2.46	0.0741	29.6	8.94	76.1	8.54	106	0.0435	2.0
LGC 13	37.1	4.02	362	193	898	53.1	2420	0.703	7.2
LGC 14	38.8	5.13	420	214	986	54.1	2310	0.732	3.6
LGC 15	8.59	1.33	520	55.3	441	39	665	0.193	1.7
LGC 16	17.2	3.3	360	112	923	40.2	1390	0.319	3.2
LGC 16A	8.03	0.771	78.1	28.6	206	14.5	332	0.193	2.6
LGC 17	4.06	0.331	43.9	18.3	122	12	180	0.0533	2.9

Note: Sample Point 10A was not analyzed for cyanide

To assess the potential impact of metal bioavailability, surficial sediment samples were analyzed to determine their acid volatile sulfide (AVS) and simultaneously extracted metals (SEM) concentrations reported at micromoles per gram (µmoles/g) of sediment. The results are shown in Table 3-4. Potential effects of metal-contaminated sediments can be predicted by determining the SEM/AVS ratio (Di Toro and others 1990). DiToro and others (1990) showed that AVS binds with metals in the sediments in a sulfide complex; once bound, the metals are not bioavailable and toxicity is not exhibited. The presence of AVS at a concentration that exceeds the SEM concentration indicates sufficient sulfide to bind the available metals. Moreover, organic carbon will also combine with toxic metals and render them unavailable, thereby reducing their toxicity (DiToro and others 2005 and EPA 2005). To factor the organic carbon the following equation is used:

$$(\Sigma SEM - AVS)\Big/_{f_{oc}} (\mu\text{moles/g}_{oc})$$

EPA (2005) reported that toxicity is not likely when the results of the above equation are ≤ 130 µmoles/g_{oc} . For those sediments where the results are between 130 µmoles/g_{oc} and 3,000 µmoles/g_{oc} they may have adverse biological effects, and those > 3,000 µmoles/g_{oc} adverse effects are expected.

Table 3-5 presents the TCLP results for the surficial sediments. No samples exceeded the RCRA limit for any TLCP parameter.

Table 3-4. Surficial Sediment: Acid Volatile Sulfides/Simultaneously Extracted Metals (AVS/SEM)

Chemical	Reporting Units	GCR-01	GCR-02	GCR-03	GCR-04	GCR-05	GCR-06	GCR-07	GCR-08	GCR-09	GCR-10	GCR-11	GCR-12	GCR-13	GCR-14	GCR-15	GRC-16	GRC-17	GRC-25	GCR-26	IHC-1	IHC-02
Acid Volatile Sulfide	umol/g	37.5	7.5	3	16.9	8.3	18.1	11.3	5.9	13.4	9.9	29.8	28.6	33.9	12.4	22.2	177	54.3	13.2	12.3	13.9	38.2
Cadmium	umol/g	0.042	0.0289	0.0276	0.0307	0.0173	0.1	0.0345	0.0175	0.0314	0.0295	0.0352	0.0335	0.0311	0.012	0.0111	0.0864	0.138	0.00808	0.0107	0.0284	0.0131
Copper	umol/g	0.356	0.455	0.418	0.271	0.262	0.871	0.893	0.583	1.02	0.401	0.72	0.741	0.341	0.315	0.175	0.325	1.1	0.0328	0.218	0.578	0.247
Lead	umol/g	0.84	0.723	0.806	0.758	2.68	1.31	1.85	0.915	1.48	0.739	2.13	1.89	1.2	0.543	0.527	2.52	2.89	0.275	0.422	1.06	0.8
Mercury	umol/g	0.00002	1.3E-05	0.00001	9.8E-06	1.1E-05	1.2E-05	1.2E-05	1.3E-05	1.8E-05	1.1E-05	1.5E-05	1.9E-05	1.6E-05	1.1E-05	1.2E-05	4.6E-05	4.4E-05	1.7E-05	1.4E-05	1.2E-05	1.1E-05
Nickel	umol/g	0.228	0.185	0.335	0.368	0.39	0.457	0.506	0.152	0.23	0.182	0.528	0.298	0.182	0.0941	0.182	0.817	0.595	0.219	0.252	0.225	0.187
Zinc	umol/g	9.82	7.16	8.18	9.12	7.46	19.6	11.3	9.38	15.2	9.78	21.8	21.5	12.9	6.63	5.45	20.6	30.5	2.71	6.32	10.5	21
SEM Sum	umol/g	11.286	8.552	9.767	10.548	10.809	22.338	14.584	11.048	17.961	11.132	25.213	24.463	14.654	7.594	6.345	24.348	35.223	3.245	7.223	12.391	22.247
SEM/AVS		0.301	1.140	3.256	0.624	1.302	1.234	1.291	1.872	1.340	1.124	0.846	0.855	0.432	0.612	0.286	0.138	0.649	0.246	0.587	0.891	0.582
ESB {SEM-AVS}	umol/g	-26.214	1.052	6.767	-6.352	2.509	4.238	3.284	5.148	4.561	1.232	-4.587	-4.137	-19.246	-4.806	-15.855	-152.652	-19.077	-9.955	-5.077	-1.509	-15.953
TOC	%	1.3	2	2.87	2.88	3.53	4.11	2.55	3.66	6.75	4.91	8.58	9.37	6.65	2.17	4.31	7.73	13	8.02	2.38	6.63	1.19
foc		0.013	0.02	0.0287	0.0288	0.0353	0.0411	0.0255	0.0366	0.0675	0.0491	0.0858	0.0937	0.0665	0.0217	0.0431	0.0773	0.13	0.0802	0.0238	0.0663	0.0119
∑SEM -AVS/foc		-2016.46	52.60	**235.77**	-220.57	71.09	103.11	128.77	**140.64**	67.58	25.08	-53.46	-44.16	-289.41	-221.47	-367.86	-1974.79	-146.75	-124.13	-213.33	-22.75	-1340.58

Chemical	Reporting Units	IHC-03	IHC-04	IHC-05	IHC-06	IHC-07	IHC-08	IHC-09	LGC-01	LGC-02	LGC-03	LGC-04	LGC-05	LGC-06	LGC-07	LGC-12	LGC-13	LGC-14	LGC-15	LGC-16	LGC-16A	LGC-17
Acid Volatile Sulfide	umol/g	24.4	2.8	89.3	3.1	3.8	2.4	90.8	169	218	73.4	64.8	37.7	95.2	65.5	4.8	21.2	33.2	3.4	31.3	23.8	8.5
Cadmium	umol/g	0.0181	0.0158	0.149	0.0171	0.00614	0.00847	0.0328	0.0272	0.0238	0.0194	0.029	0.0308	0.00924	0.0162	0.00707	0.055	0.0519	0.00418	0.0248	0.017	0.009
Copper	umol/g	0.334	0.308	0.196	0.259	0.214	0.253	0.661	0.0117	0.0105	0.0139	0.196	0.0108	0.00782	0.324	0.1	1.08	1.43	0.0953	0.283	0.212	0.130
Lead	umol/g	0.825	0.626	3.62	0.626	0.327	0.346	1.98	1.71	2.02	1.32	1.61	1.52	0.56	1.68	0.606	2.91	2.61	0.379	1.94	1.85	0.709
Mercury	umol/g	0.00001	9.8E-06	0.00001	7.9E-06	9.3E-06	0.00001	1.7E-05	6.8E-05	6E-05	6.5E-05	3.2E-05	3.5E-05	1.7E-05	0.00003	9E-06	2.2E-05	2.1E-05	9.3E-06	1.2E-05	1.2E-05	0.0018
Nickel	umol/g	0.295	0.212	0.0524	0.215	0.408	1.23	0.559	0.134	0.867	0.169	0.204	0.461	0.1	0.351	0.1	0.425	0.376	0.121	0.288	0.395	0.238
Zinc	umol/g	12.4	9.92	30.7	10.7	5.41	5.36	24	8.78	8.43	7.03	12.8	16.6	4.76	13.4	3.46	28.6	22.5	2.11	12.7	12.5	4.665
SEM Sum	umol/g	13.872	11.082	34.717	11.817	6.365	7.197	27.233	10.663	11.351	8.552	14.839	18.623	5.437	15.771	4.273	33.070	26.968	2.709	15.236	14.974	5.754
SEM/AVS		0.569	3.958	0.389	3.812	1.675	2.999	0.300	0.063	0.052	0.117	0.229	0.494	0.057	0.241	0.890	1.560	0.812	0.797	0.487	0.629	0.677
ESB {SEM-AVS}	umol/g	-10.528	8.282	-54.583	8.717	2.565	4.797	-63.567	-158.337	-206.649	-64.848	-49.961	-19.077	-89.763	-49.729	-0.527	11.870	-6.232	-0.691	-16.064	-8.826	-2.746
TOC	%	2.98	0.64	1.33	0.58	1.26	3.22	10.7	14.8	36.7	9.78	27.6	16.8	11.7	11	1.88	11.4	8.9	1.44	4.35	10.1	1.89
foc		0.0298	0.0064	0.0133	0.0058	0.0126	0.0322	0.107	0.148	0.367	0.0978	0.276	0.168	0.117	0.11	0.0188	0.114	0.089	0.0144	0.0435	0.101	0.0189
∑SEM -AVS/foc		-353.28	**1294.03**	-4103.95	**1502.95**	**203.58**	**148.99**	-594.09	-1069.84	-563.08	-663.06	-181.02	-113.56	-767.20	-452.08	-28.03	104.12	-70.02	-47.95	-369.29	-87.39	-145.31

Table 3-5. Toxic Characteristic Leachate Procedure (TCLP) Results

Chemical	Reporting Units	RCRA Limit	GCR-01	GCR-02	GCR-03	GCR-04	GCR-05	GCR-06	GCR-07	GCR-08	GCR-09	GCR-10	GCR-11	GCR-11	GCR-12	GCR-13	GCR-14
1,1-Dichloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,2-Dichloroethane	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,4-Dichlorobenzene	mg/L	7.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1,4-Dichlorobenzene	mg/L	7.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4,5-Trichlorophenol	mg/L	400	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4,5-Trichlorophenoxypropionic acid	mg/L	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2,4,6-Trichlorophenol	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4-Dichlorophenoxyacetic acid	mg/L	10	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
2,4-Dinitrotoluene	mg/L	0.13	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
4-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Arsenic	mg/L	5	0.0188	0.0073	0.0182	0.0238	0.0904	0.0543	0.0289	0.0148	0.0921	0.0072	0.0887	0.034	0.0418	0.0207	0.0076
Barium	mg/L	100	0.169	0.146	0.121	0.0895	0.961	0.298	0.456	0.476	0.771	0.462	0.572	0.745	0.589	0.542	0.619
Benzene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium	mg/L	1	0.00033	0.00042	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.003
Carbon tetrachloride	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chlordane	mg/L	0.03	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Chlorobenzene	mg/L	100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chloroform	mg/L	6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	mg/L	5	0.0047	0.0042	0.0038	0.0038	0.593	0.0075	0.0137	0.0023	0.0189	0.0025	0.0072	0.0045	0.005	0.0053	0.0034
Endrin	mg/L	0.02	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Gamma BHC - Lindane	mg/L	0.4	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Heptachlor	mg/L	0.008	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Hexachlorobenzene	mg/L	0.13	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Hexachlorobutadiene	mg/L	0.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Hexachloroethane	mg/L	3	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Lead	mg/L	5	0.0327	0.0297	0.0258	0.0278	0.667	0.68	0.234	0.0128	0.149	0.0076	0.0686	0.0639	0.0532	0.0626	0.056
Mercury	mg/L	0.2	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Methoxychlor	mg/L	10	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Methyl ethyl ketone	mg/L	200	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Nitrobenzene	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Pentachlorophenol	mg/L	100	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Pyridine	mg/L	5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Selenium	mg/L	1	0.0048	0.0048	0.0048	0.008	0.0556	0.0079	0.0088	0.0048	0.009	0.0048	0.0087	0.0077	0.0083	0.0095	0.0048
Silver	mg/L	5	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Tetrachloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Toxaphene	mg/L	0.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Trichloroethene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Vinyl chloride	mg/L	0.2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3-5. Toxic Characteristic Leachate Procedure (TCLP) Results

Chemical	Reporting Units	RCRA Limit	GCR-15	GRC-16	GRC-17	GCR-25	GCR-26	GCR-26	IHC-1	IHC-02	IHC-03	IHC-04	IHC-05	IHC-06	IHC-07	IHC-08	IHC-09
1,1-Dichloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,2-Dichloroethane	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,4-Dichlorobenzene	mg/L	7.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1,4-Dichlorobenzene	mg/L	7.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4,5-Trichlorophenol	mg/L	400	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4,5-Trichlorophenoxypropionic acid	mg/L	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2,4,6-Trichlorophenol	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4-Dichlorophenoxyacetic acid	mg/L	10	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
2,4-Dinitrotoluene	mg/L	0.13	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
4-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Arsenic	mg/L	5	0.0074	0.0072	0.0177	0.0481	0.0654	0.0373	0.0072	0.0277	0.0761	0.0258	0.179	0.0098	0.0072	0.0352	0.0702
Barium	mg/L	100	0.603	0.265	0.249	0.117	0.112	0.115	0.253	0.748	0.439	0.416	0.799	0.589	0.414	0.422	0.342
Benzene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium	mg/L	1	0.0062	0.00033	0.00033	0.00068	0.00033	0.00033	0.00033	0.00033	0.00089	0.0007	0.00033	0.0042	0.00033	0.00033	0.00033
Carbon tetrachloride	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chlordane	mg/L	0.03	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Chlorobenzene	mg/L	100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chloroform	mg/L	6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	mg/L	5	0.0054	0.0022	0.0034	0.0025	0.0033	0.0027	0.0025	0.0013	0.0066	0.0144	0.0129	0.0037	0.0025	0.0107	0.0172
Endrin	mg/L	0.02	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Gamma BHC - Lindane	mg/L	0.4	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Heptachlor	mg/L	0.008	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Hexachlorobenzene	mg/L	0.13	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Hexachlorobutadiene	mg/L	0.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Hexachloroethane	mg/L	3	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Lead	mg/L	5	0.193	0.02	0.0292	0.0047	0.0256	0.0229	0.0056	0.0064	0.12	0.159	0.0047	0.0861	0.013	0.174	0.11
Mercury	mg/L	0.2	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Methoxychlor	mg/L	10	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Methyl ethyl ketone	mg/L	200	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Nitrobenzene	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Pentachlorophenol	mg/L	100	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Pyridine	mg/L	5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Selenium	mg/L	1	0.0048	0.0085	0.0055	0.0136	0.0081	0.0048	0.0048	0.0048	0.0131	0.0122	0.0651	0.0048	0.0048	0.0074	0.0082
Silver	mg/L	5	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Tetrachloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Toxaphene	mg/L	0.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Trichloroethene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Vinyl chloride	mg/L	0.2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3-5. Toxic Characteristic Leachate Procedure (TCLP) Results

Chemical	Reporting Units	RCRA Limit	LGC-01	LGC-02	LGC-03	LGC-04	LGC-05	LGC-06	LGC-07	LGC-12	LGC-13	LGC-14	LGC-15	LGC-16	LGC-16A	LGC-17
1,1-Dichloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,2-Dichloroethane	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1,4-Dichlorobenzene	mg/L	7.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1,4-Dichlorobenzene	mg/L	7.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4,5-Trichlorophenol	mg/L	400	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4,5-Trichlorophenoxypropionic acid	mg/L	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2,4,6-Trichlorophenol	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2,4-Dichlorophenoxyacetic acid	mg/L	10	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
2,4-Dinitrotoluene	mg/L	0.13	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.011	0.005	0.005	0.005	0.005
2-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
4-Methylphenol	mg/L	200	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Arsenic	mg/L	5	0.0193	0.0072	0.0217	0.0137	0.0186	0.0362	0.0072	0.0319	0.0525	0.0842	0.103	0.0614	0.0388	0.0463
Barium	mg/L	100	0.625	0.433	0.586	0.334	0.414	0.307	0.374	0.32	0.475	0.44	0.406	0.705	0.585	0.41
Benzene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium	mg/L	1	0.00033	0.00033	0.0022	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Carbon tetrachloride	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chlordane	mg/L	0.03	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Chlorobenzene	mg/L	100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chloroform	mg/L	6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	mg/L	5	0.0037	0.0062	0.0032	0.0034	0.0046	0.0166	0.0027	0.0538	0.0105	0.0143	0.0285	0.0248	0.0092	0.0482
Endrin	mg/L	0.02	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Gamma BHC - Lindane	mg/L	0.4	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.000013	0.00001
Heptachlor	mg/L	0.008	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Hexachlorobenzene	mg/L	0.13	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Hexachlorobutadiene	mg/L	0.5	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Hexachloroethane	mg/L	3	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Lead	mg/L	5	0.195	0.0404	0.208	0.0154	0.0297	0.0716	0.0155	0.531	0.0569	0.108	0.122	0.183	0.0567	0.336
Mercury	mg/L	0.2	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Methoxychlor	mg/L	10	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Methyl ethyl ketone	mg/L	200	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Nitrobenzene	mg/L	2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Pentachlorophenol	mg/L	100	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Pyridine	mg/L	5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Selenium	mg/L	1	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.009	0.0048	0.0048	0.0095	0.0096	0.0059	0.0129
Silver	mg/L	5	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Tetrachloroethene	mg/L	0.7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Toxaphene	mg/L	0.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Trichloroethene	mg/L	0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Vinyl chloride	mg/L	0.2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Physical Parameter Results. Table 3-6 summarizes the results for percent moisture, bulk density (wet and dry), and grain size distribution for the surficial sediment. Sand and silt are the predominant particle sizes with silts comprising a greater fraction in a part of the East Branch of the GCR and in the LGC.

Table 3-6. Surficial Sediment: Moisture Content, Bulk Density, and Particle Size Distribution

Sample ID	Moisture Content	Bulk Density (lb/cubic-ft)		Gravel	Sand	Silt	Clay
		Wet	Dry	Percent			
GCR-1/3-SE-GEO	38.8	104.5	75.3	0.2	93.4	5.9	0.5
GCR-4/7-SE-GEO	53.2	100.4	65.5	0.0	75.2	22.2	2.6
GCR-8/11-SE-GEO	117.8	81.6	37.5	0.0	49.0	48.4	2.6
GCR-12/15-SE-GEO	66.7	111.2	66.7	4.8	72.3	18.4	4.1
GCR-16/17-SE-GEO	300.2	69.1	17.3	0.0	27.8	69.3	2.9
IHC-1/5-SE-GEO	41.9	102.8	72.4	0.0	85.9	12.5	1.6
IHC-6/9-SE-GEO	39.5	108.1	77.5	0.6	85.9	10.1	3.5
LGC-1/3-SE-GEO	707	64.3	8.0	0.0	10.1	76.9	13.0
LGC-4/7-SE-GEO	177.8	70.8	25.5	0.0	55.1	41.0	3.9
LGC-12/14-SE-GEO	123	80.6	36.2	5.3	37.3	56.5	0.9
LGC-15/17-SE-GEO	43.2	104.6	73.1	15.4	77.4	6.5	0.7

3.3 SUBSURFACE SEDIMENT RESULTS

A total of 80 subsurface sediment samples were collected at 40 locations in the project area. All subsurface sediment samples were analyzed for the chemical parameters discussed in Section 2.3. Each sediment core was logged and photographed, except for LGC 1, LCG2, and LGC 3. These three sediment cores were composed mostly of water with silt and colloids.

Total PAHs were calculated as the sum of the 16 priority PAHs. A summary of the chemical organic concentrations in presented in Table 3-7. Aroclor 1248 and Aroclor1254 were the principal Aroclors detected, with Aroclor 1260 also appearing in a few samples.

Table 3-7 Subsurface Sediment: Organic Chemical Concentrations

Sample Point	Depth below top of sediment Feet	TOC %	Total PAH (16) mg/kg	Total PCB mg/kg	Oil & Grease mg kg	GRO mg/kg	DRO mg/kg
GRC-1	4-5	28.90	146.59	0.22	96600	1400	44000
	9-10	8.89	46.39	0.10	822	7.6	200
GRC-2	4-5	11.50	1075.00	0.11	40900	78	25000
	6-7	9.66	4460.00	0.11	3270	13	1900
GCR-3	4-5	10.50	923.30	0.06	2240	64	24000
	7-8	9.03	14.75	0.12	940	7.8	310
GCR 4	4-5	7.12	472.40	0.11	9510	90	15000
	6-7	10.80	264.00	0.11	1160	11	2200
GCR-5	3-4	11.70	292.80	0.06	1710	7.4	24000
	5-6	19.50	1.95	0.09	1480	13	98
GCR-6	4-5	8.37	409.60	0.10	2350	25	17000
	7-8	10.60	16.40	0.14	1100	11	180
GCR-7	4-5	10.80	624.10	0.11	3990	37	23000
	6-7	2.89	77.08	0.12	2800	3.3	2600
GCR-8	1-2	7.14	44.35	4.94	10100	14	6500
	3-4	12.60	0.95	0.08	7100	11	78
GCR-9	1-2	6.18	276.40	0.10	34700	36	7400
	4-5	10.70	4.25	0.07	1510	9.7	360
GCR-10A	2-3	17.40	310.10	0.10	24600	51	15000
	4-5	10.60	2.98	0.07	1150	10	110
GCR-11	2-3	8.53	653.80	0.37	22700	32	20000
	3-4	15.30	10.12	0.07	1170	8.1	380
GCR-12	2-3	4.93	140.40	3.02	8790	4.4	6400
	3-4	5.34	147.60	2.09	7530	3.7	4900
GCR-13	1-2	3.83	181.90	2.67	2000	4.4	3300
	2-3	4.81	398.60	4.47	11000	76	13000
GCR-14	1-2	6.89	107.80	3.45	30100	57	4800
	3-4	12.40	162.60	0.06	2760	12	16000
GCR-15	1-2	3.24	60.90	1.80	2960	2.7	1700
	3-4	8.41	0.25	0.05	743	0.6	56
GCR-16	1-2	7.49	179.50	2.90	15200	13	110000
	2-2.5	2.82	26.54	0.07	7580	26	74000
GCR-17	1-2	19.10	310.10	6.38	23900	740	14000
	2-3	5.51	1.72	0.08	632	11	640
GCR 26	1-2	5.48	74.16	3.40	1130	6.2	7600
	3-4	2.54	0.17	0.03	475	0.5	13
IHC 1	1-2	5.92	2.13	0.03	542	2.5	61
	3-4	4.24	0.30	0.02	361	11	34
IHC 2	2-3	0.05	2.08	0.04	1620	2.2	28
	4-5	0.83	0.40	0.03	388	4.4	32
IHC 3	2-3	4.75	393.80	7.99	35900	18	10000
	4-5	7.09	631.00	42.58	6700	190	27000
IHC 4	4-5	2.60	216.10	13.06	2760	10	2000
	5-6	1.99	167.10	3.99	1970	21	3800
IHC 5	2-3	3.58	46.21	0.05	5160	6	3500
	5-6	0.83	24.87	0.71	1940	2.7	1200
IHC 6	1-2	0.01	1.07	0.02	472	0.5	120
	3-4	1.66	0.29	0.03	482	0.2	48
IHC 7	3-4	3.79	107.85	0.04	9600	3.1	3300
	5-6	1.21	1.72	0.03	630	2.5	31

Table 3-7 Subsurface Sediment: Organic Chemical Concentrations

Sample Point	Depth below top of sediment Feet	TOC %	Total PAH (16) mg/kg	Total PCB mg/kg	Oil & Grease mg kg	GRO mg/kg	DRO mg/kg
IHC 8	2-3	1.92	26.17	0.03	1410	2.8	820
	5-6	0.19	0.10	0.02	365	2.3	4.9
IHC 9	2-3	5.57	211.30	3.27	29300	20	9900
	5-6	0.54	0.15	0.03	317	2.2	9.5
LGC 1	2-3	20.30	98.20	0.22	29600	43	25000
	3-4	2.72	2.79	0.04	5.23	4.2	42
LGC 2	2-3	7.59	2.95	0.05	817	23	310
	3-4	1.19	0.29	0.03	439	2.5	17
LGC 3	1-2	30.20	397.60	0.19	31800	170	93000
	2-3	9.71	0.22	0.03	394	2.6	10
LGC 4	1-2	26.50	339.50	0.11	399000	850	99000
	2-3	0.12	0.10	0.02	365	0.6	4.8
LGC 5	1-2	0.01	0.09	0.02	1340	2.2	7.8
	2-3	2.39	0.29	0.03	4080	100	43
LGC 6	3-4	58.40	763.90	3.11	78000	3300	110000
	7-8	3.83	20.17	0.08	5010	2.8	990
LGC 7	2-3	42.10	33.97	4.06	5720000	720	50000
	3-4	37.10	588.50	0.15	3920000	2600	98000
LGC 12	2-3	8.49	607.71	8.92	56700	1000	79000
	4-5	7.55	414.60	1.55	39100	850	79000
LGC 13	2-3	8.29	321.00	12.70	341000	1600	69000
	4-5	12.70	586.30	2.59	68300	1200	64000
LGC 14	2-3	9.03	765.80	28.33	87400	900	45000
	3-4	10.20	923.80	0.31	68800	1800	80000
LGC 15	2-3	3.88	121.35	4.43	25100	490	47000
	4-5	5.76	128.34	2.62	23100	1400	35000
LGC 16A	3-4	11.00	598.70	15.14	110000	750	97000
	7-8	17.20	628.80	1.39	77000	2600	110000
LGC 17	1-2	18.40	507.90	0.39	48200	1000	50000
	3-4	0.42	32.54	0.05	5840	360	1700

Table 3-8 shows the subsurface sediment total metals concentrations for arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury.

Table 3-8 Subsurface Sediment: Inorganic Chemical Concentrations

Sample Point	Depth below top of sediment Feet	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Nickel mg/kg	Zinc mg/kg	Mercury mg/kg
GRC-1	4-5	95.9	15.6	257	269	6400	53.8	3.77	3.77
	9-10	119	44.3	44.3	379	1390	29.8	4920	4.64
GRC-2	4-5	428	37.7	57	559	1910	2.2	5640	8.93
	6-7	56.6	25.2	49.2	515	1420	29.9	3380	7.17
GCR-3	4-5	701	46	59.8	490	2400	7.69	6030	5.37
	7-8	106	10.5	26	160	1070	26.3	2740	2.49
GCR 4	4-5	315	27.4	44.3	391	1050	2.13	3950	5.19
	6-7	227	177	55.7	800	4520	15.6	19900	21.6
GCR-5	3-4	330	89.2	46.1	707	3760	11.6	14400	10.5
	5-6	36.1	0.897	28.7	30.2	25.8	31.6	137	0.0469
GCR-6	4-5	252	46.4	80.5	409	1710	12.4	6190	6.26
	7-8	139	38.9	38.8	368	1570	33.3	6180	5.82
GCR-7	4-5	395	67.3	61.2	516	2190	4.37	8470	4.79
	6-7	77.7	48.4	17.8	205	1340	5.86	3790	5.52
GCR-8	1-2	59.7	4.1	45.9	60.4	371	21.4	1250	0.312
	3-4	33.6	0.687	28.3	28.9	13.8	33.3	98.5	0.0412
GCR-9	1-2	218	25.4	68.9	248	1000	8.09	3380	2.48
	4-5	182	12.7	25.4	185	1680	27	3630	1.2
GCR-10A	2-3	142	55.3	43.1	378	1790	7.49	9050	4.65
	4-5	188	36.8	33.5	275	1750	28.5	6670	2.76
GCR-11	2-3	201	34.5	54.3	286	1010	4.79	5730	4.72
	3-4	70.2	2.71	25.2	57.9	290	25.2	709	7.03
GCR-12	2-3	42.3	0.778	235	207	471	96.9	1720	0.677
	3-4	66.7	2.94	217	143	407	74.4	1610	0.774
GCR-13	1-2	38.2	3.3	129	120	293	43.9	1140	0.55
	2-3	36.7	4.99	107	101	308	29.6	925	0.373
GCR-14	1-2	33.5	2.53	116	102	409	35	1120	0.81
	3-4	383	51.5	64.1	1110	8500	17.2	11900	24.7
GCR-15	1-2	37.2	1.12	117	129	253	41.1	958	0.505
	3-4	8.35	0.0809	26.4	22.6	23.7	28.7	82.3	0.0263
GCR-16	1-2	38	8.26	204	158	1080	53.1	1650	0.98
	2-2.5	5.15	0.268	4.26	13.4	80.3	9.43	11.9	0.0466
GCR-17	1-2	45.1	11.5	420	288	1180	87.7	2940	1.27
	2-3	5.2	0.436	19.2	18.7	11	22.2	65	0.0208
GCR 26	1-2	39.3	6.4	94.8	166	397	20.8	1490	1.63
	3-4	3.49	0.267	11	9.96	6.83	13.6	44.6	0.0152
IHC 1	1-2	3.17	0.118	3.94	3.24	7.78	4.38	29	0.0121
	3-4	3.91	0.0859	3.3	3.26	6.42	4.83	25.3	0.0228
IHC 2	2-3	6.22	0.0409	2.15	1.51	3.81	2.57	15.6	0.0123
	4-5	3.95	0.0904	3.94	2.01	4.66	5.14	25.4	0.0128
IHC 3	2-3	25.1	4.08	156	81.3	318	47.2	1440	0.545
	4-5	125	14.1	353	393	1290	104	3140	0.0811
IHC 4	4-5	78.5	9	396	163	803	56.4	5240	0.747
	5-6	9.06	0.146	3.88	6.71	6.14	4.01	25.8	0.0145
IHC 5	2-3	197	105	20.2	405	3100	4.97	10200	16.8
	5-6	9.1	0.639	40.9	26.3	86.9	14.6	319	0.0916

Table 3-8 Subsurface Sediment: Inorganic Chemical Concentrations

Sample Point	Depth below top of sediment Feet	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Nickel mg/kg	Zinc mg/kg	Mercury mg/kg
IHC 6	1-2	10.9	0.238	4.75	5.18	18	5.02	120	0.023
	3-4	9.23	0.0443	6.13	11.8	16.4	5.77	40.9	0.0131
IHC 7	3-4	146	102	16.1	225	1840	6.95	4540	5.7
	5-6	5.05	0.374	5.03	22.8	27	5.08	62.5	0.0131
IHC 8	2-3	7.11	1.98	5.38	19.1	49.5	8.68	257	0.11
	5-6	1.94	0.162	3.64	1.53	4.37	3.12	16.2	0.0113
IHC 9	2-3	94.7	10.9	348	162	683	47	4140	0.805
	5-6	4.69	0.138	3.81	2.01	4.62	3.72	23.5	0.0122
LGC 1	2-3	45.3	9.97	122	209	896	40.9	1350	0.922
	3-4	22.4	6.58	15.4	38.9	97.2	16.7	1310	0.183
LGC 2	2-3	22.8	0.793	13.9	27.1	42.2	15	112	0.0271
	3-4	6.38	0.311	7.85	5.85	9.65	8.62	42.7	0.0145
LGC 3	1-2	184	19.7	45.6	164	5450	25.1	3400	1.05
	2-3	4.43	0.238	6.62	7.01	8.26	7.51	43.2	0.013
LGC 4	1-2	217	16	237	257	13700	195	8700	2.83
	2-3	1.8	0.0383	3.37	1.26	3.72	3.09	12.4	0.0121
LGC 5	1-2	2.42	0.0349	3.01	1.6	3.85	3.11	17.5	0.0109
	2-3	6.6	0.0482	4.48	5.33	5.99	3.6	15.7	0.0142
LGC 6	3-4	197	85.4	1290	563	16300	510	12400	4.39
	7-8	27.5	5.05	10.1	22.4	273	10.5	844	0.0175
LGC 7	2-3	103	8.91	2620	317	1810	157	3730	2.55
	3-4	210	19	178	279	18000	134	9500	3.89
LGC 12	2-3	29	12.7	582	196	2400	68.1	2500	1.49
	4-5	44.5	15.9	280	191	4750	124	3000	2.07
LGC 13	2-3	32.8	13.3	642	194	3250	75.7	2660	1.18
	4-5	62.7	41.9	758	441	10800	227	5900	3.59
LGC 14	2-3	44.4	24.2	843	321	4490	147	3980	2.52
	3-4	70.1	6.77	101	179	7460	71.9	3770	1.77
LGC 15	2-3	5.47	1.62	86.5	27.4	690	13.2	365	0.124
	4-5	3.47	0.46	67.3	16.9	189	9.42	171	0.0933
LGC 16A	3-4	45.5	11.6	1480	318	2010	153	3900	1.26
	7-8	105	39.4	697	372	10600	360	5060	3.19
LGC 17	1-2	113	48	700	402	8110	236	6540	3.26
	3-4	4.35	0.194	30.8	4.78	66.2	10.3	50.3	0.0141

3.4 PORE WATER RESULTS

A total of 11 sediment pore water samples were collected at 11 locations in the project area. Three of the pore water samples were collected approximately 4 feet below the sediment surface from piezometers. The remaining samples were extracted from surface sediment using a laboratory centrifuge. All sediment pore water samples were analyzed for the chemical parameters discussed in Section 2.4.

Total PAHs were calculated as the sum of the 16 priority PAHs. A summary of the chemical organic concentrations in presented in Table 3-9.

Table 3-9 Sediment Pore Water: Organic Chemical Concentrations

Sample Point	Total PCBs µg/L	Total PAH (16) µg/L	Total Organic Carbon mg/L	Dissolved Organic Carbon mg/L
GRC-2	0.789	843.100	124	125
GCR 4	0.491	426.000	83.7	83.6
GCR-6	0.491	102.900	112	117
GCR-9	0.468	0.800	79.2	78.9
GCR-11	0.475	0.800	26.4	27.9
GCR-12	0.477	0.800	9.5	9.6
GCR 15	0.468	0.800	26.1	26.2
IHC 2	0.479	0.800	29.7	31.7
IHC 9	0.447	0.800	13.4	11.4
LGC 4	0.447	0.800	14.2	15.8
LGC 6	0.449	0.800	19.9	22.1

Select total and dissolved metals are shown in Table 3-10 and 3-11, respectively.

Table 3-10 Sediment Pore Water: Total Inorganic Chemical Concentrations

Sample Point	Arsenic mg/L	Cadmium mg/L	Chromium mg/L	Copper mg/L	Lead mg/L	Nickel mg/L	Zinc mg/L	Mercury mg/L
GRC-2	0.0154	0.00044	0.0071	0.0015	0.0119	0.0119	0.0273	0.00006
GCR 4	0.0147	0.0015	0.0121	0.0207	0.778	0.0064	0.293	0.00022
GCR-6	0.0408	0.0021	0.0253	0.03	0.233	0.0244	0.377	0.00016
GCR-9	0.0078	0.00033	0.0063	0.0055	0.0162	0.0041	0.0789	0.00006
GCR-11	0.0077	0.00036	0.0119	0.0099	0.0335	0.0061	0.104	0.00006
GCR-12	0.0085	0.00067	0.0159	0.0129	0.0527	0.0044	0.182	0.000089
GCR-15	0.0052	0.00033	0.0054	0.0045	0.0175	0.0032	0.0667	0.00006
IHC 2	0.0062	0.00033	0.003	0.0022	0.0057	0.0023	0.0151	0.00006
IHC 9	0.0048	0.00033	0.003	0.0018	0.0081	0.004	0.0264	0.00006
LGC 4	0.0111	0.00033	0.0186	0.0045	0.0392	0.0064	0.0604	0.00006
LGC 6	0.0114	0.00033	0.0466	0.02	0.0508	0.0119	0.123	0.000082

Table 3-11 Sediment Pore Water: Dissolved Inorganic Chemical Concentrations

Sample Point	Arsenic mg/L	Cadmium mg/L	Chromium mg/L	Copper mg/L	Lead mg/L	Nickel mg/L	Zinc mg/L	Mercury mg/L
GRC-2	0.016	0.00033	0.0024	0.0024	0.004	0.0123	0.0093	0.00006
GCR 4	0.0086	0.00033	0.0008	0.0024	0.0014	0.0048	0.0094	0.00006
GCR-6	0.0308	0.00033	0.0011	0.0038	0.002	0.0181	0.0387	0.00006
GCR-9	0.008	0.00033	0.00059	0.0013	0.0003	0.0046	0.0045	0.00006
GCR-11	0.006	0.00033	0.0012	0.0023	0.0011	0.0061	0.0073	0.00006
GCR-12	0.0053	0.00033	0.00067	0.0026	0.00034	0.0032	0.0069	0.00006
GCR-15	0.0031	0.00033	0.00053	0.0025	0.00032	0.002	0.0043	0.00006
IHC 2	0.0062	0.00033	0.00088	0.00097	0.00021	0.0025	0.002	0.00006
IHC 9	0.0032	0.00033	0.00086	0.00071	0.00054	0.0038	0.0026	0.00006
LGC 4	0.005	0.00033	0.0019	0.0005	0.00031	0.0052	0.002	0.00006
LGC 6	0.0039	0.00033	0.0022	0.0027	0.00033	0.0084	0.002	0.00006

4.0 DATA SUMMARY

The results detailed in this report will provide information for the remedial options feasibility study as well as help determine the current baseline conditions of sediments within the project area. Additional sampling in parts of the project area is planned for the April 2015. An addendum to this report will discuss the results of the April sampling. The addendum will also provide additional discussion on the spatial distribution of contaminants of concern within the project area.

Total PCB concentrations ranged from 0.02 to 81.15 mg/kg. PCB concentrations in the GCR were between 0 and 10 mg/kg, which is consistent with previous investigations east and west of the GCR section. The highest PCB concentration is located on the IHC. The 81.15 mg/kg result exceeds the TSCA limit of 50 mg/kg. Sediment removed from this section of the IHC will need special handling and disposal. Additional sampling in April will attempt to delineate the extent of the TSCA sediment. A PCB result of 23.02 mg/kg was detected at IHC-9 at the north end of the IHC were the non-navigation channel ends. PCB concentrations in the LGC were non-detect in the western end and increased in the east end at the transition from the navigation to non-navigation section of the waterway with 28.33 mg/kg detected at LGC-14 at 2-3 feet below the sediment surface.

Total PAH concentrations, measured as the sum of 16 priority PAHs in the grab samples collected in the project area, vary widely in the project area and ranged from 1.35 to 211.2 mg/kg in the surficial sediments and 0.25 to 4460 mg/kg in the subsurface sediments. In general, the PAH concentrations found in the project area are relatively high and exceed both the effects-range low value of 4.022 mg/kg and the effects-range medium value of 44.792 mg/kg. These sediment quality guidelines are commonly used to assess potential for impact to benthos (Long et al., 1995). Oil and grease, GRO and DRO products are highest in the LGC, with lower concentrations in the GCR and IHC. Metals concentrations vary widely within the study area with higher total concentrations associated with the west branch GCR and the eastern end of the LGC.

The sediment samples were tested for AVS, SEM and total organic carbon. The SEM - AVS results reported by the laboratory showed that the SEM - AVS in 33 of the 48 samples tested, to be negative, indicating that these samples are not expected to exhibit toxicity because the metals are bound to a sulfide complex. For the remaining samples, the above equation was applied to factor in

the presence of organic carbon in the sediments. The results showed that seven samples had results that were ≤ 130 µmoles/g_{oc} , indicating they pose a low risk for adverse effects. The following samples had results between 130 µmoles/g_{oc} and 3,000 µmoles/g_{oc} and they may have adverse biological effects: GCR-03 (235.77 µmoles/g_{oc}), GCR-08 (140.64 µmoles/g_{oc}), IHC-04 (1,294.03 µmoles/g_{oc}), IHC-06 (1,502.95 µmoles/g_{oc}), IHC-07 (203.58 µmoles/g_{oc}), and IHC-08 (148.99 µmoles/g_{oc}).

None of the samples for the surface sediment, which would potentially be dredged and disposed offsite at a licensed landfill, exceeded the limits for any TCLP parameter. Surficial sediment removed as part of this project would not be disposed as a RCRA hazards waste. Subsurface sediment in the LGC that would potentially be dredged as part of the remedial action will be samples and analyzed in April by the TCLP to verify if the deeper sediment is also non-hazardous.

Physical parameter analysis of the surficial sediment included percent moisture, bulk density, and grain size analysis. Dry bulk density ranged from 8 to 77.5 lb/cubic feet. Grain size, measured as percent fines (the sum of the silt and clay fractions), ranged from 6.4 to 89.9 percent. Sediment samples with lower bulk density and higher fine content is associated with the LGC area. Samples from the GCR and IHC have a higher sand content and a higher bulk density.

Pore water analysis for surficial sediment detected no PAHs above the MDL and low concentrations of metals. Three subsurface pore water samples were collected on the west branch GCR. The highest total PAH concentration of 843.1 µg/L was detected at GCR-2. This concentration is similar to pore water impacts detected upstream west of Indianapolis Boulevard in a section remediated in 2011. The total PAH concentration decreased as the sampling moved downstream of GCR-2. Subsurface metal concentrations are similar or slightly higher than the surficial sediment pore water results.

5.0 REFERENCES

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