DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207-3199

REPLY TO
ATTENTION OF

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OHIO EPA NEDO

February 14, 2012

Environmental Analysis Section

SUBJECT: Ashtabula Harbor, Ashtabula County, Ohio—Great Lakes Restoration Initiative (GLRI) Dredging (OEPA ID Number 123860)

Mr. Joseph Loucek
Ohio Environmental Protection Agency
Division of Surface Water
P.O. Box 1049
Columbus, Ohio 43216-1049

Dear Mr. Loucek:

This is in follow-up to our Section 401 water quality certification (WQC) application submitted to Ohio Environmental Protection Agency (OEPA) on January 5, 2012 and subsequently determined to be administratively complete. This also responds to the February 6, 2012 OEPA letter sent from Mr. John Schmidt of the Division of Surface Water. We appreciate OEPA's continued attentiveness to this project.

We are providing the following information:

a. Dredged Material Discharge Evaluation Documents. This also serves to respond to OEPA Comment 1 in the February 10, 2012 letter.

This project includes two main Ashtabula Harbor dredging reaches:

1. *Lower River Channel and small portion of Outer Harbor area*—These areas are located in the lower River Channel between Stations 120+00 and 107+75, and along the West Breakwater in the Outer Harbor between Stations 16+67 and 17+77. Material in these areas was determined to not meet Federal guidelines for open-lake placement. The 2012 evaluation of this material completed in accordance with joint U.S. Environmental Protection Agency (USEPA)/U.S. Army Corps of Engineers (USACE) protocols and guidelines for the testing and evaluation of Great Lakes dredged material was provided to OEPA in our January 5, 2012 WQC application. An evaluation of the discharges in the form of return water (effluent) associated with the management and upland placement of this dredged material is included as Enclosure 1.

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2. *Southern Reach*—This area is located in the upper River Channel between Stations 198+00 and 213+36. Material in the reach between Stations 198+00 and 210+00 was determined to not meet Federal guidelines for open-lake placement. The 2011 evaluation of this material is included as Enclosure 2. An evaluation of the discharges in the form of return water associated with the management and upland placement of this dredged material is addressed in Enclosure 1. In addition, material in the Southern Reach between Stations 210+00 and 213+36 was determined to meet Federal guidelines for open-lake placement. The 2012 evaluation of this material, which includes an evaluation of the dredged material discharge, is included as Enclosure 3.

b. Summary of Dredged Material Discharge Evaluations. This also serves to respond to OEPA Comments 2 and 3 in the February 10, 2012 letter. The Section 404(b)(1) Evaluation for this project will detail the discharges of dredged material associated with this project. An abbreviated characterization of the dredged material discharges is provided as follows:

1. *Discharge of Return Water (Effluent) from Management and Upland Placement of Dredged Material*—This specifically relates to the material dredged from the entire lower River Channel, along the West Breakwater in the Outer Harbor between Stations 16+67 and 17+77, and Southern Reach between Stations 198+00 and 210+00.

(a) **Dredged Material Testing**—These channel sediments were sampled and tested in the Fall of 2011. The primary objective of the investigation was to characterize return water from the upland management and disposal of the dredged material. This testing was previously coordinated with OEPA. The sediment samples were collected from a series of harbor management units. The chemistry of this effluent was determined through a modified elutriate test (MET), which is a laboratory elutriate simulation of dredged material effluent quality; the test conservatively predicts the release of contaminants from dredged material during disposal. Supernatant from the MET was analyzed for the following: metals (23 per TAL including mercury), cyanide, total Kjeldahl nitrogen (TKN), NH_3, total phosphorus (P), polycyclic aromatic hydrocarbons (PAHs) (16 priority pollutants), total organic carbon (TOC), pesticides, oil & grease (O&G) and PCBs (as Aroclor mixtures). Data generated from this test include dissolved (water phase) and total (water and solids phase) concentrations, as well as total suspended solids (TSS) concentrations after an up to 24-hour settling period. In addition to the MET, the following two elutriate toxicity tests (water column bioassays) were performed: (1) standard 48-hour *Ceriodaphnia dubia* (daphnid) acute toxicity test across 6.25%, 12.5%, 25%, 50% and 100% elutriates (and a control), with survival as the biological measurement endpoint; and (2) standard 96-hour *Pimephales promelas* (fathead minnow) acute toxicity test across 6.25%, 12.5%, 25%, 50% and 100% elutriates (and a control), with survival as the biological measurement endpoint. Based on past testing efforts, total PCBs were the primary contaminant of interest in the return water and regarded as the only potential effluent COC.

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(b) **Effluent Generation**—Effluent would be generated at the Pinney Dock offloading site from excess free water associated with the dredged material transported in the scow, as well as in the form of runoff from the Elkem Pond 5C.

(c) **Effluent Discharge Water Quality and Contaminants of Concern (COCs)**

(1) MET. The MET results indicated low releases of metals, other inorganics and organics from sediment to water, and indicated that the discharge of return water associated with the dredged material would comply with applicable water quality standards (WQSs).

With respect to PCBs, the results of elutriate PCB and TSS analyses are included as Enclosure 4 for easy reference. The data show both dissolved and total concentrations of total PCBs across all elutriates to be non-detectable at laboratory reporting limits (LRLs) of 0.1 μg/L to 0.2 μg/L. Therefore, total PCBs was not identified as a COC in the effluent. In this regard, the discharge of effluent would not result in an unacceptable adverse impact to aquatic life. TSS elutriate concentrations after settling ranged from 30 to 130 mg/L (median 120 mg/L); these data were used in tandem with the non-detectable PCB concentrations to establish a TSS threshold for effluent management (TSS and PCBs could not be correlated due to non-detectable PCBs in the elutriate). Comparison of elutriate chemical concentrations to WQSs protective of aquatic life indicate that limiting TSS in return water to a concentration of 100 mg/L would not result in an unacceptable risk to aquatic life. This TSS concentration is a threshold value previously used and accepted by OEPA at Lake Erie confined disposal facilities (CDFs), and is less than the median of measured TSS concentrations measured in elutriate from this project.

Data from a column settling test on the more fine grained lower River Channel material were used to generate a linear TSS-turbidity correlation curve, and associate TSS and turbidity values. The following linear relationship was established: Turbidity = TSS/0.6369 ($R^2 = 0.98$). Using this equation, a TSS concentration of 100 mg/L yields a turbidity level of approximately 150 Nephelometric Turbidity Units (NTU). Therefore, it is proposed that effluent from the Pinney Dock offloading site be discharged from a USACE-approved site upon attaining a field measured turbidity level of 150 NTU. Similarly, runoff water from Elkem Pond 5C will be directed to a surface ditch down gradient of Elkem's site discharge location, and will be discharged through an existing outfall into Lake Erie upon attaining a field measured turbidity level of 150 NTU.

(2) Elutriate Toxicity Testing. The results of these water column bioassays are presented in Enclosure 5 for reference.

- *C. dubia*—Survival of this test species across all samples and dilutions was mainly 100% (range 88% to 100%). Relative to the laboratory control survival of 100%, these results indicate no statistically significant reduced survival across all elutriate treatments.

• *P. promelas*—Except for the 50% and 100% dilutions of most samples, survival of this test species was not statistically different relative to the laboratory control (92%). Data and information strongly suggests that the observed toxicity to *P. promelas* exposed to the 50% and 100% elutriate treatments is attributable to ammonia. For example, simple linear regression showed a significant negative correlation between bioassay experiment-derived *P. promelas* lethal concentration (LC) 50 and unionized ammonia (R= -0.94; P=0.02). With respect to dissolved ammonia measurements in the MET supernatant, elutriate concentrations ranged from 2.1 to 6.2 mg/L and averaged 4.8 mg/L across management units. The maximum elutriate concentration of 6.2 mg/L was within the observed *P. promelas* toxicity threshold range of >5.6 to 7.2 mg/L. Based on this information, total ammonia was regarded as a preliminary water column COC. Note, however, that ammonia releases through effluent would rapidly dilute upon discharge: ammonia is not persistent and quickly dissipates in the water column.

The bioassay data show that significant mortality to *P. promelas* in the laboratory occurred between the two- and 24-hour exposure periods, and at total ammonia concentrations exceeding a threshold between >5.6 and 7.2 mg/L. This stated, it should also be noted that the laboratory MET and elutriate bioassays address contaminants released from the sediment, such as from pore water, and tests are also designed for a hydraulic (and not mechanical) dredging operation. In reality in the field, the vast majority of the return water in this project will originate from river/lake water entrained in the clamshell bucket during dredging, which will serve to dilute contaminants in the effluent. Nevertheless, it is proposed that the discharge of effluent at the Pinney Dock offloading site be directed to the Outer Harbor and be limited to intermittent, two hour increments. The discharge of runoff from Elkem Pond 5C will also be limited to intermittent, two-hour increments. Given the relevant information, we believe this would be a conservative measure to address any potential total ammonia concerns.

Further details with respect to the discharges are to be developed after a dredging contract is awarded. These will be based on a performance-based scope of work under which the USACE would specify results a contractor is to achieve, rather than the method which a contractor is required to use. Control of water would be dictated by the contractor-selected dredging and sediment handling/placing means and methods; design of water control features will be the contractor's responsibility. Among other work plans, the contractor would develop a water management plan describing the planned methods for managing water entrained during dredging as well as storm water run-on and runoff in compliance with standards set forth by the USACE to ensure the discharge of dredged material meets Section 404 (b)(1) guidelines, including compliance with applicable State WQSs (e.g., control of run-on, runoff and entrained water; monitoring for TSS through real time turbidity measurements with no discharge until attaining a turbidity level that corresponds to a TSS criterion of 100 mg/L). The water management plan would describe the methods to be used in preventing and controlling storm water run-on and runoff (including any lined and bermed work areas for storage and staging of dredged material), methods for collecting and managing water that accumulates at the disposal site, and address effluent monitoring and reporting. Since USACE requires WQC (or waiver of thereof) in order to accept contract bids on this project, we cannot commit to any methods and means until after contract award. Submittal of work plans developed by the contractor may be submitted to OEPA.

2. *Open-Lake Discharge of Dredged Material*—This specifically relates to the material dredged from the Southern Reach between Stations 210+00 and 213+36. Bulk sediment contaminant concentrations, toxicity and bioaccumulation modeling, elutriate and bioassay data indicate no unacceptable water column and benthic impacts associated with open-lake placement of this dredged material.

(a) **Dredged Material Testing**—These channel sediments were sampled and tested in the Fall of 2011. The objective of the investigation was to characterize sediments with regard to meeting Federal guidelines for open-lake placement. This testing was previously coordinated with OEPA.

(b) **Physical Characteristics**—The channel sediments were comprised of 60.7% sands with the remainder silts and clays. However, it is anticipated that a large portion of the material ultimately being dredged from this reach would be composed of sands, gravel and cobble.

(c) **Dredged Material COCs**—Bulk contaminant concentrations in the channel sediments were compared to those at the open-lake areas in an effort to identify potential COCs.

(1) Metals. Metal concentrations in the channel sediments were generally comparable to those of the open-lake area sediments, and are not of significant toxicological concern.

(2) TOC and Other Inorganic Parameters (cyanide, TKN, ammonia, total P, TOC and O&G). Nitrogen (total and ammonia), total P and O&G concentrations were generally similar among the channel and open-lake area sediments. Cyanide was mainly not detected in the sediments, except in one core sample which showed a total concentration of 6 mg/kg. Cyanides are present as free cyanides (the most toxic form) or complexes (relatively nontoxic). Free cyanides are not persistent in the environment; they are volatile, soluble and have a low affinity for sediment adsorption. Therefore, cyanide was not identified as a COC.

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(3) PAHs. The channel sediments showed total PAH levels ranging from 1658 µg/kg to 8869 µg/kg. Total PAH concentrations in the lake sediment samples ranged from 2845 µg/kg to 4102 µg/kg. Two discrete sites showed slightly elevated total PAH concentrations in comparison to open-lake area sediments. Since the sediment PAH mixtures at these sites showed pyrogenic tendencies, PAHs are likely to be strongly associated with black carbon and largely not bioavailable. This is supported by previous solid phase bioassay data on channel sediments in this area with similar levels of PAHs, which showed insignificant toxicity in terms of growth and survival as biological measurement endpoints. Therefore, PAHs were not identified as a COC in these samples.

(4) PCBs. Aroclors in the channel sediments were mainly not detectable at LRLs ranging from 37 µg/kg to 130 µg/kg. Aroclor 1248 was measured at 87 µg/kg at one discrete site. Application of a site-specific theoretical (or thermodynamically-defined) bioaccumulation potential (TBP) model predicted that the bioaccumulation of total PCBs from these sediments in target oligochaete worms would be 87 µg/kg and below that which would occur relative to open-lake area sediments. Therefore, PCBs were not identified as a COC in this sample.

(5) Pesticides. Most pesticides in the channel sediments were non-detectable. Four,4-DDE was detected at similar levels in the channel and open-lake area sediments, with a maximum of 2 µg/kg at ASR-11 (Lower). These concentrations are not of toxicological concern.

(d) **Elutriate Testing**—Open-water discharge of the dredged material would consist of a series of discrete, almost instantaneous discharges, resulting in short-term, intermittent and unsteady impacts on the water column. The release of contaminants are determined through elutriate testing, the results of which are compared to acute water quality criteria for the protection of aquatic life to evaluate compliance with water quality standards. The elutriate data show low releases of contaminants that would appear to comply with applicable WQSs.

(e) **Water Column Bioassays**—The mean survival of *C. dubia* across all elutriate dilutions was 100%. The mean survival of *P. promelas* ranged from 84% (100% treatment) to 96% (12.5% treatment) and was not statistically different from the laboratory control mean survival of 92%.

c. OEPA Comment 4 - Admixture References. When placed into Elkem Pond 5C, the dredged material will need to achieve certain minimum material property requirements. These minimum properties include:

1. *Unconfined compressive strength (Qu)*: Equal to 5.2 psi or undrained shear strength of 2.6 psi (Qu/2).

2. *Density*: Moist or saturated density of 85% of the optimum dry density (likely 90 pcf to 110 pcf) as established by laboratory testing for the specific sediments as detailed below.

These properties are predicated by both the needs of the closure plan for the final cover design, as well as the movement of construction equipment to place and spread the dredged material in the pond. Material properties will be verified through in-place testing as discussed below. An alternative considered to meet these properties would be to treat the more fine grained dredged material with a commercial mixture of quicklime and cement, such as Calciment® by mixing. This method has been used in a number of similar projects. Pre-design testing has indicated that this is a viable alternative for treating the dredged material. Laboratory strength testing on semi-compacted sediment samples treated with various percentages (by weight) of Calciment® indicates that moisture contents in the range of 36.5% to 42.5% are required to meet the minimum strength requirement of 2.6 psi. Samples treated with 15% and 20% Calciment® resulted in moisture contents of 39.5% and 34%, respectively, after a 24-hour curing period. Laboratory tests conducted on 10% and 15% Calciment® treated samples resulted in all of the other required material properties being met; however, 24 hour moisture contents were higher than the required strength moisture content range. Therefore, treating the fine grained dredged material with 15% to 20% Calciment® would most likely achieve the desired material properties at placement time. It should be noted that the actual percentage of Calciment® required will depend upon the initial moisture content of the dredged material; additional dosages may be required to obtain the desired material properties. The selected contractor may utilize other methods of material treatment to meet project requirements for the placed sediments. Granular dredged material (such as that expected in the upper reaches of the Southern Reach) has the capability to freely drain and may not require the use of an additive to achieve the specified properties.

d. OEPA Comment 5 - Material Placement at Disposal Site. Enclosure 6 is a project site map showing areas available to the contractor at Pinney Dock during offloading, as well as the route from Pinney Dock to Elkem for truck transport of dredged material. To improve placement conditions in Pond 5C, the USACE has requested Elkem to dewater the pond as soon as possible. This will enhance drying of the existing in-place sediments and improve the placement base conditions which are expected to produce a one foot think crust at the time of placement. In-place sediments will be very soft beneath the dried crust and control measures may be required to facilitate placement of the dredged material (depending on the contractor's operations and the final properties of the sediments being placed).

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In-place testing of dredged material will be conducted after placement in the pond. After each 5,000 cubic yards of dredged material is placed in the pond, the contractor will be required to determine the placed unconfined compressive strength using ASTM D 2938. In addition, density tests will be performed in the field to ensure the material is placed and compacted to 85% of the optimum dry density based on a modified (reduced, 15-blow) compactive effort using ASTM Standard 698. Note that a final grading plan for the pond following dredged material disposal has not been finalized and will be forthcoming.

The USACE anticipates continued coordination with OEPA (and other project stakeholders) as project plans and specifications are developed for contract bid documents. However, as previously indicated, many project details will ultimately be determined by the contractor and subject to USACE approval.

We appreciate your cooperation in this matter.

Questions pertaining to this matter should be directed to Mr. Andrew M. Lenox (716-879-4378; andrew.m.lenox@usace.army.mil) or Mr. Scott W. Pickard at (716-879-4404; scott.w.pickard@usace.army.mil) by writing to the following address: U.S. Army Corps of Engineers, 1776 Niagara Street, Buffalo, New York 14207-3199.

Sincerely,

for

Martin P. Wargo, PWS
Supervisory Biologist
Environmental Analysis Section

Enclosures

January 17, 2012

TECHNICAL MEMORANDUM

SUBJECT: Evaluation of Ashtabula Harbor Strategic Navigation Dredging (SND) Modified Elutriate Test (MET) and Water Column Bioassay Data

PURPOSE

The purpose of this memorandum is to assess Ashtabula Harbor sediment elutriate data with regard to evaluating dredged material return water (effluent) quality and demonstrating compliance with applicable State water quality standards (WQSs). This is accomplished by comparing MET chemical concentrations to WQSs and evaluating water column toxicity through bioassays.

EXECUTIVE SUMMARY

Elutriate and water column toxicity testing of Ashtabula sediments do not indicate that the discharge of return water associated with Ashtabula SND would result in a violation of applicable WQSs. Elutriate data indicate low releases of ubiquitous contaminants (such as metals and organics), from sediment to water. Comparison of elutriate chemical concentrations to water quality criteria protective of aquatic life, indicate that return water limited to a total suspended solids (TSS) concentration of 100 mg/L would not result in an unacceptable risk to aquatic life (corroborated by water column biological effects testing).

BACKGROUND

The discharge of dredged material effluent from a contained land or water area is defined as a dredged material discharge in 33 CFR 323.2 (d) and 40 CFR 232.2 (e). As such it is regulated under Sections 404 and 401 of the Clean Water Act (CWA). Section 401 provides the State with a certification role as to compliance of the discharge with applicable State WQSs. This evaluation utilizes technical guidance provided in the Inland Testing Manual (ITM) (U.S. Environmental Protection Agency [USEPA]/U.S. Army Corps of Engineers [USACE] 1998) and the Upland Testing Manual (UTM) (USACE 2003) in determining the potential for contamination-related impacts associated with the discharge of dredged material in waters regulated under Section 404 of the CWA.

During the Ashtabula Harbor SND project, dredged material that will be discharged to Lake Erie includes free water generated during sediment offloading (river water entrained in a clamshell bucket during dredging) and runoff generated during upland placement. The primary contaminant of concern (COC) associated with the dredged material is total polychlorinated biphenyls (PCBs); the return water quality is determined through predictive laboratory testing including METs and water column bioassays. The

MET is a laboratory elutriate simulation of dredged material effluent quality. Sediment and site water are mixed into a slurry (~150 g/L), which is aerated (ensuring oxidizing conditions) and allowed to settle for 24 hours. The supernatant is extracted and analyzed, the results of which define the concentration of contaminants in dredged material effluent. Detailed procedures for the test are provided in Appendix B of USACE (2003). The test is designed to account for the settling processes and geochemical changes occurring in supernatant water during disposal operations and predict the release of contaminants to discharged effluent. As described in Chapter 4 of USACE (2003), the MET samples are analyzed for both dissolved and total concentrations of contaminants, and TSS concentration, allowing for a determination of both dissolved and particle-associated contaminant concentrations. The MET simulates a hydraulic disposal scenario and is considered conservative in predicting contaminant releases from a mechanical disposal operation. Per Chapter 5 of USACE (2003), immediately after disposal, precipitation runoff water quality from exposed dredged material is similar to effluent water produced during filling.

Material will be both dredged and placed upland mechanically. As a result, discharges will not be continuous, but rather a series of discrete discharges, resulting in intermittent, unsteady and short-term effects on the water column. Thus, these MET data are evaluated primarily against WQSs associated with acute exposure, such as threshold water column concentrations established for the protection of aquatic life. These criteria establish the highest concentration of a material in surface water to which aquatic life can be exposed briefly without resulting in an unacceptable effect. These would include Inside Mixing Zone Maximum (IMZM)/Outside Mixing Zone Maximum (OMZM) criteria established for the Lake Erie Basin (OEPA 2009). Comparisons can also be made to chronic criteria, which establish the highest concentration of a material in surface water to which aquatic life can be exposed indefinitely without resulting in an unacceptable effect, although these types of exposure conditions will not occur as a result of this project. While MET data are compared to water column standards, they represent concentrations at the point of discharge and are not representative of mixing in the water column subsequent to discharge.

METHODS

The Ashtabula Harbor SND project will primarily occur down to an elevation as deep as authorized Federal navigation channel depth between River Channel Stations 120+00 and 107+75 near the mouth of the river (Lower Reach), and River Channel Stations 198+00 and 210+00 near the upstream limit of the Federal navigation channel (Upper Reach) (Figure 1).

Lower Reach

Sediment core samples were collected from five locations (LRR-1 through LRR-5) in this reach, as shown in Figure 2. The samples were collected from the sediment surface (varying elevation) to one-foot below the authorized depth of the Federal navigation channel (-27 ft LWD[1]). The entire contents of all five cores were composited to represent one management unit (MU) sample from this reach (LRRMU). Sample information is summarized in Table 1. The following water quality analyses were conducted on the composite MU sample:

- MET supernatant (total and dissolved): metals (23 per TAL including mercury), total cyanide (CN), total kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3), total phosphorus (P), polycyclic aromatic hydrocarbons (PAHs – 16 priority pollutants), total organic carbon (TOC), pesticides, oil & grease (O&G) and PCBs (Aroclors); TSS was also measured after up to 24 hours of settling time.
- Water column bioassays, including: (1) standard 48-hour water flea (*Ceriodaphnia dubia*) elutriate acute toxicity test, and (2) standard 96-hour fathead minnow (*Pimephales promelas*) elutriate acute toxicity test. Both tests utilized survival as the biological measurement endpoint.

Upper Reach

In this reach, core samples were collected from the sediment surface (varying elevation) to one-foot below the authorized depth of the Federal navigation channel (-17 ft LWD). Sediments in the reach were represented by four MUs shown in Figure 3: ASRMU-1B between Stations 198+00 and 205+00 (sediment composite from five locations, ASR1 through ASR-5), ASRMU-2A and ASRMU-2B between Stations 205+00 and 210+00 (sediment composite from five locations, ASR-6 through ASR-10) and ASRMU-3 between Stations 210+00 and 213+36 (sediment composite from three locations, ASR-11 through ASR-13). Sample information is summarized in Table 1. The following water quality analyses were conducted on each composite MU sample:

- MET supernatant (total and dissolved): metals (23 per TAL including mercury), CN, TKN, NH_3, total P, PAHs (16 priority pollutants), TOC, pesticides, O&G and PCBs (Aroclors), as well as physical analyses (grain size and hydrometer); TSS was also measured after up to 24 hours of settling time.
- Water column bioassays, including (1) standard 48-hour *C. dubia* elutriate acute toxicity test, and (2) standard 96-hour *P. promelas* elutriate acute

[1] 569.2 feet above mean water level at Rimouski, Quebec, International Great Lakes Datum 1985 (IGLD85)

toxicity test. Both tests utilized survival as the biological measurement endpoint.

RESULTS

MET

Tables 2 through 6 present the results of the MET performed on the Ashtabula Harbor MU sediments. Elutriate data are presented as both dissolved and total concentration measurements.

TSS concentrations established during the test ranged from 30 mg/L (LRRMU) to 130 mg/L (ASRMU-2A) (Table 2).

Inorganics (CN, TKN, NH_3, total P, TOC and O&G)

The inorganic chemistry elutriate results are presented in Table 2. Low releases were noted for total P, TKN, and TOC; cyanide was not detected at a laboratory reporting limit (LRL) of 0.01 mg/L.

Ammonia concentrations were similar for the dissolved and total phases, and ranged from 2.1 to 6.2 mg/L. Ammonia releases associated with Ashtabula Harbor dredged material return water would be expected to rapidly dilute to below these levels and comply with the WQS upon discharge into the water column. Using exceptional warm-water habitat and a water temperature of 20°C and pH of 8.1, sediments in LRRMU (dissolved 6.2 mg/L) and ARSMU-2A (dissolved 4.6 mg/L) exceed a OMZM criterion of 4.5 mg/L, without consideration of mixing in the water column. Such an exceedance prior to mixing are unremarkable as ammonia is not persistent and rapidly dissipates in the water column. Additional discussion regarding ammonia toxicity is included in the presentation of the *P. promelas* bioassay results.

Metals

The metal elutriate results are shown in Table 3. The test indicates low releases of metals; total and dissolved metal concentrations do not exceed Ohio WQSs for the Protection of Aquatic Life.

PAHs

The PAH elutriate results are shown in Table 4. Releases of PAHs were generally non-detectable in both total and dissolved phase at laboratory reporting limits (LRLs) ranging from 1 to 6.7 ug/L. Any detected concentrations were estimated and ranged from 0.3 to 1.4 ug/L (Table 4); none exceeded Ohio WQSs for the Protection of Aquatic Life.

PCBs

Aroclor elutriate results are shown in Table 5. No releases of Aroclors were detected in the total or dissolved phase at LRLs ranging from 0.1 to 0.2 ug/L.

Although total PCBs is the primary COC due to the bioaccumulation risk associated with an unconfined aquatic setting, these MET data are an expected result, considering the presence of primarily aged/weathered contamination sorbed to sediment associated organic matter. The vast majority of sediment-associated PCBs (as well as other hydrophobic, neutral organic contaminants) typically remain tightly partitioned to the sediment. Since the PCBs in this case would be closely associated with sediment and tend to not desorb to water (i.e., partition to the aqueous phase), the most prudent method would be to manage the associated effluent for TSS. Thus, a primary requirement for the placement of material within the Elkem embankments (not unlike other dredged material confined disposal facilities [CDFs]) is the retention of solids.

Pesticides

Pesticide elutriate results are shown in Table 6. Generally, no releases of pesticides were detected in the dissolved or total phase at LRLs ranging from 0.011 to 0.25 ug/L. The pesticide 4,4 DDD was detected in the total phase in ASRMU-1B sediment at an estimated concentration of 0.0056 ug/L. These low releases do not constitute a risk to aquatic life.

Water Column Bioassays

Both elutriate bioassays performed on the MU sediment samples determined lethal responses to elutriate and involved exposures to five elutriate treatments (100%, 50%, 25%, 12.5% and 6.25%) and a performance control. The results of these bioassays are summarized in Table 7. Water column bioassays compliment the elutriate data by considering contaminant interactive effects (synergistic and antagonistic) as well as the effects of unmeasured contaminants or those without promulgated standards for comparison or screening purposes.

C. dubia—Survival of this test species across all samples and dilutions was mainly 100%; the lowest survival was 88% (LRRMU, 12.5% elutriate concentration). These results do not indicate significantly reduced survival across the elutriate treatments.

P. promelas—Survival of this test species was generally equivalent to the laboratory control (92.0%) except for the 50 and 100% dilutions of most samples. Given the high survival of *C. dubia*, the observed toxicity to *P. promelas* exposed to the 50 and 100% elutriate treatment is interpreted to be the result of ammonia. First, as invertebrates are considered less sensitive to ammonia relative to vertebrates, the lack of observed toxicity of the 100% and 50% elutriate treatment to *C. dubia* supports the presumption that the reduced *P. promelas* survival in the same treatment was attributable to ammonia. Second, fish such as *P. promelas* can be sensitive to ammonia in bioassays, and the bioassay data strongly support that ammonia caused the observed toxicity: ammonia concentrations in the 50 and 100% treatments resulting in significant toxicity (32 to 100% mortality) ranged from 7.2 to 18 mg/L; ammonia concentrations in the 50 and 100% treatments with survival greater than 80% ranged from 2.6 to 5.6 mg/L. These data indicate that reduced survival of *P. promelas* was generally related to higher ammonia concentrations. Further, the substantially reduced survival observed in the bioassays was initially evident at ammonia concentrations between 5.6 and 7.2 mg/L. Data generated from Fairchild *et al.* (2005) suggest such a threshold range would result in reduced survival of *P. promelas* in the laboratory. They exposed several fish species to ammonia in the laboratory over a chronic 28-day duration, and the most sensitive fish species was *P. promelas* exposed as 4-day olds. For this species, they reported a no observed effect concentration (NOEC), lowest observed effect concentration (LOEC) and chronic value (ChV; the geometric mean of the NOEC and LOEC) of 0.31, 0.60 and 0.43 mg/L unionized ammonia, respectively. At 20°C and the reported pH of 8.34, this ChV equates to a total ammonia concentration of approximately 7.2 mg/L. The ChV is considered a protective value (Adams and Rowland 2002), and this 28-day value should be conservative for a 96-hour *P. promelas* elutriate test conducted at 20°C. If the *P. promelas* elutriate test were conducted at 25°C (as in the standard bioassays in this case), the ChV reported by Fairchild *et al.* (2005) would translate to approximate total ammonia ChV of 6.3 mg/L. This information reinforces the conclusion that ammonia was the cause of the toxicity observed in the 50 and 100% elutriates. Upon discharge, ammonia would dissipate in the water column and not persist at the elevated levels measured during the bioassay. No other contaminant of concern was apparent through the elutriate tests, as such return water discharged to the water column is not predicted to result in acute toxicity to aquatic life.

Effluent Management

The elutriate data across both dredging reaches indicate low levels of ubiquitous contaminants in the dredged material effluent. They show very low releases of contaminants from sediment to water and associated low toxicity, and indicate that return water associated with the dredged material would not result in any unacceptable, adverse water quality impacts. Total PCBs, as the primary COC, were not detected in elutriates in either the dissolved or particulate phase, or on a total basis. The predominant load of contamination in the effluent would be particle-bound (i.e., associated with suspended and colloidal particles with strongly adsorbed or ion exchange held contaminants). Since PCBs in return water would be principally partitioned in the solid phase, a conservative management measure would be to limit the direct discharge of effluent with a TSS concentration of 100 mg/L. Such a TSS threshold is within the range of solids concentrations established during the METs (TSS range 30 to 130 mg/L) and as such would result in similar water quality at the point of discharge as predicted during the tests. Turbidity can be used to indicate dredged material effluent suspended solids concentration on a site-specific basis (Thackston et al. 2000) and it can be efficiently used in the field (e.g., it can readily be measured) to monitor TSS at the point of discharge. Data from a column settling test on the more fine-grained Lower River material were used to generate a linear TSS-turbidity correlation curve, and associate TSS and turbidity values. The following linear relationship was established: TSS = Turbidity*(0.6369), R^2 = 0.9838. A TSS concentration of 100 mg/L, yields a turbidity level of about 150 Nephelometric Turbidity Units (NTU) (Schroeder and Hudson 2012). Accordingly, limiting turbidity in effluent discharged from this project to 150 NTU would be a conservative field criterion.

CONCLUSIONS

This evaluation of MET and water column bioassay data do not indicate significant water column impacts associated with the discharge of dredged material in the form of return water. MET as well as SET data on these sediments do not indicate that dissolved contaminants in effluent would be of concern or have the potential to violate promulgated and relevant WQSs. A large portion of the dredged material effluent contaminant load is particle-associated; as such TSS is considered the primary contaminant pathway of concern in return water. Based on the MET and column settling test data, limiting return water to a turbidity of 150 NTU would be a conservative measure and be protective of aquatic life.

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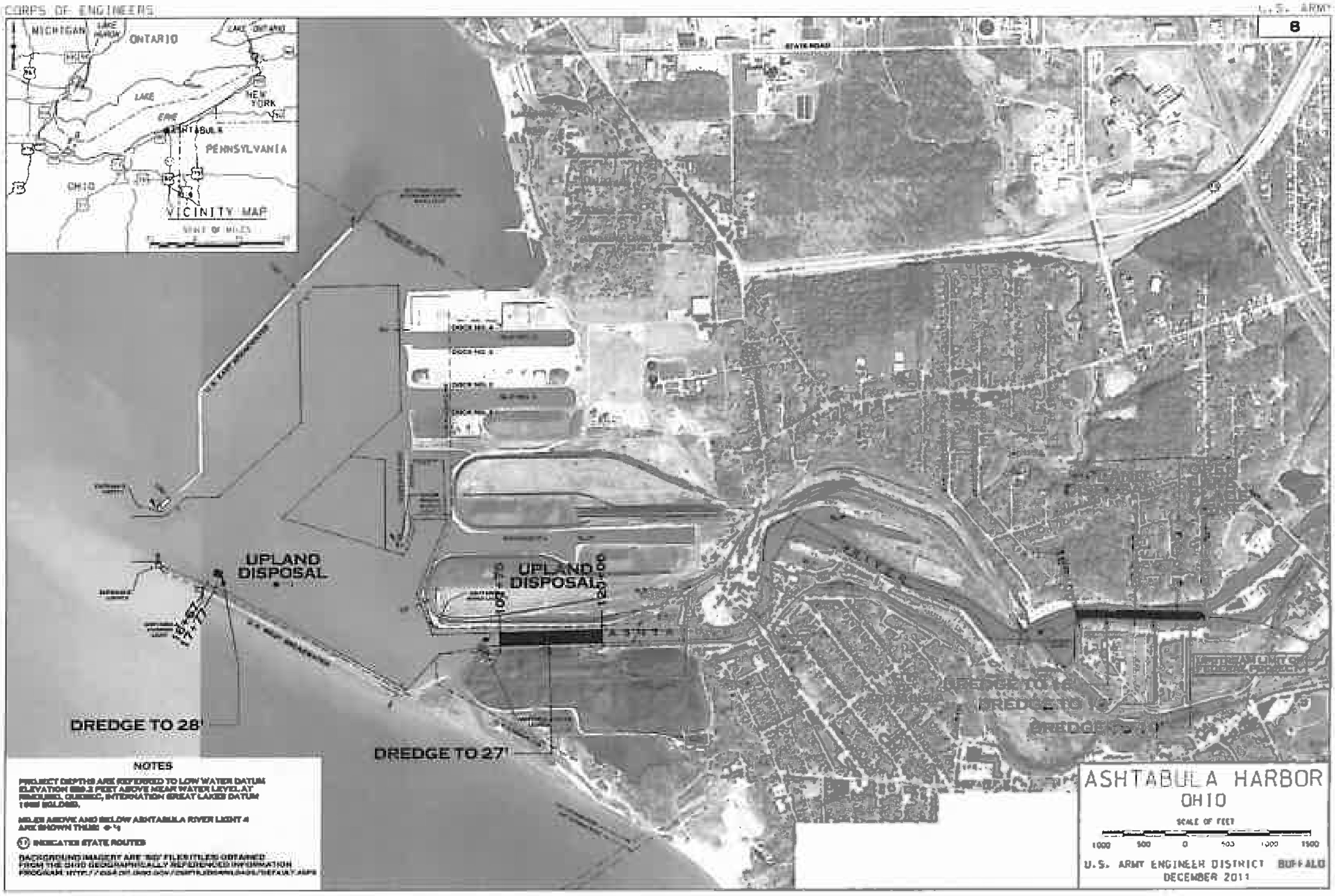
Figure 1

MINIMUM DEGRADATION ALTERNATIVE
(DREDGE 11 ACRES, DEPTHS AS SHOWN)



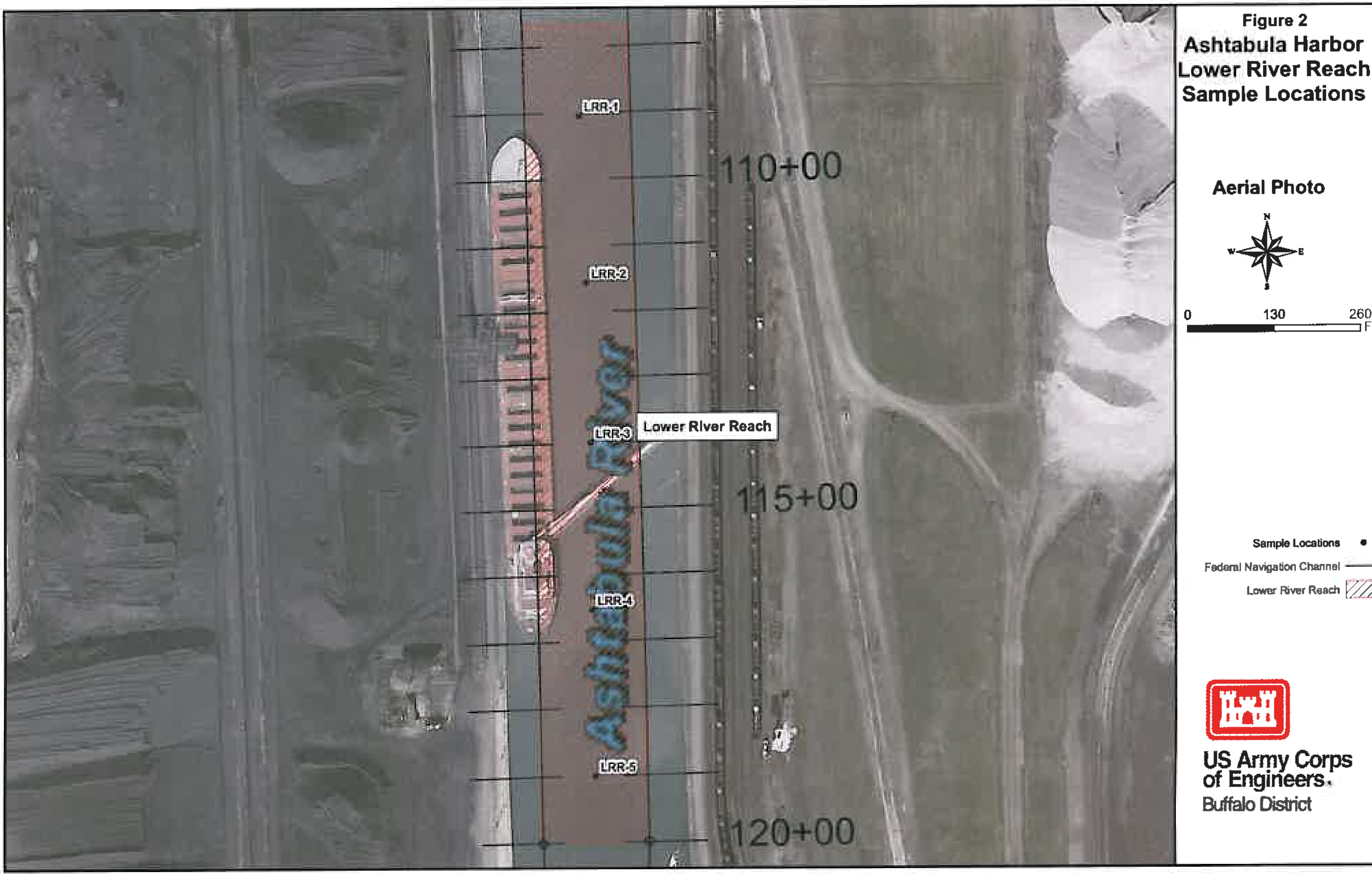


Figure 2
Ashtabula Harbor
Lower River Reach
Sample Locations
Aerial Photo
N
S
E
W
0
130
260
Feet
Sample Locations
Federal Navigation Channel
Lower River Reach
US Army Corps of Engineers
Buffalo District
110+00
115+00
120+00
LRR-1
LRR-2
LRR-3
LRR-4
LRR-5
Lower River Reach
Ashtabula River

Figure 3
Ashtabula Harbor
Southern Reach
Sample Locations

Aerial Photo

0 175 350 Feet

2011 Sample Locations
Federal Navigation Channel
Management Units
ASRMU-1
ASRMU-2
ASRMU-3

US Army Corps of Engineers.
Buffalo District

TABLE 1: Ashtabula Harbor 2011 Sample Information

Management Unit	Date/Time	Sample ID	Latitude	Longitude	Type	Surface Depth (-LWD)	Study Depth (-LWD)	Penetration Depth (-LWD)	Recovery (ft of core)
LRRMU	10/4/11 - 1110	LRR-1	41.90841143	-80.79815370	Core	17	29	12	12
	10/4/11 - 1200	LRR-2	41.90772089	-80.79806666	Core	11.6	29	18	16
	10/4/11 - 1250	LRR-3	41.90701238	-80.79809741	Core	13.8	29	17	14.8
	10/4/11 - 1325	LRR-4	41.90631810	-80.79808300	Core	16.5	29	12.3	9.9
	10/4/11 - 1400	LRR-5	41.90575228	-80.79809142	Core	16.8	29	11.5	10
ASRMU-1B	10/7/11 - 1505	ASR-1	41.88949850	-80.79773237	Core	11.4	17	3	2.2
	10/5/11 - 1055	ASR-2	41.88917624	-80.79791763	Core	12.7	17	5.4	4.8
	10/5/11 - 1205	ASR-3	41.88881196	-80.79767811	Core	8.6	17	8.7	7
	10/5/11 - 1415	ASR-4	41.88840414	-80.79792382	Core	8.7	17	8	5.5
	10/7/11 - 1410	ASR-5	41.88800128	-80.79772950	Core	11.3	17	5.5	4.5
ASRMU-2A & ASRMU-2B	10/8/11 - 910	ASR-6	41.88770036	-80.79787264	Core	7.6	17	9	4.6
	10/8/11 - 950	ASR-7	41.88748911	-80.79782949	Core	3.9	17	13.5	6.6
	10/8/11 - 1025	ASR-8	41.88721640	-80.79774659	Core	1.8	17	13.5	6.3
	10/8/11 - 1125	ASR-9	41.88691264	-80.79777737	Core	1	17	13.5	5
	10/8/11 - 1220	ASR-10	41.88656864	-80.79796427	Core	2	17	17	3
ASRMU-3	10/7/11 - 1220	ASR-11	41.88633701	-80.79785951	Core	1.2	17	11	2.6
	10/7/11 - 1120	ASR-12	41.88611078	-80.79788067	Core	1.5	17	12	3.7
	10/7/11 - 1030	ASR-13	41.88577342	-80.79779512	Core	2.6	17	12	3

TABLE 2: Inorganic Chemistry Analyses on Ashtabula Harbor Management Unit Elutriate Samples and Open-Lake Placement Area (AD) Site Water (Biohabitats, 2012).

Analyte (mg/L)	AD SITE WATER	Ashtabula Harbor Management Unit									
		LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Oil and Grease	0.7 J	0.8 J	0.9 J	2.5 J	0.67 J	5 U	0.84 J	1.6 J	1.3 J	1.2 J	1.7 J
Nitrogen, ammonia	0.034 J	5.2	6.2	3.8	4.2	5.1	4.6	4.2	4.2	2.1	2.1
Phosphorus, total	0.023 UJ	0.07	0.01 U	0.043	0.01 U	0.17	0.02 UJ	0.15	0.014 UJ	0.13	0.01 J
Nitrogen, total kjeldahl	0.58 UJ	5.8	5.3	4.7	3.3	5.1	4.5	4.1	3.5	2.4	1.8
Cyanide, total	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Total Suspended Solids	1 UJ	32		47		130		120		130	
Total Organic Carbon	2.3	2.7	3.1	3	3.3	3.2	3.3	3	3.2	2.6	2.9

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 3: Metals Analyses on Ashtabula Harbor Management Unit Elutriate Samples and Open - Lake Placement Area (AD) Site Water (Biohabitats 2012).

Analyte (mg/L)	AD SITE WATER	Ashtabula Harbor Management Unit									
		LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	0.07	1.4 J	0.043	0.68	0.057	2.6	0.09	2.2	0.062	2.2	0.046
Antimony	0.00052 J	0.001 J	0.00047 J	0.0011 J	0.00047 J	0.0025 U	0.001 U	0.0025 U	0.001 U	0.0025 U	0.001 U
Arsenic	0.0011	0.0052 J	0.0036	0.0039	0.0031	0.0095	0.005	0.0071	0.0038	0.0057	0.0028
Barium	0.022	0.045	0.2	0.098	0.22	0.083	0.2	0.064	0.2	0.074	0.18
Beryllium	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0002 J	0.0004 U	0.00013 J	0.0004 U	0.00015 J	0.0004 U
Cadmium	0.0004 U	0.00021 J	0.0004 U	0.00079	0.0004 U	0.00057	0.0004 U	0.00053	0.0004 U	0.00036 J	0.0004 U
Calcium	39	34	32	37	34	32	29	33	29	34	29
Chromium	0.00056 J	0.0038 J	0.0013 J	0.013	0.0019 J	0.016	0.0014 J	0.016	0.0016 J	0.0066	0.0012 J
Cobalt	0.00012 J	0.0015 J	0.00021 J	0.00086 J	0.0002 J	0.0032	0.00034 J	0.0026	0.00023 J	0.0026	0.00018 J
Copper	0.0014 J	0.0049 J	0.00097 J	0.003	0.00062 J	0.0091	0.00072 J	0.0074	0.0006 J	0.0071	0.00055 J
Iron	0.23	3.7 J	0.15	1.9	0.17	7.3	0.18	6.1	0.16	6.5	0.14
Lead	0.0004 J	0.005	0.00015 J	0.0041	0.00018 J	0.02	0.00063	0.017	0.00036 J	0.014	0.00023 J
Magnesium	8.8	8 J	7.4	8.7	7.6	8.3	6.8	8.7	7.3	8.4	6.5
Manganese	0.0072	0.11 J	0.07	0.05	0.032	0.2	0.12	0.086	0.021	0.16	0.081
Mercury	0.0002 U	0.0002 U	0.0002 U	0.00008 J	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Nickel	0.0016 J	0.0042 J	0.0013 J	0.0053 UJ	0.004 J	0.0083 UJ	0.004 U	0.0075	0.004 U	0.0071 UJ	0.004 U
Potassium	1.6	2.6	2.6	2.7	2.4	3.5	2.7	3.2	2.6	2.9	2.1
Selenium	0.00066 J	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Silver	0.0015 U	0.0015 U	0.0006 U	0.00026 J	0.0006 U	0.00026 J	0.0006 U	0.00027 J	0.0006 U	0.0015 U	0.0006 U
Sodium	9.4	8.6	11	11	12	9.8	11	10	12	11	11
Thallium	0.00017 J	0.0008 U	0.002 U	0.000096 J	0.002 U	0.000066 J	0.002 U	0.000072 J	0.002 U	0.0008 U	0.002 U
Vanadium	0.0005 J	0.0044	0.00092 J	0.03	0.014	0.022	0.003	0.022	0.0053	0.006	0.0013 J
Zinc	0.075	0.027 J	0.051	0.029	0.045	0.061	0.05	0.064	0.041	0.044	0.036

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 4: Polycyclic Aromatic Hydrocarbon (PAH) Analyses on Ashtabula Harbor Management Unit Elutriate Samples and Open-Lake Placement Area (AD) Site Water (Biohabitats, 2012).

PAH (ug/L)	AD SITE WATER	Ashtabula Harbor Mangement Unit									
		LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
2-methylnaphthalene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	5.1 U	5.8 U	5.7 U	5.7 U
acenaphthene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	**0.3 J**	6.3 U	**1.4 J**	**0.77 J**	5.7 U	5.7 U
acenaphthylene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	5.1 U	5.8 U	5.7 U	5.7 U
anthracene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	5.1 U	5.8 U	5.7 U	5.7 U
benzo(a)anthracene	0.91 UJ	1.1 U	1.2 U	1.3 U	1.3 UJ	1.1 U	1.3 U	1 U	1.2 U	1.1 U	1.1 U
benzo(a)pyrene	0.91 UJ	1.1 U	1.2 U	1.3 U	1.3 UJ	1.1 U	1.3 U	1 U	1.2 U	1.1 U	1.1 U
benzo(b)fluoranthene	0.91 UJ	1.1 U	1.2 U	1.3 U	1.3 UJ	1.1 U	1.3 U	1 U	1.2 U	1.1 U	1.1 U
benzo(ghi)perylene	1.8 UJ	2.2 U	2.3 U	2.7 U	2.6 UJ	2.2 U	2.5 U	2 U	2.3 U	2.3 U	2.3 U
benzo(k)fluoranthene	0.91 UJ	1.1 U	1.2 U	1.3 U	1.3 UJ	1.1 U	1.3 U	1 U	1.2 U	1.1 U	1.1 U
chrysene	0.91 UJ	1.1 U	1.2 U	1.3 U	1.3 UJ	1.1 U	1.3 U	1 U	1.2 U	1.1 U	1.1 U
dibenz(a,h)anthracene	1.8 UJ	2.2 U	2.3 UJ	2.7 U	2.6 UJ	2.2 U	2.5 U	2 U	2.3 U	2.3 U	2.3 U
dibenzofuran	3.6 UJ	4.4 U	4.7 U	5.3 U	5.2 UJ	4.4 U	5.1 U	4 U	4.7 U	4.5 U	4.6 U
fluoranthene	1.8 UJ	2.2 U	2.3 U	2.7 U	2.6 UJ	2.2 U	2.5 U	**0.31 J**	2.3 U	2.3 U	2.3 U
fluorene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	**0.54 J**	**0.3 J**	5.7 U	5.7 U
indeno(1,2,3-cd)pyrene	1.8 UJ	2.2 U	2.3 U	2.7 U	2.6 UJ	2.2 U	2.5 U	2 U	2.3 U	2.3 U	2.3 U
naphthalene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	5.1 U	5.8 U	5.7 U	5.7 U
phenanthrene	1.8 UJ	2.2 U	2.3 U	**0.32 J**	2.6 UJ	2.2 U	2.5 U	**0.82 J**	**0.52 J**	2.3 U	2.3 U
pyrene	4.5 UJ	5.6 U	5.8 U	6.7 U	6.5 UJ	5.6 U	6.3 U	**0.35 J**	5.8 U	5.7 U	5.7 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 5: PCB Anaylses on Ashtabula Harbor Management Unit Elutriate Samples and Open-Lake Reference Area (AD) Site Water (Biohabitats, 2012).

		Ashtabula Harbor Management Unit									
	AD SITE WATER	LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
PCB (ug/L)	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aroclor 1016	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1221	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1232	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1242	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1248	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1254	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1260	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U

U - Not detected at or above the specified LRL

TABLE 6: Pesticides Analyses on Ashtabula Harbor Management Unit Elutriate Samples and Open-Lake Placement Area (AD) Site Water (Biohabitats, 2012).

		Ashtabula Harbor Management Unit									
	AD SITE WATER	LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
Pesticide (ug/L)	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
4,4-DDD	0.01 U	0.012 U	0.011 U	0.0056 J	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
4,4-DDE	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
4,4-DDT	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
Aldrin	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
alpha-BHC	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
alpha-Chlordane	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
beta-BHC	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
chlordane (total)	0.21 U	0.23 U	0.22 U	0.25 U	0.23 U	0.22 U	0.23 U	0.22 U	0.24 U	0.24 U	0.25 U
delta-BHC	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
dieldrin	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endosulfan I	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endosulfan II	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endosulfan sulfate	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endrin	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endrin aldehyde	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
endrin ketone	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
gamma-BHC (lindane)	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
gamma-Chlordane	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
heptachlor	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
heptachlor epoxide	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
methoxychlor	0.01 U	0.012 U	0.011 U	0.012 U	0.011 U	0.011 U	0.012 U	0.011 U	0.012 U	0.012 U	0.012 U
toxaphene	0.21 U	0.023 U	0.022 U	0.25 U	0.23 U	0.22 U	0.23 U	0.22 U	0.24 U	0.24 U	0.25 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 7: Water Column Bioassay Results on Ashtabula Harbor Management Unit Elutriate Samples (Biohabitats, 2012).

Management Unit/Sample	Elutriate Treatment Concentration	Percent Survival 48 hour *Ceriodaphnia dubia*	Percent Survival 96 hour *Pimephales promelas*	Ammonia Concentration (mg/L)
Laboratory Control	0.0%	100.0%	92.0%	0.3
LRRMU	6.25%	96.0%	98.0%	
LRRMU	12.5%	88.0%	92.0%	
LRRMU	25.0%	100.0%	96.0%	
LRRMU	50.0%	100.0%	66.0%	8.7
LRRMU	100.0%	92.0%	0.0%	17.0
ASRMU-1B	6.25%	100.0%	80.0%	
ASRMU-1B	12.5%	100.0%	90.0%	
ASRMU-1B	25.0%	100.0%	96.0%	
ASRMU-1B	50.0%	92.0%	68.0%	7.2
ASRMU-1B	100.0%	100.0%	0.0%	14.0
ASRMU-2A	6.25%	96.0%	84.0%	
ASRMU-2A	12.5%	100.0%	90.0%	
ASRMU-2A	25.0%	96.0%	90.0%	
ASRMU-2A	50.0%	100.0%	90.0%	5.6
ASRMU-2A	100.0%	100.0%	20.0%	11.0
ASRMU-2B	6.25%	100.0%	94.0%	
ASRMU-2B	12.5%	100.0%	92.0%	
ASRMU-2B	25.0%	100.0%	84.0%	
ASRMU-2B	50.0%	100.0%	68.0%	8.6
ASRMU-2B	100.0%	100.0%	0.0%	18.0
ASRMU-3	6.25%	100.0%	96.0%	
ASRMU-3	12.5%	100.0%	96.0%	
ASRMU-3	25.0%	100.0%	92.0%	
ASRMU-3	50.0%	100.0%	88.0%	2.6
ASRMU-3	100.0%	100.0%	84.0%	5.1

Evaluation of Ashtabula Harbor Southern Reach Sediments

1.0 Introduction

Ashtabula Harbor sediments between river-based Stations 198+00 and 213+36 (upstream limit of Federal navigation channel) (Figure 1) were sampled and analyzed in the fall of 2010. This reach of Ashtabula Harbor approaches the southern limit of the Federal navigation channels in the river and as such is referred to as the "Southern Reach." The primary objective of this evaluation is to characterize the Southern Reach sediments with respect to potential dredging and dredged material management restrictions based on guidance contained in the 1998 U.S. Environmental Protection Agency (USEPA)/U.S. Army Corps of Engineers (USACE) Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998). This evaluation will form the basis of a follow-up sediment sampling/analysis plan for the dredging of Southern Reach sediments.

2.0 Background

The Southern Reach is situated within the Ashtabula River Area of Concern (AOC) with major pollutants of concern listed as mercury, chromium, lead, zinc, chlorinated organic compounds, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and low level radionuclides (USEPA 2011). Radionuclide analysis is not included in this evaluation as the Ohio Department of Health Bureau of Radiation Protection (ODH BRP) has indicated to the USACE that the Southern Reach is upstream of areas of known radioactive contamination within Ashtabula Harbor (ODH BRP 2011). Fields Brook, a tributary to the river, has been identified as the primary source of PCB contamination to the AOC (Figure 1) (USEPA 2011). Due to contaminated sediments in Ashtabula Harbor Federal navigation channels, routine maintenance dredging upstream of the Fifth Street Bridge was discontinued in the 1960's. Between 2006 and 2008, USEPA conducted a mass removal of contaminated sediments (630,000 cubic yards [CY]) between the Fifth Street Bridge (Station 139+00) to a line immediately downstream of the Southern Reach along the southern end of the Upper River Turning Basin (Station 198+00) under the Great Lakes Legacy Act (GLLA) of 2002 (Figure 1). Since the Southern Reach was not dredged under this project, contaminated sediments remain which are thought to have accumulated mainly from recurrent Lake Sieches that gradually served to move some sediment upstream. Although the Southern Reach was dredged to a depth of -6 ft LWD[1] in 1994, it remains well above the authorized depth of -16 ft LWD. Nevertheless, recent (2009 and 2010) soundings evidence that some surface material has moved out of this section since the completion of the GLLA dredging; channel depths immediately upstream of the Turning Basin have increased from typical maximum depths of -6 to -8 ft LWD, to about 10 ft below LWD.

3.0 Scope of Evaluation

This assessment of Ashtabula Harbor Southern Reach sediments considers bulk sediment data obtained in 1990 (Woodward-Clyde Consultants 1993) and 2010 (USACE 2010a), along with biological effects test data generated in 2010 (USACE 2010a). Using Federal guidelines for determining whether dredged material is suitable for open-lake placement, biological effects testing will serve as the main basis for contaminant determinations. Historical information, as well as sediment physical, chemical and elutriate data, will be considered in determining potential impacts to the water column and benthic environment and in further evaluating sediments at discrete locations. The following is a summary of the two Ashtabula Harbor sediment sampling/testing investigations used in this evaluation.

General Bulk Sediment Chemical Analysis (Woodward-Clyde Consultants 1993)

In 1990, as part of a larger Ashtabula River Investigation, sediment core samples were obtained at 100 ft intervals along the Southern Reach and analyzed for 12 hazardous constituents: octachlorostyrene, PCBs (as Aroclors), lead, chromium, pyrene, fluoranthene, phenanthrene, hexachlorobutadiene, hexachloro benzene, chlorobenzene, toluene, and total carcinogenic polycyclic aromatic hydrocarbons (PAHs) (summed concentrations of benzo [a] anthracene, benzo [a] pyrene, benzo [b] fluoranthene, benzo [k] fluoranthene, chrysene, dibenzo [a,h] anthracene and indeno [1,2,3-cd] pyrene). Cores were characterized in 2 ft intervals with bottom depths ranging from -4 to -19 ft LWD. Of these parameters, PCBs were the most characterized. As part of the investigation, sediments were

[1] Low Water Datum (LWD) is 569.2 feet above Mean Water Level at Rimouski, Quebec (IGLD 1985) (International Great Lakes Datum 1985)

also analyzed for physical characteristics including grain size and Total Organic Carbon (TOC). Because Southern Reach sediments have not been substantially disturbed since this investigation, these data will be considered in conjunction with the 2010 investigation. Sample locations are shown in Figure 2.

General Bulk Sediment Chemical Analysis, Elutriate Testing and Bioassays (USACE 2010a)

A total of 10 sites within the Southern Reach, locations URC-1 through URC-10, were sampled in 2010. Figure 2 shows these discrete sample locations. These sites were nested within three separate management units (MUs) referred to as URCMU-1, URCMU-2 and URCMU-3 (Figure 2). Subsamples of the discrete samples were composited into the MU samples. In addition, a total of eight discrete surface samples were collected from Lake Erie, representing two areas of Lake Bottom sediments. Core samples from the Southern Reach were attempted at all sampling locations down to an elevation of about -16 ft LWD. Core samples could only be penetrated until sand, gravel or other obstructions were encountered and discrete surface grab samples had to be obtained at two of the sites. Figure 3 shows discrete sample locations ALRA-1 through ALRA-4 and ALRB-1 through ALRB-2, subsamples from which were also composited into lake samples ALRA and ALRB, respectively. Table 1 displays sample information, including core depths, locations and dates. Core sample bottom depths ranged from about -4 to -17 feet LWD. Core sample recovery ranged from about 1.5 to 5 feet. Core and surface grab samples within each MU were composited for the MU samples. The following tests were applied to these sediment samples:

- **Physical Characteristics**—Grain size distribution performed on MU composite samples; percent solids and percent moisture were analyzed for in discrete and MU composite samples.
- **Bulk chemistry**—Performed on all discrete and MU composite samples. Parameters included metals, inorganics, TOC, PCBs (209 congeners), PAHs (16 Priority Pollutants [PP]) and pesticides. MU composite samples were also analyzed for PCBs as Aroclor mixtures.
- **Standard elutriate test (SET)**—Performed on MU composite samples for the above listing of bulk chemistry contaminants.

- **Solid phase bioassays (acute toxicity)**—Performed on MU composite samples.
  Standard 10-day *Hyalella azteca* (amphipod), with survival as the biological measurement endpoint.
  Standard 10-day *Chironomus dilutus* (mayfly nymph), with survival and growth as the biological measurement endpoints.
- **Standard 28-day *Lumbriculus variegatus* bioaccumulation test for PCBs** (congeners)—Performed on MU composite samples.

Except for the SET, the above suite of tests was also performed on discrete and composite samples from the two open-lake reference areas. The open-lake reference area results will be used for comparison with the Southern Reach data.

4.0 Sediment Testing Results and Evaluation

Physical Testing

Table 2 presents the results of sieve analyses performed on the sediment samples. The Southern Reach MUs are classified as mainly silt (range of 41.1 to 50.1%) and sand (range of 38.5 to 50.8%). Clay content ranged from 8.1 to 11.4%. Immediately downstream, channel sediments are finer grained until the channel reaches the Outer Harbor, where coarser grained sediments become again become more prevalent. The open-lake reference areas sediments were mainly silt (52.4 and 67.9%), with sand (20.5 and 16%) and clay (27.1 and 16.1%) making up significant proportions.

Solid Phase Bioassays (Survival and Growth)

The solid phase bioassays were intended to evaluate the acute toxicity associated with sediment associated contaminants such as metals, PAHs and pesticides. The results of these bioassays applied to the Southern Reach MUs and open-lake area sediments are presented in Table 3 and summarized as follows:

H. azteca

The mean survival of this species across all Southern Reach MU sediments ranged from 92% to 98%, and was not statistically different relative to the two open-lake reference area sediments (both 92%).

C. dilutus

The survival of this species was 100% across all MU sediments. The mean (ashed) growth of *C. dilutus* across the Southern Reach MU sediments ranged from 0.887 to 1.097 mg, and were not statistically different in comparison to the open-lake reference area sediments (0.880 [ALRA] and 1.152 mg [ALRB]).

These solid phase bioassay data evidenced no toxicological difference between the Southern Reach MU and open-lake reference area composite sediments.

Bulk Sediment Contaminant Concentration

Contaminant concentrations in both Southern Reach discrete and MU sediments were compared to those at the two open-lake reference areas. Discrete concentrations in the Southern Reach which notably exceeded the maximum discrete lake area concentration were noted and subjected to additional discussion with regard to their potential to cause unacceptable toxicity.

Heavy Metals

The results of bulk metals analyses on sediments are presented in Table 4. Numerous metals showed higher concentrations in the discrete Southern Reach samples when compared to the maximum open-lake reference area concentration. Concentrations were highest at sites URC-3 and URC-4 (between stations 200+00 and 202+00) at depths of -10 to -16 ft LWD; metals which substantially exceeded the maximum lake values include barium, cadmium, chromium, vanadium, silver and mercury. The composited MU samples were generally combatable with lake concentrations; URCMU-2 showed the most contamination with regard to metals, with higher concentrations of barium, cadmium, chromium and vanadium, when compared to the maximum open-lake reference area concentrations.

Although each of the MUs did not show significant lethality or reduced growth, discrete sites URC-3 and URC-4 may individually exhibit adverse acute toxicity due to metals. These sites have concentrations well above those of the MU composite samples and open-lake reference area sediments.

Further, they have chromium, cadmium and mercury concentrations greater than the Severe Effect Level (SEL), which are sediment concentrations above which effects are likely to occur (Ontario Ministry of Environment Screening Level Guidelines [Burton, 2002]). Site URC-4 at a depth of -13 to -15 ft LWD had the highest concentrations; this included cadmium at 29 mg/kg (SEL is 10 mg/kg, maximum lake result was 2.7 mg/kg, maximum composite result was 9 mg/kg), chromium at 700 mg/kg (SEL is 110 mg/kg, maximum lake result was 38 mg/kg, maximum composite result was 96 mg/kg), mercury at 2.5 mg/kg (SEL is 2 mg/kg, maximum lake result was 0.23 mg/kg, maximum composite result was 0.22 mg/kg). These data indicate that sediments at these individual sites may not be suitable for open-lake placement. The concentrations of metals in the remaining discrete sites within the MUs are generally comparable to those in the composited MU samples and as such likely do not exhibit significant acute toxicity with respect to metals contamination. Note that sites URC-3 and URC-4 represent the deepest cores obtained in the 2010 sampling effort.

With respect to historic chromium data, Figure 4 provides a profile of the 1990 versus 2010 data. Although limited, the historic data are consistent with the 2010 results in that elevated concentrations are located at similar locations and depths within the Southern Reach.

Without further evaluation of sediments at sites URC-3 and URC-4 (additional solid phase bioassays), chromium, cadmium and mercury are considered contaminants of concern (COCs) between Stations 200+00 and 202+00 at depths of -10 to -16 ft LWD, with respect to open-lake placement.

TOC and Other Inorganic Parameters

Bulk inorganic analyses of sediments are presented in Table 5. With respect to TOC content, discrete Southern Reach samples ranged from 0.17 to 2.3%, and discrete open-lake reference area samples ranged from 0.90 to 1.7%. TOC levels for the Southern Reach MUs ranged from 1.4 to 1.7%, which was comparable to the 1.2 and 1.7% TOC level observed in the open-lake reference areas.

PAHs

Table 6 presents bulk PAH results for the Southern Reach and open-lake reference areas. The 16 USEPA PP PAH compounds and 2-methylnaphthalene were summed to determine total PAHs (non-detectable concentrations were valued at the LRL). The Southern Reach sediment samples showed total PAH levels ranging from 1,185 ug/kg to 12,255 ug/kg. Figure 5 shows the sediment PAH profile for the Southern Reach. Total PAH concentrations in the open-lake reference area sediments ranged from 1,432 ug/kg to 6,161 ug/kg. Some discrete concentrations in the Southern Reach were greater than those measured at the open-lake reference areas; however the composited MU samples were comparable to discrete sites in the lake.

Ratios of select PAH compounds were computed to evaluate whether the PAH profiles showed pyrogenic or petrogenic tendencies. Such PAH information is important as the PAH assemblages resulting from predominantly pyrogenic (combustion-related) sources differ from those of predominantly petrogenic (petroleum-related) sources. The dominant species in PAH mixtures from pyrogenic sources are the parent compounds, while alkyl species dominate petrogenic PAH assemblages. Thus, a pyrogenic assemblage of PAHs characterized by the 16 parent PAHs would be expected to have much less uncertainty associated with the true total PAH concentration in comparison to a petrogenic assemblage. The 16 parent PAH compounds have been reported as representing about one to two thirds of the actual total PAH concentration in pyrogenic assemblages (Hawthorne et al., 2006). Additional value in interpreting PAH sources is that sediment-associated pyrogenic PAHs often exhibit unusual partitioning behavior, and are often more persistent, and less mobile, bioavailable and toxic in comparison to petrogenic PAHs (Neff et al., 2005). PAH mixtures that arise from pyrogenic sources indicate the presence of black carbon forms that have exhibited an unusually strong partitioning behavior. Such PAHs strongly adsorb to this black carbon, limiting their concentration in interstitial water, and thus reducing mobility, bioavailability and toxicity (on a bulk sediment concentration basis) (e.g., Pastorok *et al.* 1994).

A PAH profile showing a phenanthrene/anthrene (PH/AN) ratio less than 10 and afluoranthene/pyrene (FL/PY) ratio of about one are indicative of pyrogenic sources (Brown et al., 2005). A predominantly petrogenic profile would show a PH/AN ratio greater than 15 and a FL/PY ratio significantly less than one (Brown et al., 2005). Neff et al. (2005) states that the FL/PY ratio can approach or exceed a value of one in pyrogenic assemblages. Most of the PAH ratios across the Southern Reach and open-lake reference area sediments indicated predominantly pyrogenic sources (table 6). However, PAH ratios at sites URC-3, URC-4, URC-6 and URC-7 suggest a PAH profile indicative of petrogenic sources. While the ratios are marginally petrogenic, they reveal a different profile than that encountered at the other sites, suggesting that they may be of toxicological concern. Figure 6 compares the PAH compound profiles of composite samples URCMU-3 and ALRB with the discrete sample URC-3 (-14 to -6 ft LWD), as an example of the different PAH compositions seen. Sample URC-3 is characterized by a much larger proportion of pyrene when compared to composite samples ALRB and URCMU-3; this distribution was similar amongst samples URC-4, URC-6 and URC-7 as well. None of the composite samples used in the solid phase bioassays showed petrogenic ratios.

Due to greater bioavailability associated with PAHs of petrogenic origin as well as potentially greater amounts of unmeasured alkylated PAHs, PAH contamination at sites URC-3, URC-4, URC-6 and URC-7 at sediment depths of -9 to -16 ft LWD may not have been adequately represented in the solid phase bioassays. Therefore, the risk of these PAH mixtures to benthic macro invertebrates was estimated using hydrocarbon narcosis and equilibrium partitioning (EqP) models (USEPA, 2003). This approach assumes that the risk of PAH mixtures to benthic organisms is attributable to the number of PAH toxic units that are freely dissolved in sediment pore water, and is used to calculate EqP Sediment Benchmark Toxic Units, Final Chronic Value ($\sum ESBTU_{FCV}$) (USEPA 2003). TOC is an important partitioning parameter as it acts to sequester PAHs in the sediment phase, thus lowering the amount of PAHs available in the water phase. $ESBTU_{FCV}$s were calculated as follows:

Equation 1

$$ESBTU_{FCV} = \frac{C/f_{OC}}{C_{OC,\,PAHi,\,FCVi}}$$

Where:
$C_{OC,\,PAHi,\,FCVi}$ = Final chronic value (FCV) concentration in sediment ($\mu g/g_{OC}$) (see USEPA 2003)

C = Concentration of PAH compound in sediment (µg/g dry weight)
f_{OC} = Decimal fraction of TOC in sediment (TOC) (µg/g_{OC} dry weight)

Freshwater sediments containing $\sum ESBTU_{FCV} < 1.0$ of a mixture of 34 or more PAH compounds are acceptable for the protection of aquatic organisms. Conversely, $\sum ESBTU_{FCV} \geq 1.0$ suggest that sensitive benthic organisms may be affected by the PAH mixture. Table 7 presents the final toxic units (based on acute critical body burden of 13.9 µmol/g lipid for Hyalalla azteca [Kreitinger, personal communication; USEPA 2003]) ($\sum ESBTU_{FAV,34}$) for the PAH mixtures in samples URC-3 (14-16), URC-4 (10-12 and 13-15), URC-6 and URC-7, specific to *H. azteca*, a key benthic test species used to evaluate acute toxicity of dredged sediments in standard bioassays (USEPA/USACE 1998). PAH equilibrium partitioning toxicity modeling utilizes a minimum of 34 PAH compounds (18 parent PAHs and 16 alkyl derivatives) (USEPA, 2003). Since sediments were only analyzed for 16 parent PAH compounds (USEPA PPs), an uncertainty factor had to be applied to account for the unmeasured mostly alkyl PAHs. USEPA recommends the use of an uncertainty factor of 11.5 at 95% confidence for 13 parent PAHs (USEPA 2003). The $\sum ESBTU_{FAV,34}$ ranged from 0.799 to 1.559. Each of these sites, except for URC-4 (10-12), had $\sum ESBTU_{FAV,34} > 1.0$, suggesting the potential for unacceptable PAH-associated acute toxicity in these sediments. As such, without additional biological effects testing or analytical measurement of alkylated PAHs, total PAHs were retained as a COC at sites URC-3 (14-16), URC-4 (13-15), URC-6 and URC-7 at depths of -9 ft to -16 ft LWD.

PCBs

Table 8 presents the PCB congener distributions in MU and lake area sediments and tissue by homologue groups as well the USEPA identified 13 dioxin-like PCBs (DeGrandchamp and Barron 2005). The Southern Reach sediments contain mainly tetra-chlorinated congeners (~50% of total), while PCBs in the open-lake reference area sediments were more evenly distributed across tetra, penta and hexa-chlorinated congeners (between 20-30% each). Open-lake reference area sediments contained a greater proportion of dioxin-like congeners compared to the Southern Reach (10% vs. 3%). These differing fingerprints indicate different sources of PCBs.

Congener distributions in tissue typically show a different fingerprint than the associated sediments because bioaccumulation in biological systems tends to concentrate congeners of higher chlorine content (DeGrandchamp and Barron, 2005). The congener distribution in Southern Reach tissue samples were similar to the distribution in sediments, mainly characterized as penta-chlorinated congeners (~50%), although there was a slightly greater proportion of penta-chlorinated congeners and less tri-chlorinated congeners. The open-lake reference area tissue samples showed increased occurrence of hexa- and hepta-chlorinated congeners, with declines in tri- and tetra-chlorinated congeners from sediment to tissue.

Table 9 presents total PCB sediment concentration results. Individual congener concentrations were summed to determine total PCB concentrations, with non-detected congeners valued at the LRL (reporting limits were sufficiently low to have a negligible impact on the total sum). Total PCB concentrations in the open-lake reference area sediments ranged from 16.1 to 209.3 ng/g and were generally greater in area ALRB. Concentrations in the Southern Reach were generally much higher relative to the open-lake reference areas, with a maximum concentration of 10,796 ng/g at site URC-4. Some discrete sites (URC-1, URC-2, URC-5, URC-9 and URC-10) showed total PCB concentrations that were comparable to, or lower than, the open-lake reference areas; these samples had core bottom depths ranging from -4 to -11 ft LWD and were either surface samples or top of the core samples.

Figure 7 shows the Southern Reach sediment profile of total PCB concentrations for 1990 and 2010. The profiles are generally comparable for total PCB concentrations in terms of location and magnitude. The 1990 profile provides better characterization with regard to depth as deeper cores were obtained. Soundings (2009 and 2010) indicate a recent loss of bottom sediments and deepening in the reach, which has resulted in higher PCB levels near the sediment-water interface. With the exception of the segment upstream of Station 209+00, the 1990 PCB sediment profile shows elevated PCB concentrations throughout the Southern Reach at all depths sampled.

Standard *L. variegatus* 28-day bioaccumulation experiments were applied to the MU and open-lake reference area sediments because bioaccumulation is an appropriate biological measurement endpoint to evaluate the potential toxicological impacts of PCBs in the aquatic environment. Table 10 summarizes the results of these tests.

Benthic biota-sediment accumulation factors (BSAFs) are a general measure of contaminant bioavailability and can be used to model bioaccumulation. Using the bioaccumulation experiment data, total PCB BSAFs were calculated for experimental replicates a follows:

Equation 2

$$BSAF = (C_T/L)/(C_S/TOC)$$

Where:

C_T = Whole body tissue concentration of total PCBs in replicate (ng/g wet weight)
L = Concentration of lipid in replicate (percent of wet weight)
C_s = Concentration of total PCBs in composite sediment sample (ng/g dry weight)
TOC = Total organic carbon concentration in composite sediment sample (percent of dry weight)

For the BSAF calculations, total PCB sediment and tissue concentrations were determined by summing individual congeners, with non-detected congeners valued at the LRL (reporting limits were sufficient to have negligible effect on the total sum). Mean BSAFs were calculated across five experimental replicates for each MU and open-lake reference area. Table 10 includes the BSAF calculations.

Mean total PCB concentrations in tissue for the Southern Reach ranged from 631.72 ug/kg to 1,792.74 ug/kg, with mean BSAFs ranging from 1.70 to 2.43. URCMU-1 and URCMU-2 had mean BSAFs of 2.42 and 2.43 respectively, while URCMU-3 had a lower mean BSAF of 1.70. Sediments in URCMU-3 sediments were the most fine grained among the Southern Reach MUs (61.5% silt and clay, compared to 56.1% and 49.2% silt and clay for URCMU-1 and URCMU-2, respectively). The BSAFs observed from URCMU-1 and URCMU-2 sediments are greater than a theoretical maximum organic chemical bioavailability value of 1.72 (maximum of 1.72 times the TOC-normalized concentration of the chemical in sediment could be accumulated in the lipid of an organism based on EqP modeling) (McFarland and Clarke 1986). In addition, the mean BSAFs were greater than the total PCB Grand Mean of 1.28 for all benthic organisms in the laboratory and comparable to the total PCB Grand Mean of 2.39 for all benthic organisms in the field (U.S. Army Engineer Research and Development Center [USAERDC] 2011). One factor in this greater bioavailability may be the comparably more coarse grained nature of the URCMU-1 and URCMU-2 sediments, which can result in less surface area for contaminant adsorption. In comparison, PCB bioavailability in open-lake reference area sediments was much less, as mean tissue concentrations for the two reference areas were 19.94 (ALRA) and 29.54 (ALRB) ug/kg, with BSAFs of 0.22 and 0.26, respectively. This is consistent with the 28.09 ug/kg mean of tissue concentration measurements associated with the ALRA sediments in 2009 (USACE 2010b). The composite sediment tested in 2009 had a total PCB concentration of 42.99 ug/kg and resulting BSAF of 1.48 (USACE 2010b). These results were unexpected for the open-lake reference areas and PCB adsorption to black carbon may be a significantly contributing factor. Lake sediments at identical areas or at areas in the general vicinity have previously yielded mean total PCB BSAFs of 1.48 (USACE 2010b) and 1.28 (Pickard, unpublished data).

Regardless of these evidenced differences in lake sediment PCB bioavailability, the bioaccumulation experiments on the three Southern Reach MU sediments indicate that PCB bioaccumulation from the sediments is unacceptable for placement in the lake environs. This is based on the fact that the range in lipid-normalized PCB tissue concentrations of 462.12 ug/kg-lipid to 2,060.12 ug/kg-lipid across the three MU sediments was higher than the mean lipid-normalized PCB residue of 63.34 ug/kg-lipid associated with the 2009 disposal area sediments (USACE 2010b).

To evaluate bioaccumulation of PCBs from discrete sediment samples, the theoretical (or thermodynamically-defined) bioaccumulation potential (TBP) model (Equation 1) was employed. TBP is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, in sediments into benthic organisms (McFarland 1984). This model is expressed as:

Equation 3

$$TBP = BSAF\ (L)\ (C_s/TOC)$$

Where:

TBP = Predicted whole body tissue concentration of the neutral organic compound (μg/kg wet weight)
BSAF = Biota-sediment accumulation factor

L = Concentration of lipid in target animals (percent of wet weight)
C_s = Concentration of neutral organic compound in sediment (μg/kg dry weight)
TOC = Total organic carbon concentration in sediment (percent of dry weight)

TBP is a screening tool that tends to err on the conservative side. The target animal used in this case is an oligochaete worm. In this model, 1% lipid content, an average characteristically representative of oligochaete worms (e.g., Ankley *et al.* 1992, Pickard *et al.* 2001) was used. A mean total PCB BSAF of 2.18 was calculated across all Southern Reach replicate BSAFs and used in the model. Note that all samples from Woodward-Clyde Consultants (1993) were not analyzed for TOC; therefore, a mean TOC of 2.86% calculated from those samples that measured TOC during the sampling event was utilized in the model predictions.

Table 11 presents the TBP calculations, and Figure 8 shows the resulting TBP sediment profile. Discrete Southern Reach site TBP predictions which exceeded the maximum open-lake reference or placement area TBP values (USACE 2010b) are deemed to be unsuitable for open-lake placement. The maximum open-lake reference and placement area TBP values were 206 ug/kg and 69 ug/kg respectively. The TBP predictions across all Southern Reach discrete sites ranged from 12 to 8,541 ug/kg, most of which were above the lake TBP values. While the TBP results for Sites URC-1 and URC-2 were low (range 28 to 34 ug/kg), the relative proximity to Sites 194-01 and 192-01 (Woodward-Clyde Consultants, 1993), which indicated much higher PCB bioaccumulation (range 499 to 8,541 ug/kg), was assumed to more representative based on existing information. Site URC-5 was situated outside of the Federal navigation channel. The TBP results at near surface discrete Sites URC-9 and URC-10 upstream of Station 210+00 were 12 ug/kg and 23 ug/kg, and much lower in comparison to the open-lake reference and placement area TBP values. Therefore, based on existing information, PCBs are considered a COC in the Southern Reach sediments within the Federal navigation channel between Stations 198+00 and 210+00 due to unacceptable PCB bioaccumulation. Sediments upstream of Station 210+00 may be suitable for open lake placement upon additional PCB characterization at depth.

Pesticides

Table 12 presents the results of bulk pesticides analyses. Most pesticides in the Southern Reach and open-lake reference area sediment samples were non-detectable. Four,4-dichlorodiphenyldichloroethylene (DDE) was measured at sites URC-3, URC-4 and URC-6, ranging from 0.77 ug/kg to 3.2 ug/kg, and at one open-lake reference area site (ALRB) at 1.5 ug/kg. These concentrations are just above LRLs and are not of toxicological concern. None of the MU or open-lake reference area composite samples had detectable concentrations of 4,4-DDE. Beta-BHC was measured above detection limits more consistently in the Southern Reach, but was non-detectable at the lake areas. Detected concentrations in the Southern Reach ranged from 4.0 to 220 ug/kg. The highest concentration measured in a composite sample was 18 ug/kg (URCMU-1). This, in tandem with the solid phase bioassay data, indicates that concentrations of beta-BHC of up to 18 ug/kg do not result in significant acute toxicity. However, concentrations at sites URC-3 (82 and 100 ug/kg at depths of -12 to 14 ft and -14 to -16 ft LWD respectively) and URC-4 (220 ug/kg at depth of -13 to -15 ft LWD) are well above that level and may be of toxicological concern, and as such may not be suitable for open-lake placement. Without additional biological effects testing, beta-BHC is considered a COC at sites URC-3 (-12 to -16 ft LWD) and URC-4 (-13 to -15 ft LWD) with regard to open-lake placement of the sediments.

SET

SET data simulate the release of dissolved contaminants from a hydraulic dredged material placement operation in open waters and may be considered a worst case analysis for the release of dissolved contaminants from a mechanical dredged material placement operation (USEPA/USACE 1998). The contaminant releases are compared to applicable and relevant water quality standards (WQSs) to evaluate compliance. Tables 13 through 19 present the results of SET performed on the Southern Reach and open-lake reference area composite sediments, along with dissolved concentrations in the lake waters.

Metals

The metal elutriate results are shown in Table 13. The dissolved metal concentrations do not exceed any Ohio WQS.

Inorganics

The inorganic parameter elutriate results are presented in Table 14. Releases of nitrogen are evident; ammonia results for the Southern Reach range from 6.2 to 10.1 mg/L which exceed Ohio WQSs without considering mixing in the water column. Total ammonia is an atypical COC because it is not persistent. While it is toxic in sediment only at high concentrations, ammonia can temporarily reach high enough concentrations to become acutely toxic to fish in bioassays (invertebrates are typically not as sensitive as fish to ammonia levels [USEPA 1999]). Therefore, ammonia toxicity is most appropriately characterized in the water column. Fairchild *et al.* (2005) exposed several fish species to ammonia in the laboratory over a chronic 28-day duration. The most sensitive fish species was *P. promelas* exposed as 4-day olds. For this species, they reported a no observed effect concentration (NOEC), lowest observed effect concentration (LOEC) and chronic value (ChV; the geometric mean of the NOEC and LOEC) of 0.31, 0.60 and 0.43 mg/L unionized ammonia (NH_3), respectively. At 20°C and the reported pH of 8.34, this ChV equates to a total ammonia concentration of approximately 7.2 mg/L. The ChV is considered a protective value (Adams and Rowland 2002), and this 28-day value should be conservative for a 96-hour *P. promelas* elutriate test conducted at 20°C. In addition, these values are also conservative in terms of a 96-hour elutriate test since this study used water renewal to maintain stable ammonia concentrations over the course of the test, while in a static elutriate exposure the ammonia concentration should decrease over time, and uses a much shorter exposure period (as in field conditions during the open-lake placement of dredged material). If the *P. promelas* elutriate test were conducted at 25°C, the ChV reported by Fairchild *et al.* (2005) would translate to approximate total ammonia ChV of 6.3 mg/L. In addition, Fairchild *et al.* (2005) reported no *P. promelas* mortality after 7 days of exposure to 0.31 mg/L NH_3 (or 3.7 mg/L total ammonia at 25°C). USEPA (1999) provides a total ammonia species mean chronic value (SMCV) for *P. promelas* set equal to 3.09 mg/L at a pH of 8.

Short-term fate (STFATE) modeling of ammonia in the water column after dredged material placement would be needed to evaluate whether these elutriate results represent an unacceptable risk. The STFATE model considers parameters such as mixing conditions in the lake, the amount of material to be placed and sediment characteristics to determine contaminant concentrations in the water column over time after disposal. Based on the model results, further evaluation would consider the magnitude and duration of exposure in the water column to determine if the contaminant presents an unacceptable risk.

PAHs

PAH elutriate results are shown in Table 15. Numerous PAH compounds were detected in the elutriate, although the dissolved concentrations measured (less than 1 ug/L) do not exceed any Ohio WQS.

PCBs

Aroclor elutriate results are shown in Table 16. No Aroclors were detected at LRLs ranging from 0.1 to 0.3 ug/L.

Table 17 shows total PCB elutriate results based on sum of individual congeners. Except for lake water, congeners not detected were valued at the LRL (LRLs were adequately low to have negligible impact on the total concentration except for the lake water, where non-detectable congeners were valued at 0). Lake water showed a background total PCB concentration of 0.21 ng/L, while the Southern Reach sediments elutriate produced dissolved concentrations ranging from 62.2 ng/L (URCMU-1) to 126.6 ng/L (URCMU-2). STFATE modeling of total PCB concentrations in the water column after dredged material placement would be needed to evaluate whether these elutriate results represent an unacceptable risk.

Table 18 shows the congener distributions for the Southern Reach elutriate and lake water sample. The Southern Reach congener distributions are similar to those observed in the bulk sediments. The lake water concentrations showed a larger proportion of di-chlorinated congeners in comparison to Southern Reach elutriates.

Pesticides

Pesticide elutriate results are shown in Table 19. Pesticide releases were non-detectable at LRLs ranging from 0.011 μg/L to 0.26 μg/L, and do not exceed any Ohio WQS.

5.0 Conclusions

The 2010 investigation shows widespread PCB contamination within the Southern Reach sediments, with limited metal, PAH and pesticide contamination. Metals, PAHs and pesticides were noted to be of particular concern at sites URC-3 and URC-4 between Stations 200+00 and 202+00, and are collocated with the highest PCB concentrations. These two sites also represent the deepest sediment samples obtained from the Southern Reach in 2010, at depths ranging from -10 to -16 ft LWD. This is not inconsistent with the Woodward-Clyde Consultant (1993) data, which showed the most contaminated sediments at depths of -8 to -14 ft LWD, throughout the harbor. Contamination in the Southern Reach sediments is generally highest in the downstream areas and decreases moving upstream. Cumulatively, the 1993 and 2010 data indicate that the most contaminated sediments exist between Stations 200+00 and 205+00. Soundings and current conditions suggest this material may be moving downstream.

Given existing information on the extent, bulk concentration, bioavailability and bioaccumulation of PCBs associated with sediments collected from the Southern Reach, it is concluded that total PCBs are a COC in all sediments dredged from the Federal navigation channel between Stations 198+00 and 210+00 because placement of dredged material in the lake environs would result in unacceptable PCB bioaccumulation. This evaluation also identified chromium, cadmium, mercury and beta-BHC as COCs at sites URC-3 and URC-4, as well as total PAHs at sites URC-3, URC-4, URC-6 and URC-7, all of which are located between Stations 198+00 and 210+00. Sediments dredged from the Federal navigation channel upstream of Station 210+00 may be acceptable for open-lake placement with additional characterization, including a full suite of bulk chemical analysis. Based on existing information, it is concluded that all Southern Reach material within the Federal navigation channel between Stations 198+00 and 210+00 does not meet Federal guidelines for unconfined open-lake placement.

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Figures

FIGURE 1: Ashtabula Harbor Southern Reach

US Army Corps of Engineers
Buffalo District

FIGURE 2: Ashtabula Harbor Southern Reach Sample Locations

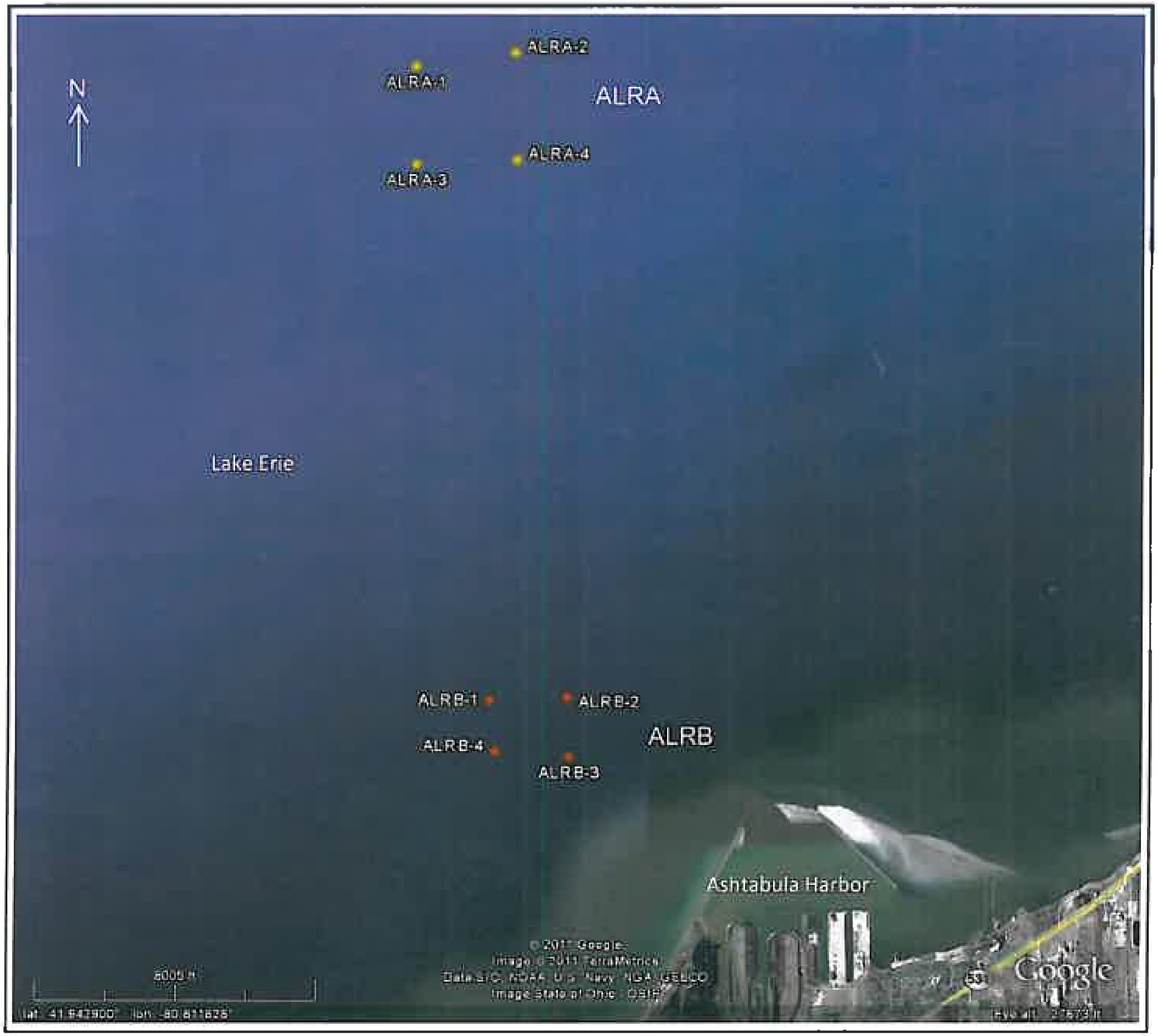


FIGURE 3: Open-Lake Reference Areas and Sampling Locations

FIGURE 4: Ashtabula Harbor Southern Reach Sediment Profile: Chromium Concentrations (mg/kg)

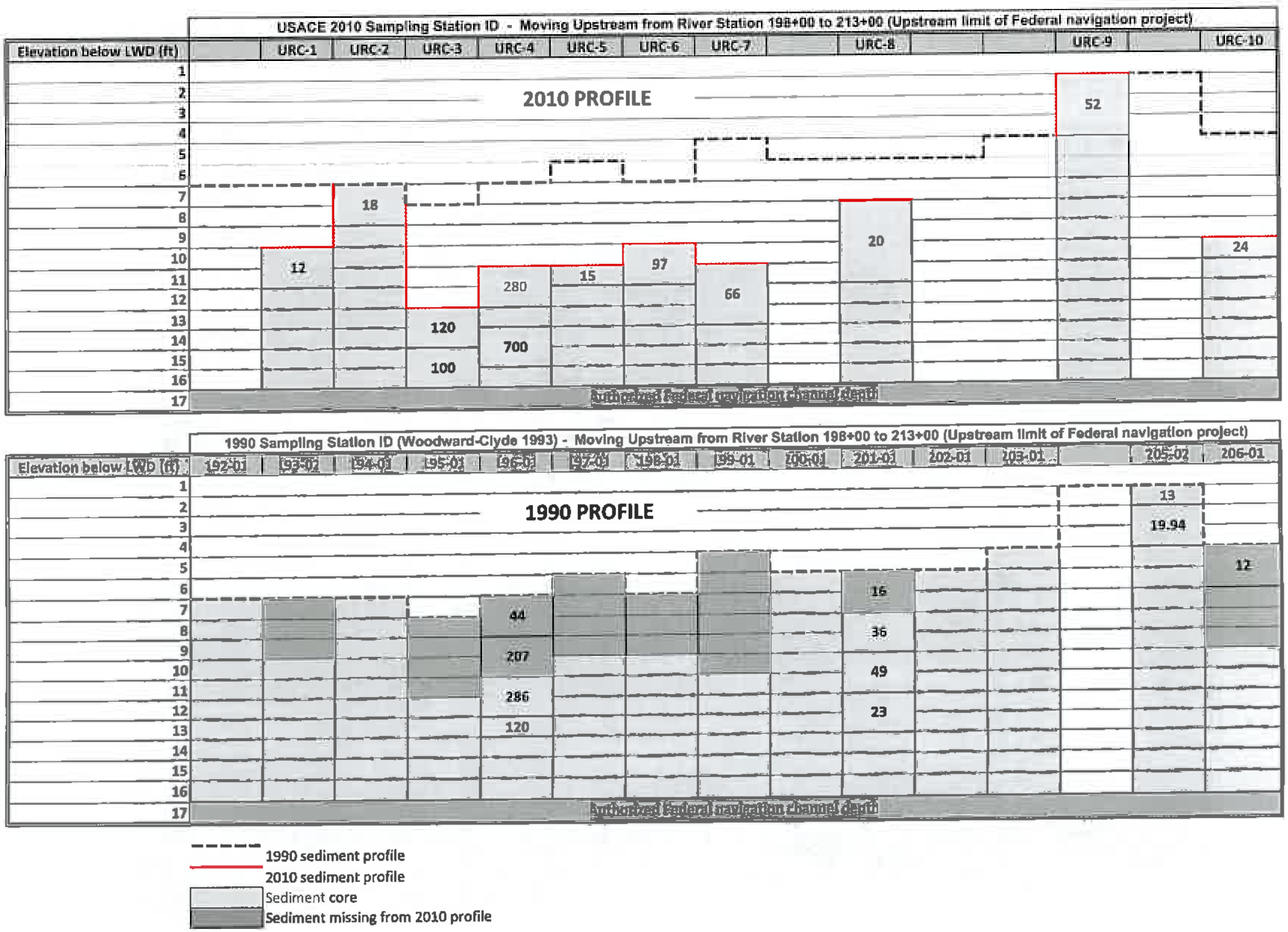
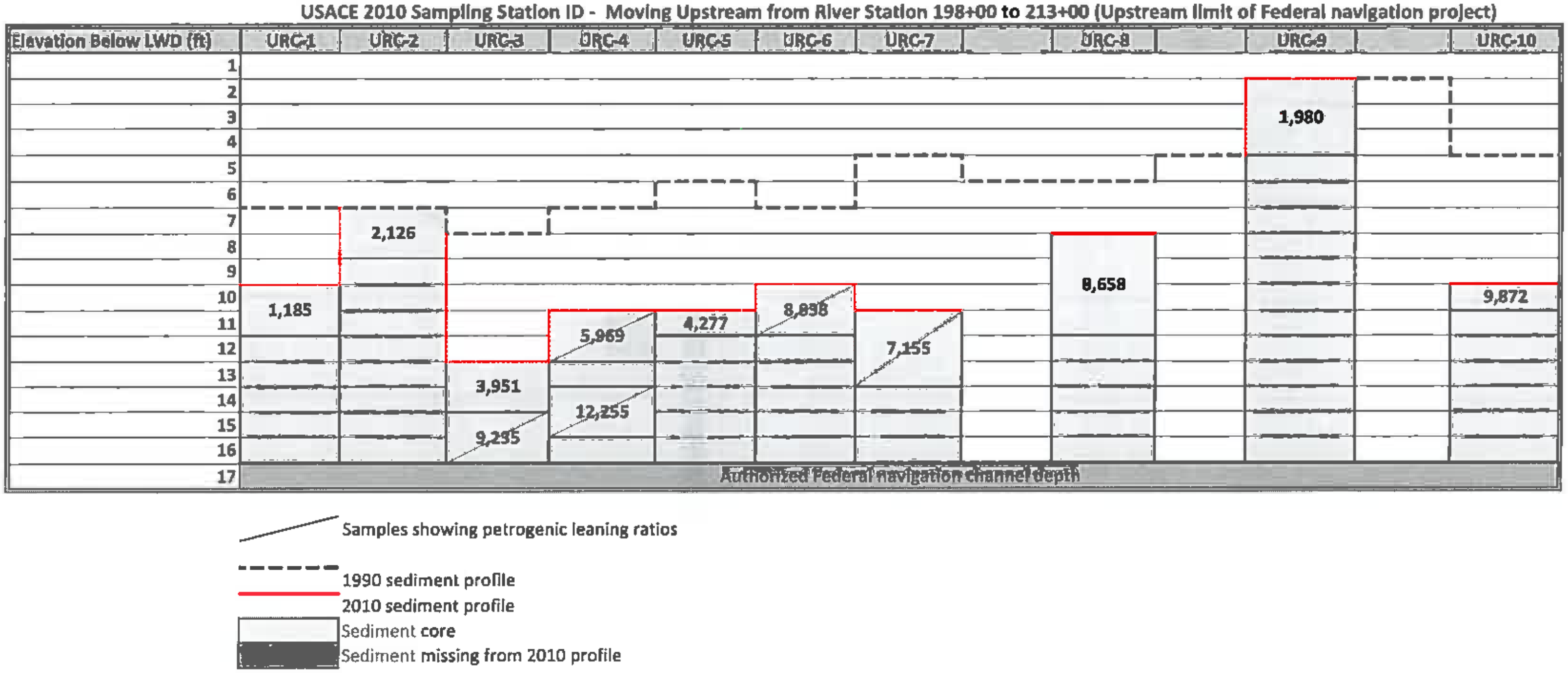


FIGURE 5: Ashtabula Harbor Southern Reach Sediment Profile: Total PAH Concentrations (ug/kg)

USACE 2010 Sampling Station ID - Moving Upstream from River Station 198+00 to 213+00 (Upstream limit of Federal navigation project)



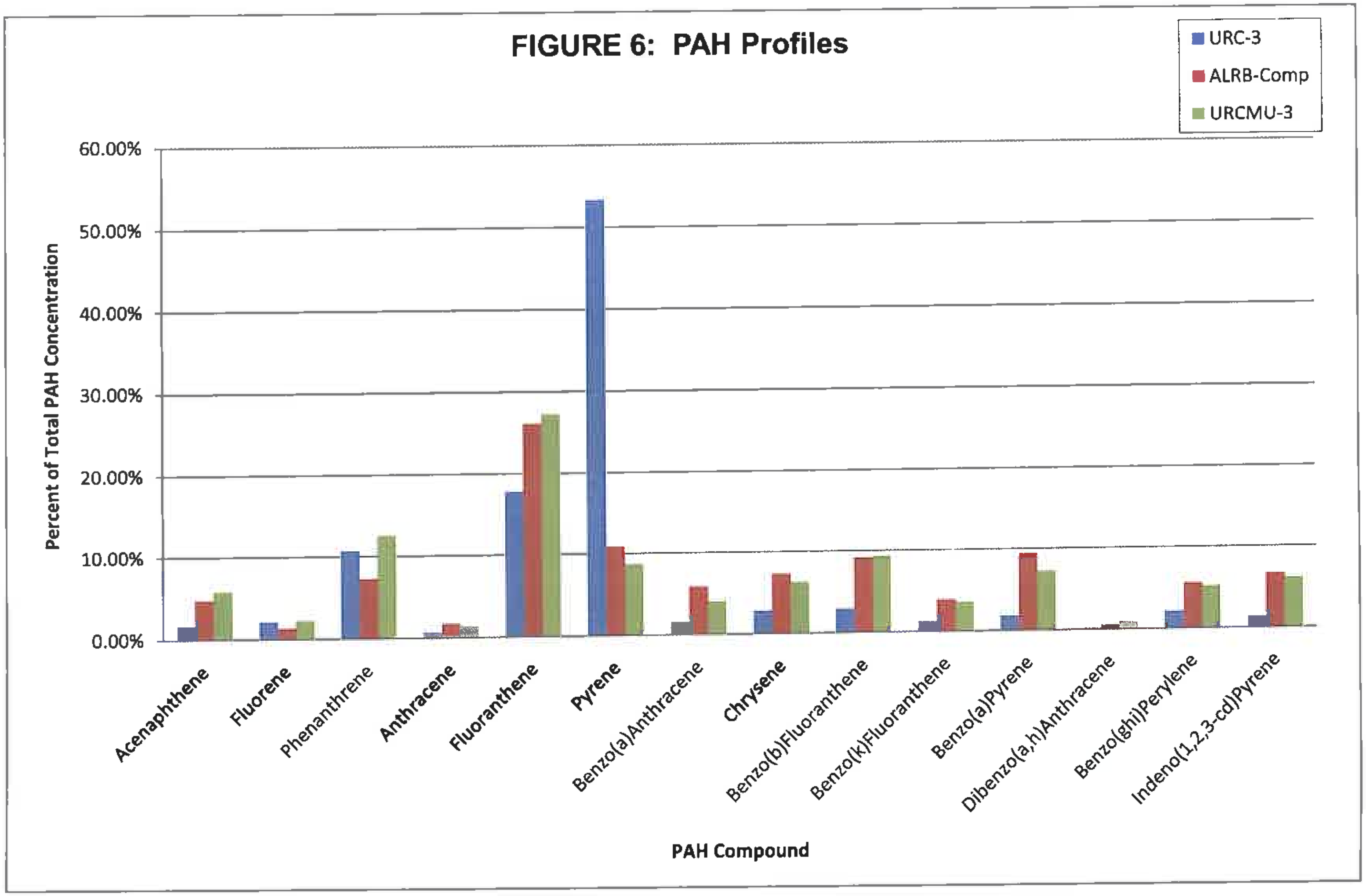


FIGURE 6: PAH Profiles
URC-3
ALRB-Comp
URCMU-3
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of Total PAH Concentration
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(a)Anthracene
Chrysene
Benzo(b)Fluoranthene
Benzo(k)Fluoranthene
Benzo(a)Pyrene
Dibenzo(a,h)Anthracene
Benzo(ghi)Perylene
Indeno(1,2,3-cd)Pyrene
PAH Compound

FIGURE 7: Southern Reach Sediment Profile: Total PCB Concentrations (ng/g)

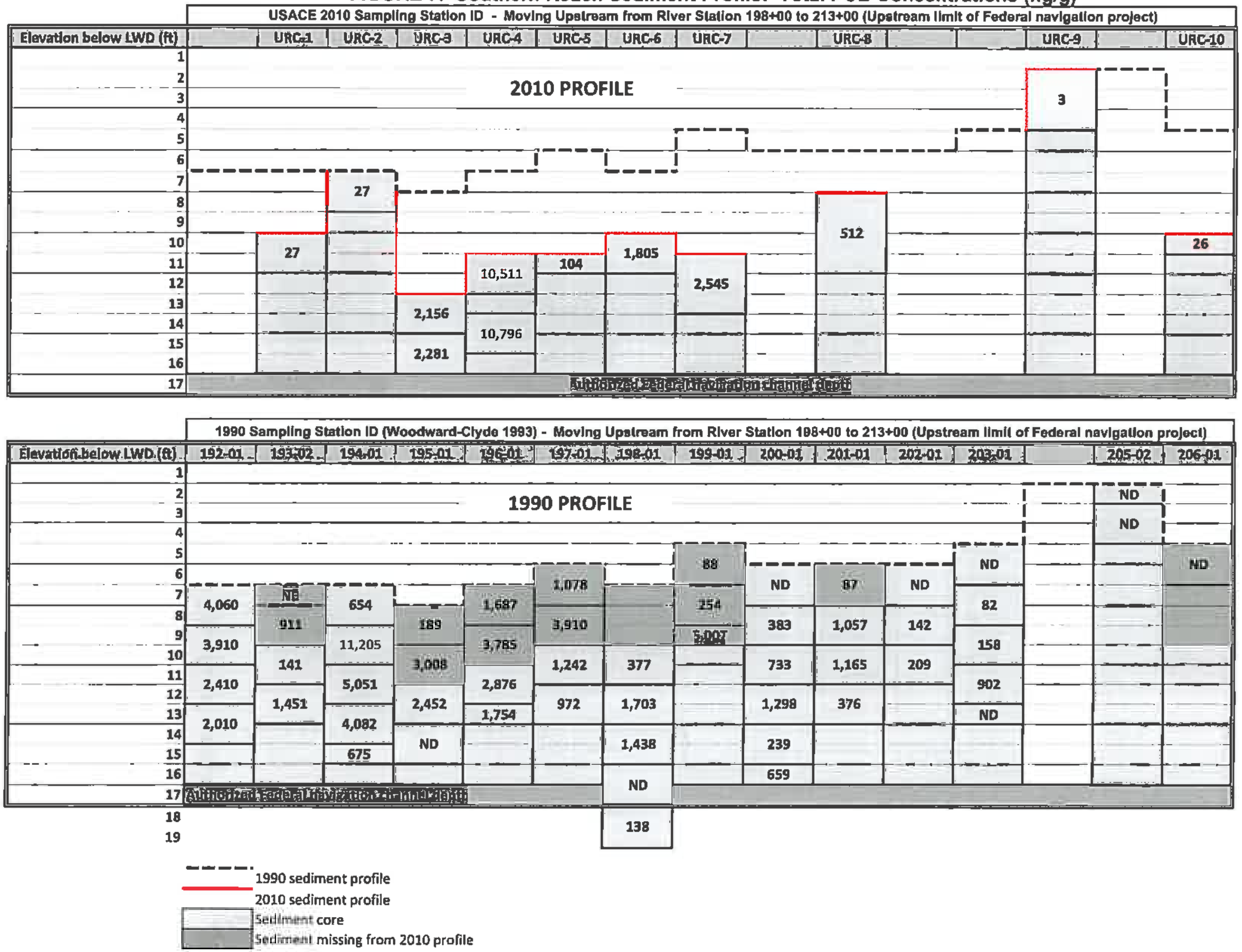
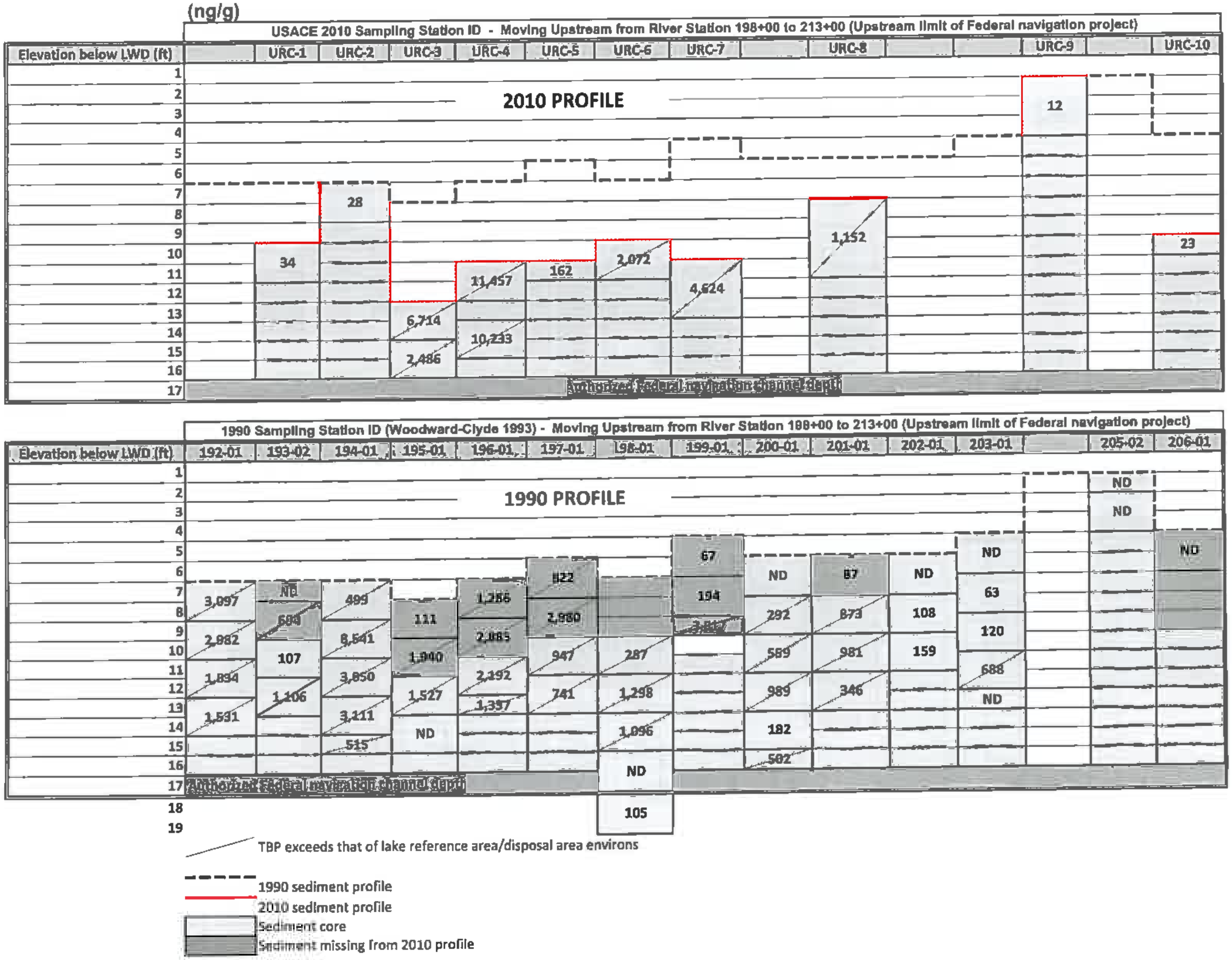


FIGURE 8: Ashtabula Harbor Southern Reach Sediment Profile: Total PCB Theoretical Bioaccumulation Potential (ng/g)



Tables

TABLE 1: 2010 Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sample Location Data

Management Unit	Sample ID	Date/Time	Latitude	Longitude	Type	Depth/Elevation*
ALRA	ALRA-1	9/23/10 - 0900	41.97856667	-80.82718333	Surface	62'
	ALRA-2	9/23/10 - 0910	41.97933333	-80.81676666	Surface	63'
	ALRA-3	9/23/10 - 0920	41.971	-80.8275	Surface	62'
	ALRA-4	9/23/10 - 0930	41.97105	-80.817	Surface	60'
ALRB	ALRB-1	9/23/10 - 0950	41.92896667	-80.82176666	Surface	47'
	ALRB-2	9/23/10 - 1000	41.92968333	-80.8125	Surface	45'
	ALRB-3	9/23/10 - 1010	41.92433333	-80.8136666	Surface	45'
	ALRB-4	9/23/10 - 1020	41.92496667	-80.8214	Surface	45'
URCMU-1	URC-1	9/14/10 - 1000	41.88951667	-80.79776667	Core	-9'5" to -11'5"
	URC-2	9/14/10 - 1040	41.88926667	-80.79776667	Core	-6'4" to -8'
	URC-3	9/14/10 - 1110	41.88911667	-80.79793333	Core	-12' to -17'2"
URCMU-2	URC-4	9/14/10 - 1410	41.88886667	-80.7978	Core	-10' to -15'3"
	URC-5	9/14/10 - 1520	41.88853333	-80.798	Surface**	-10
	URC-6	9/14/10 - 1610	41.88818333	-80.79788333	Core	-9'5" to -11'5"
URCMU-3	URC-7	9/15/10 - 0915	41.88793333	-80.79795	Core	-9' to -12'8"
	URC-8	9/15/10 - 0950	41.88723333	-80.79801667	Core	-7' to -11'6"
	URC-9	9/15/10 - 1030	41.8865	-80.79791667	Core	-1' to -4'
	URC-10	9/15/10 - 1100	41.88576667	-80.79815	Surface**	-9

*Highlighted sample elevations are in feet below LWD (based on real-time gauge readings); others are in depth (based off of vessel depth gauge).

**Core sample attempted at location, no recoverable penetration obtained, so surface samples obtained.

TABLE 2: Particle Size Distribution of Management Unit Composite Samples (USACE, 2010a).

Particle Size	Open-Lake Reference Areas		Southern Reach Management Units		
	ALRA	ALRB	URCMU-1	URCMU-2	URCMU-3
Gravel	0	0	0	0	0
Sand	20.5	16	43.9	50.8	38.5
Silt	52.4	67.9	45.6	41.1	50.1
Clay	27.1	16.1	10.5	8.1	11.4

TABLE 3: Results of 10-day Toxicity Tests (Bioassays) on Management Unit Composite Samples (USACE, 2010a).

Sample I.D.	Test species			
	Hyalella azteca	*Chironomus dilutus*		
	Percent Survival (%)	Percent Survival (%)	AFDW Avg. (mg) [1]	Biomass Avg. (mg) [2]
Laboratory Control	96	100	1.163	1.163
ALRA-Comp	92	100	0.880	0.880
ALRB-Comp	92	100	1.152	1.152
URCMU-1	92	100	1.097	1.097
URCMU-2	94	100	0.887	0.887
URCMU-3	98	100	1.084	1.084

[1] Average ash-free-dry weight (AFDW) is total AFDW of the surviving organisms

[2] Biomass weight is the total AFDW of surviving organisms divided by the initial number of organisms

Note: 1. Average AFDW of *Chironomus dilutus* at test initiation = 0.191 mg

2. Statisitically significant differences ($p < 0.05$) between the open-lake reference area (ALRA and ALRB) and management unit sediments are indicated by:

TABLE 4: Bulk Metals Analyses on Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediments (USACE, 2010a)

Metal - mg/kg	Southern Reach URCMU-1					Southern Reach URCMU-2					Southern Reach URCMU-3				
	URC-1	URC-2	URC-3 (12-14)	URC-3 (14-16)	URCMU-1	URC-4 (10-12)	URC-4 (13-15)	URC-5	URC-6	URCMU-2	URC-7	URC-8	URC-9	URC-10	URCMU-3
Aluminum	6,500	11,000	8,400	16,000	11,000	9,500	14,000	9,200	10,000	12,000	14,000	11,000	8,100	15,000	15,000
Arsenic	7.2	11	9.6	16	10	9.9	12	7.7	13	11	14	9.1	11	11	11
Barium	26	52	89	290	69	220	510	54	87	110	120	55	92	82	71
Beryllium	0.38	0.53	0.42	0.78	0.53	0.56	0.9	0.52	0.57	0.57	0.66	0.54	0.51	0.76	0 65
Cadmium	0.33	0.59	4.2	10	2.6	27	29	0.58	5.6	9	6.3	1	5.1	0.88	1.6
Calcium	2,000	2,800	4,300	10,000	3,300	16,000	1,700	3,900	3,800	6,100	5,200	3,300	2,200	4,500	4,400
Chromium	12	18	[illegible]	100	32	180	700	15	97	96	66	20	52	24	30
Cobalt	7.3	12	7.4	12	11	9.8	13	9.5	11	10	12	9.9	9.4	15	12
Copper	17	24	18	30	24	29	43	22	23	24	23	20	18	35	27
Iron	22,000	33,000	27,000	40,000	29,000	28,000	36,000	26,000	32,000	31,000	3,600	28,000	27,000	39,000	35,000
Lead	17	23	23	51	29	46	56	21	32	31	[illegible]	25	48	39	38
Magnesium	2,700	4,400	3,400	6,400	4,200	3,700	5,300	3,500	4,300	4,600	5,600	4,400	3,500	5,600	5,300
Manganese	200	410	360	520	350	360	500	420	370	410	490	360	250	490	430
Nickel	17	26	19	36	25	33	[illegible]	21	29	26	29	22	23	32	29
Potassium	670	1,200	650	1,100	1,000	970	1,000	1,100	1,100	1,100	1,200	1,200	1,000	1,800	1,400
Selenium	0.44 J	0.4 J	0.22	0.43	0.28	0.4	0.47	0.44	0.47	0.34	0.38	0.29	0.29	0.66	0.5
Sodium	39 J	61 J	80	170	85	340 U	270	80 J	63 J	110	80	64	64	120	95
Thallium	[illegible] J	0.17 J	0.12	[illegible]	0.23	0.18	[illegible]	0.17	0.21	0.2	0.21	0.15	0.17	0.29	0.19
Vanadium	8.5	14	[illegible]	[illegible]	30	[illegible]	[illegible]	13	[illegible]	[illegible]	[illegible]	19	76	21	35
Zinc	65	99	90	190	100	190	260	90	170	130	180	90	140	150	140
Antimony	0.25	0.33	0.4	0.63	0.46	0.43	[illegible]	0.31	0.42	0.29	0.46	0.47	0.24	0.52	0.26
Silver	0.081	0.064	[illegible]	[illegible]	[illegible]	[illegible]	5.2	0.085	[illegible]	0.098	[illegible]	0.2	0.054	0.23	0.079
Mercury	0.019 J	0.025 J	0.087	1.5	0.15	0.23	2.5	0.14	0.12	0.16	0.13	0.13	0.032	0.067 J	0.073

U - Not detected at or above the specified LRL.

J - Estimated concentration

[shaded] Greater than maximum open-lake reference area concentration

Metal - mg/kg	Open-Lake Reference Area A (ALRA)					Open-Lake Reference Area B (ALRB)				
	ALRA-1	ALRA-2	ALRA-3	ALRA-4	ALRA-Comp	ALRB-1	ALRB-2	ALRB-3	ALRB-4	ALRB-Comp
Aluminum	14,000	17,000	16,000	11,000	15,000	13,000	11,000	12,000	14,000	11,000
Arsenic	4.9	9.6	10	14	11	11	8.9	9.4	11	8.2
Barium	65	[illegible]	82	81	82	54	46	53	57	42
Beryllium	0.65	[illegible]	0.87	0.61	0.84	0.67	0.58	0.65	0.72	0.55
Cadmium	1.2	2.4	[illegible]	1.4	2.5	1.8	1.5	2.6	1.8	1.7
Calcium	8,900	[illegible]	10,000	7,100	9,600	14,000	14,000	12,000	15,000	13,000
Chromium	21	34	[illegible]	21	35	26	23	30	27	22
Cobalt	10	[illegible]	12	10	12	11	9.6	10	12	9.1
Copper	23	[illegible]	41	22	38	33	31	35	35	27
Iron	28,000	33,000	33,000	30,000	32,000	33,000	30,000	30,000	[illegible]	29,000
Lead	26	[illegible]	49	28	46	33	29	39	35	28
Magnesium	7,800	8,900	8,600	6,000	8,400	9,400	8,900	8,600	[illegible]	8,300
Manganese	400	590	640	640	630	490	470	450	550	440
Nickel	28	40	43	29	39	33	28	32	34	27
Potassium	2,100	2,500	2,700	1,700	2,600	1,900	1,600	1,800	1,900	1,500
Selenium	0.48	1	1.1	0.63	1.2	0.62	0.53	0.62	0.65	0.54
Sodium	170	270	200	160	190	170	260	150	160	130
Thallium	0.3	0.39	0.39	0.25	0.39	0.28	0.26	0.31	0.31	0.28
Vanadium	23	29	30	23	29	21	18	20	22	17
Zinc	110	200	190	120	180	150	140	170	160	130
Antimony	0.41	0.81	0.78	0.34	0.67	0.58	0.44	0.52	0.55	0.54
Silver	0.13	0.3	0.85	0.13	0.26	0.19	0.15	0.25	0.26	0.22
Mercury	0.23	0.15	0.12	0.11	0.091 U	0.13	0.063	0.082	0.096	0.21

U - Not detected at or above the specified LRL.

[shaded] Maximum concentration measured in open-Lake reference areas

TABLE 5: Bulk Inorganic Chemistry Analyses on Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediments (USACE, 2010a)

Parameter - mg/kg	Southern Reach URCMU-1					Southern Reach URCMU-2					Southern Reach URCMU-3				
	URC-1	URC-2	URC-3 (12-14)	URC-3 (14-16)	URCMU-1	URC-4 (10-12)	URC-4 (13-15)	URC-5	URC-6	URCMU-2	URC-7	URC-8	URC-9	URC-10	URCMU-3
Total Kjeldahl Nitrogen	472	1,590	1,120	1,870	1,890	1,370	2,070	2,070	1,170	1,950	1,620	1,000	584	2,180	1,340
Ammonia Nitrogen	32.9	99.9	116	[illegible]	113	168	79.7	79.7	148	174	263	[illegible]	53.9	164	123
Phosphorus	200	408	337	527	479	396	523	523	430	505	453	464	267	580	409
Oil and Grease	370	[illegible]	160	150U	230	320	[illegible]	1,100	1,000	200	1,200	940	[illegible]	1,800	260
Total Cyanide	1.2U	1.5U	1.3U	1.5U	1.6U	1.6U	1.7U	2.0U	0.49 J	1.6U	1.5U	[illegible]	1.2U	2.3U	1.7U
Total Organic Carbon	1,700 J	21,000	7,000	20,000	14,000	20,000	23,000	14,000	19,000	14,000	12,000	9,700	5,900	24,000	17,000
Percent Solids	83.6	69.6	77.4	62.9	64.3	62.7	53.8	53.8	70.1	57	67	69.7	83.7	46.3	70.7
Percent Moisture	19	34	21	35	36	39	42	50	32	39	33	28	19	56	42

U - Not detected at or above the specified LRL

J - Estimated concentration

[grey shading] Greater than maximum open-lake reference area concentration

Parameter (mg/kg)	Open-Lake Reference Area A (ALRA)					Open-Lake Reference Area B (ALRB)				
	ALRA-1	ALRA-2	ALRA-3	ALRA-4	ALRA-Comp	ALRB-1	ALRB-2	ALRB-3	ALRB-4	ALRB-Comp
Total Kjeldahl Nitrogen	1,590	2,640	3,000	1,370	2,250	1,330	1,050	954	1,290	1,300
Ammonia Nitrogen	96.5	144	198	83.6	172	91	64.7	65.1	85.1	81.1
Phosphorus	547	773	[illegible]	597	802	599	542	521	558	536
Oil and Grease	230U	320	300U	230	270U	[illegible]	170U	230	190U	180U
Total Cyanide	2.3U	3.0U	3.0U	1.9U	2.7U	1.9U	1.7U	1.7U	1.9U	1.8U
Total Organic Carbon	13,000	16,000	17,000	9,000	17,000	13,000	11,000	9,100	12,000	12,000
Percent Solids	44.4	30.9	32.1	50.4	34	50.7	[illegible]	57.5	54.2	54
Percent Moisture	56	67	[illegible]	47	63	48	42	42	47	44

U - Not detected at or above the specified LRL

[grey shading] Maximum concentration measured in open-lake reference area

TABLE 6: Bulk Polycyclic Aromatic Hydrocarbon (PAH) Analyses on Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediments (USACE, 2010a), and Associated PAH Compound Ratios

PAH - ug/kg	Southern Reach URCMU-1					Southern Reach URCMU-2					Southern Reach URCMU-3				
	URC-1	URC-2	URC-3 (12-14)	URC-3 (14-16)	URCMU-1	URC-4 (10-12)	URC-4 (13-15)	URC-5	URC-6	URCMU-2	URC-7	URC-8	URC-9	URC-10	URCMU-3
2-Methylnaphthalene	15 U	19 U	16 U	19 U	20 U	20 U	21 U	25 U	18 U	20 U	18 U	17 U	15 U	28 U	20 U
Acenaphthene	82	60	310	150	140	410	790	170	270	190	220	700	130	300	360
Acenaphthylene	70	64	140	130	79	66	150	120	79	20 U	18 U	17 U	49	210	20 U
Anthracene	24	26	100	54	28	37	71	42	67	39	52	110	38	57	85
Benzo(a)anthracene	35	95	210	140	120	95	110	210	170	220	130	570	130	440	250
Benzo(a) pyrene	50	170	190	160	180	130	200	370	220	360	210	740	130	890	450
Benzo(b) fluoranthene	56	220	230	260	230	250	340	400	370	430	300	700	140	980	580
Benzo(g,h,i) perylene	71	120	130	190	130	150	230	320	230	280	170	420	95	700	320
Benzo(k) fluoranthene	14 J	64	89	110	55	70	71	170	100	180	100	330	52	440	220
Chrysene	48	160	250	250	170	370	400	360	260	380	230	670	120	820	390
Dibenzo(a,h) anthracene	52	26	10 J	14 J	25	15 J	32	37	16 J	42	24	60	11 J	94	55
Fluoranthene	320 M	560 M	1,100	1,600	700 M	990	2,000	940 M	1,700	1,100	1,400	2,300 M	480 M	2,100 M	1,700
Fluorene	51	31	70	190	62	120	240	39	140	62	120	92	35	45	140
Indeno(1,2,3-cd) pyrene	43	92	130	120	120	95	160	340	140	250	140	510	100	780	380
Naphthalene	9 J	19 U	46 B	88	8 J	51 B	140 B	14 J	38	21 B	33 B	42 B	15	28 U	20 U
Phenanthrene	150	190	540	960	230	500	1,100	310	820	380	590	570	210	660	780
Pyrene	95	210	390	4,800	220	2,600	6,200	410	4,200	530	3,400	810	230	1,300	540
Total PAHs	1,185	2,126	3,951	9,235	2,502	5,969	12,255	4,227	8,838	4,504	7,155	8,659	1,980	9,872	6,310
PH/AN	6.25	7.31	5.40	17.78	8.21	13.51	15.49	7.38	12.24	9.74	11.35	5.18	5.53	11.58	9.18
FL/PY	3.37	2.67	2.82	0.35	3.18	0.38	0.32	2.29	0.40	2.08	0.41	2.84	2.09	1.62	3.15

U - Not detected at or above specified LRL
J - Estimated concentration
B - Analyte detected in the asociated Method Blank
M - Manual integration used to determine area response.

(shaded) Petrogenic Leaning Ratios

PAH - ug/kg	Open-Lake Reference Area A (ALRA)					Open-Lake Reference Area B (ALRB)				
	ALRA-1	ALRA-2	ALRA-3	ALRA-4	ALRA-Comp	ALRB-1	ALRB-2	ALRB-3	ALRB-4	ALRB-Comp
2-Methylnaphthalene	55 U	74 U	71 U	46 U	67 U	46 U	42 U	43 U	45 U	44 U
Acenaphthene	55 U	74 U	330	46 U	130	410	310	270	360	170
Acenaphthylene	120	74 U	130	150	170	170	80	170	45 U	81
Anthracene	30 J	69 J	63 J	15 J	34 J	110	77	79	86	60
Benzo(a)anthracene	100	180	240	48	130	360	250	260	290	210
Benzo(a) pyrene	200	400	450	100	250	570	390	380	440	340
Benzo(b) fluoranthene	390	510	510	210	330	550	380	480	470	330
Benzo(g,h,i) perylene	140	270	280	73	160	340	260	290	300	200
Benzo(k) fluoranthene	60	120	150	33 J	87	240	160	160	190	140
Chrysene	120	200	290	72	160	410	300	320	350	260
Dibenzo(a,h) anthracene	55 U	27 J	18 J	17 J	67 U	31 J	20 J	11 J	21 J	19 J
Fluoranthene	510	820	1,000	290 M	550	1,400	1,100 M	1,300 M	1,200	940 M
Fluorene	30 J	37 J	52 J	15 J	18 J	67	53	53	57	46
Indeno(1,2,3-cd) pyrene	170	270	370	87	210	400	280	280	320	240
Naphthalene	47 J	31 J	56 J	57	25 J	57	37 J	40 J	46	8 J
Phenanthrene	130	240	260	78	140	390	330	320	350	260
Pyrene	200	360	390	95	230	610	460	490	510	390
Total PAHs	2,412	3,756	4,660	1,432	2,758	6,161	4,529	4,946	5,080	3,738
PH/AN	4.33	3.48	4.13	5.20	4.12	3.55	4.29	4.05	4.07	4.33
FL/PY	2.55	2.28	2.56	3.05	2.39	2.30	2.39	2.65	2.35	2.41

U - Not detected at or above specified LRL
J - Estimated concentration
M - Manual integration used to determine area response

TABLE 7: Acute Equilibrium Partitioning-Based Sediment Benchmark Toxic Units (ESBTUs) Specific to *Hyalella azteca* for PAH Compound Mixture in Select Ashtabula Harbor Southern Reach Sediment Samples

PAH compound	$C_{oc,PAHi,FAVi}$ (µg/g$_{OC}$)*	URC-3 (14-16) Concentration PAH (µg/g)	TOC (% dec)	C_{oc} (µg/g$_{OC}$)	$ESBTU_{FAVi}$
Acenaphthene	3047	0.150	0.02	7.5	0.002461437
Acenaphthylene	2807	0.130	0.02	6.5	0.002315639
Anthracene	3684	0.054	0.02	2.7	0.000732899
Benzo(a)Anthracene	5216	0.140	0.02	7	0.001342025
Benzo(a)Pyrene	5988	0.160	0.02	8	0.001336005
Benzo(b)Fluoranthene	6023	0.260	0.02	13	0.002158393
Benzo(ghi)Perylene	6081	0.190	0.02	9.5	0.001562243
Benzo(k)Fluoranthene	6789	0.110	0.02	5.5	0.000810134
Chrysene	5235	0.250	0.02	12.5	0.002387775
Dibenzo(a,h)Anthracene	6966	0.014	0.02	0.7	0.000100488
Fluoranthene	4389	1.600	0.02	80	0.018227387
Fluorene	3341	0.190	0.02	9.5	0.00284346
Indeno(1,2,3-cd)Pyrene	6918	0.120	0.02	6	0.000867303
Naphthalene	2391	0.088	0.02	4.4	0.001840234
Phenanthrene	3698	0.960	0.02	48	0.012979989
Pyrene	4328	4.800	0.02	240	0.055452865
Total PAHs (16)		9.22			
$\Sigma ESBTU_{FAV,16}$					0.107418276
Uncertainty factor					11.5
$\Sigma ESBTU_{FAV,34}$					1.235310177

PAH compound	$C_{oc,PAHi,FAVi}$ (µg/g$_{OC}$)*	URC-4 (10-12) Concentration PAH (µg/g)	TOC (% dec)	C_{oc} (µg/g$_{OC}$)	$ESBTU_{FAVi}$
Acenaphthene	3047	0.410	0.02	20.5	0.006727929
Acenaphthylene	2807	0.066	0.02	3.3	0.001175632
Anthracene	3684	0.037	0.02	1.85	0.000502172
Benzo(a)Anthracene	5216	0.095	0.02	4.75	0.00091066
Benzo(a)Pyrene	5988	0.130	0.02	6.5	0.001085504
Benzo(b)Fluoranthene	6023	0.250	0.02	12.5	0.002075378
Benzo(ghi)Perylene	6081	0.150	0.02	7.5	0.00123335
Benzo(k)Fluoranthene	6789	0.070	0.02	3.5	0.00051554
Chrysene	5235	0.370	0.02	18.5	0.003533906
Dibenzo(a,h)Anthracene	6966	0.015	0.02	0.75	0.000107666
Fluoranthene	4389	0.990	0.02	49.5	0.011278195
Fluorene	3341	0.120	0.02	6	0.00179587
Indeno(1,2,3-cd)Pyrene	6918	0.095	0.02	4.75	0.000686615
Naphthalene	2391	0.051	0.02	2.55	0.001066499
Phenanthrene	3698	0.500	0.02	25	0.006760411
Pyrene	4328	2.600	0.02	130	0.030036969
Total PAHs (16)		5.95			
$\Sigma ESBTU_{FAV,16}$					0.069492295
Uncertainty factor					11.5
$\Sigma ESBTU_{FAV,34}$					0.799161393

PAH compound	$C_{oc,PAHi,FAVi}$ (µg/g$_{OC}$)*	URC-4 (13-15) Concentration PAH (µg/g)	TOC (% dec)	C_{oc} (µg/g$_{OC}$)	$ESBTU_{FAVi}$
Acenaphthene	3047	0.790	0.023	34.3	0.01127267
Acenaphthylene	2807	0.150	0.023	6.5	0.002323384
Anthracene	3684	0.071	0.023	3.1	0.000837936
Benzo(a)Anthracene	5216	0.110	0.023	4.8	0.000916911
Benzo(a)Pyrene	5988	0.200	0.023	8.7	0.00145218
Benzo(b)Fluoranthene	6023	0.340	0.023	14.8	0.00245436
Benzo(ghi)Perylene	6081	0.230	0.023	10	0.001644466
Benzo(k)Fluoranthene	6789	0.071	0.023	3.1	0.0004547
Chrysene	5235	0.400	0.023	17.4	0.003322121
Dibenzo(a,h)Anthracene	6966	0.032	0.023	1.4	0.000199728
Fluoranthene	4389	2.000	0.023	87	0.019812377
Fluorene	3341	0.240	0.023	10.4	0.003123251
Indeno(1,2,3-cd)Pyrene	6918	0.160	0.023	7	0.001005568
Naphthalene	2391	0.140	0.023	6.1	0.002545779
Phenanthrene	3698	1.100	0.023	48	0.01293296
Pyrene	4328	6.200	0.023	270	0.062284015
Total PAHs (16)		12.23			
$\Sigma ESBTU_{FAV,16}$					0.126582406
Uncertainty factor					11.5
$\Sigma ESBTU_{FAV,34}$					1.455697675

PAH compound	$C_{oc,PAHi,FAVi}$ (µg/g$_{OC}$)*	URC-6 Concentration PAH (µg/g)	TOC (% dec)	C_{oc} (µg/g$_{OC}$)	$ESBTU_{FAVi}$
Acenaphthene	3047	0.270	0.019	14.2	0.004663776
Acenaphthylene	2807	0.079	0.019	4.2	0.001481259
Anthracene	3684	0.067	0.019	3.5	0.000957198
Benzo(a)Anthracene	5216	0.170	0.019	8.9	0.00171537
Benzo(a)Pyrene	5988	0.220	0.019	11.6	0.001933692
Benzo(b)Fluoranthene	6023	0.370	0.019	19.5	0.00323322
Benzo(ghi)Perylene	6081	0.230	0.019	12	0.00199067
Benzo(k)Fluoranthene	6789	0.100	0.019	5.3	0.000775248
Chrysene	5235	0.260	0.019	13.7	0.002613985
Dibenzo(a,h)Anthracene	6966	0.016	0.019	0.8	0.000120888
Fluoranthene	4389	1.700	0.019	89	0.020385893
Fluorene	3341	0.140	0.019	7.4	0.002205454
Indeno(1,2,3-cd)Pyrene	6918	0.140	0.019	7	0.001065109
Naphthalene	2391	0.038	0.019	2.0	0.00083647
Phenanthrene	3698	0.820	0.019	43	0.011670604
Pyrene	4328	4.200	0.019	221	0.051075007
Total PAHs (16)		8.82			
$\Sigma ESBTU_{FAV,16}$					0.106723842
Uncertainty factor					11.5
$\Sigma ESBTU_{FAV,34}$					1.227324185

PAH compound	$C_{oc,PAHi,FAVi}$ (µg/g$_{OC}$)*	URC-7 Concentration (µg/g)	TOC (% dec)	C_{oc} (µg/g$_{OC}$)	$ESBTU_{FAVi}$
Acenaphthene	3047	0.220	0.012	18.3	0.006017
Acenaphthylene	2807	0.018	0.012	1.5	0.000534
Anthracene	3684	0.052	0.012	4.3	0.001176
Benzo(a)Anthracene	5216	0.130	0.012	10.8	0.002077
Benzo(a)Pyrene	5988	0.210	0.012	17.5	0.002923
Benzo(b)Fluoranthene	6023	0.300	0.012	25.0	0.004151
Benzo(ghi)Perylene	6081	0.170	0.012	14	0.00233
Benzo(k)Fluoranthene	6789	0.100	0.012	8.3	0.001227
Chrysene	5235	0.230	0.012	19.2	0.003661
Dibenzo(a,h)Anthracene	6966	0.024	0.012	2.0	0.000287
Fluoranthene	4389	1.400	0.012	117	0.026582
Fluorene	3341	0.120	0.012	10.0	0.002993
Indeno(1,2,3-cd)Pyrene	6918	0.140	0.012	12	0.001686
Naphthalene	2391	0.033	0.012	2.8	0.00115
Phenanthrene	3698	0.590	0.012	49	0.013295
Pyrene	4328	3.400	0.012	283	0.065465
Total PAHs (16)		7.14			
$\Sigma ESBTU_{FAV,16}$					0.135555
Uncertainty factor					11.5
$\Sigma ESBTU_{FAV,34}$					1.558884

*Based on acute critical body burden of 13.9 µmol/g lipid for *Hyalella azteca* (Kreitinger, personal communication; USEPA 2003).

TABLE 8: PCB Congener Distributions in Management Unit Sediment and Tissue Samples (L. variegatus) for Ashtabula Harbor Southern Reach and Open Lake Reference Areas (% of total)

	Open-Lake Reference Area Sediment		Southern Reach Sediment		
Homologue Group	ALRA	ALRB	URCMU-1	URCMU-2	URCMU-3
Mono-Chlorinated Biphenyls (1)	0%	0%	0%	0%	0%
Di-Chlorinated Biphenyls (2)	1%	2%	2%	1%	2%
Tri-Chlorinated Biphenyls (3)	11%	13%	22%	22%	25%
Tetra-Chlorinated Biphenyls (4)	28%	32%	46%	53%	52%
Penta-Chlorinated Biphenyls (5)	26%	27%	15%	17%	16%
Hexa-Chlorinated Biphenyls (6)	20%	17%	5%	3%	3%
Hepta-Chlorinated Biphenyls (7)	9%	7%	3%	1%	1%
Octa-Chlorinated Biphenyls (8)	2%	2%	1%	0%	0%
Nona-Chlorinated Biphenyls (9)	0%	0%	1%	0%	0%
Deca-Chlorinated Biphenyls (10)	0%	0%	5%	1%	1%
Dioxin-Like (EPA 13)	11%	9%	3%	4%	3%

	Open-Lake Reference Area Tissue		Southern Reach Tissue		
Homologue Group	ALRA	ALRB	URCMU-1	URCMU-2	URCMU-3
Mono-Chlorinated Biphenyls (1)	0%	0%	0%	0%	0%
Di-Chlorinated Biphenyls (2)	1%	1%	0%	0%	1%
Tri-Chlorinated Biphenyls (3)	4%	4%	15%	17%	16%
Tetra-Chlorinated Biphenyls (4)	12%	14%	51%	54%	53%
Penta-Chlorinated Biphenyls (5)	25%	28%	21%	22%	23%
Hexa-Chlorinated Biphenyls (6)	32%	31%	6%	4%	5%
Hepta-Chlorinated Biphenyls (7)	18%	17%	3%	1%	1%
Octa-Chlorinated Biphenyls (8)	5%	4%	1%	0%	0%
Nona-Chlorinated Biphenyls (9)	1%	1%	1%	0%	0%
Deca-Chlorinated Biphenyls (10)	1%	1%	2%	1%	0%
Dioxin-Like (EPA 13)	6%	6%	3%	3%	3%

TABLE 9: Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediment Total PCB Concentrations (USACE, 2010a).

Southern Reach						Open-Lake Reference Area			
Site	PCBs (ng/g)	Site	PCBs (ng/g)	Site	PCBs (ng/g)	Site	PCBs (ng/g)	Site	PCBs (ng/g)
URC-1	26.89	URC-4 (10-12)	10,511.08	URC-7	2,545.24	ALRA-1	16.13	ALRB-1	209.35
URC-2	27.19	URC-4 (13-15)	10,796.22	URC-8	512.75	ALRA-2	68.54	ALRB-2	174.93
URC-3 (12-14)	2,155.96	URC-5	103.83	URC-9	3.32	ALRA-3	135.33	ALRB-3	120.73
URC-3 (14-16)	2,281.11	URC-6	1,805.67	URC-10	25.47	ALRA-4	51.18	ALRB-4	165.19
URCMU-1	360.84	URCMU-2	1,035.85	URCMU-3	878.14	ALRA-Comp	111.29	ALRB-Comp	143.29

TABLE 10: Total PCB Tissue Replicate Results (USACE, 2010a) and BSAF Calculations for Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediments

	Tissue Sample	C_T (ng/g)	Lipid (decimal %)	C_S (ng/g)	TOC (decimal %)	BSAF	Notes
Open-Lake Reference Area	ALRA A	21.60	0.013	111.3	0.017	0.25	Mean BSAF: 0.26
	ALRA B	20.68	0.011	111.3	0.017	0.29	
	ALRA C	19.46	0.011	111.3	0.017	0.27	
	ALRA D	19.07	0.011	111.3	0.017	0.26	
	ALRA E	18.89	0.012	111.3	0.017	0.24	
	ALRB A	28.94	0.0089	143.3	0.012	0.27	Mean BSAF: 0.22
	ALRB B	26.93	0.013	143.3	0.012	0.17	
	ALRB C	33.10	0.012	143.3	0.012	0.23	
	ALRB D	28.21	0.012	143.3	0.012	0.20	
	ALRB E	30.53	0.012	143.3	0.012	0.21	
Southern Reach	URCMU-1 A	619.84	0.0086	360.8	0.014	2.80	Mean BSAF: 2.42
	URCMU-1 B	727.02	0.014	360.8	0.014	2.02	
	URCMU-1 C	600.75	0.013	360.8	0.014	1.79	
	URCMU-1 D	567.17	0.012	360.8	0.014	1.83	
	URCMU-1 E	643.83	0.0068	360.8	0.014	3.67	
	URCMU-2 A	1,812.13	0.0091	1,035.9	0.014	2.69	Mean BSAF: 2.43
	URCMU-2 B	1,545.09	0.0075	1,035.9	0.014	2.78	
	URCMU-2 C	2,141.57	0.012	1,035.9	0.014	2.41	
	URCMU-2 D	1,689.20	0.011	1,035.9	0.014	2.08	
	URCMU-2 E	1,775.70	0.011	1,035.9	0.014	2.18	
	URCMU-3 A	900.69	0.0103	878.1	0.017	1.69	Mean BSAF: 1.70
	URCMU-3 B	837.74	0.0093	878.1	0.017	1.74	
	URCMU-3 C	968.47	0.009	878.1	0.017	2.08	
	URCMU-3 D	888.30	0.011	878.1	0.017	1.56	
	URCMU-3 E	887.24	0.012	878.1	0.017	1.43	

TABLE 11. Bulk sediment total PCB data, and associated total PCB theoretical bioaccumulation potential (TBP) predictions for Ashtabula Harbor Southern Reach and Open-Lake Reference and Placement Area Sediments (Note: yellow highlight - bulk concentration exceeds that of respective reference/disposal area environs;* red highlight - TBP exceeds that of respective reference/disposal area environs; blue highlight - reference/disposal value used) (based on data from Woodward-Clyde Consultants 1993).

Harbor Management Unit/Lake Area	Sampling site	Analyses year	Elevation below LWD (feet)	Total PCB Concentration (ug/kg)	TOC (decimal %)	Lipid (decimal %)	BSAF	TBP (ug/kg)	Comments
Southern Reach	192-01	1990	14	2,009	0.0286	0.01	2.18	[illegible]	
	192-01	1990	12	2,406	0.0286	0.01	2.18	[illegible]	
	192-01	1990	10	3,912	0.0286	0.01	2.18	[illegible]	
	192-01	1990	8	4,063	0.0286	0.01	2.18	[illegible]	
	193-02	1990	13	1,451	0.0286	0.01	2.18	[illegible]	
	193-02	1990	11	141	0.0286	0.01	2.18	107	
	193-02	1990	9	911	0.0286	0.01	2.18	[illegible]	
	194-01	1990	15	675	0.0286	0.01	2.18	[illegible]	
	194-01	1990	14	4,082	0.0286	0.01	2.18	[illegible]	
	194-01	1990	12	5,051	0.0286	0.01	2.18	[illegible]	
	194-01	1990	10	11,205	0.0286	0.01	2.18	[illegible]	
	194-01	1990	8	654	0.0286	0.01	2.18	[illegible]	
	195-01	1990	13	2,452	0.035	0.01	2.18	[illegible]	
	195-01	1990	11	3,008	0.0338	0.01	2.18	[illegible]	
	195-01	1990	9	189	0.0371	0.01	2.18	111	
	196-01	1990	13	1,754	0.0286	0.01	2.18	[illegible]	
	196-01	1990	12	2,876	0.0286	0.01	2.18	[illegible]	
	196-01	1990	10	3,785	0.0286	0.01	2.18	[illegible]	
	196-01	1990	8	1,687	0.0286	0.01	2.18	[illegible]	
	197-01	1990	13	972	0.0286	0.01	2.18	[illegible]	
	197-01	1990	11	1,242	0.0286	0.01	2.18	[illegible]	
	197-01	1990	9	3,910	0.0286	0.01	2.18	[illegible]	
	197-01	1990	7	1,078	0.0286	0.01	2.18	[illegible]	
	198-01	1990	19	138	0.0286	0.01	2.18	105	
	198-01	1990	15	1,438	0.0286	0.01	2.18	[illegible]	
	198-01	1990	13	1,703	0.0286	0.01	2.18	[illegible]	
	198-01	1990	11	377	0.0286	0.01	2.18	[illegible]	
	199-01	1990	9	5,007	0.0286	0.01	2.18	[illegible]	
	199-01	1990	8	254	0.0286	0.01	2.18	194	
	199-01	1990	6	88	0.0286	0.01	2.18	67	
	200-01	1990	16	659	0.0286	0.01	2.18	[illegible]	
	200-01	1990	15	239	0.0286	0.01	2.18	182	
	200-01	1990	13	1,298	0.0286	0.01	2.18	[illegible]	
	200-01	1990	11	733	0.0286	0.01	2.18	[illegible]	
	200-01	1990	9	383	0.0286	0.01	2.18	[illegible]	
	201-01	1990	13	376	0.0237	0.01	2.18	[illegible]	
	201-01	1990	11	1,165	0.0259	0.01	2.18	[illegible]	
	201-01	1990	9	1,057	0.0264	0.01	2.18	[illegible]	
	201-01	1990	7	87	0.0217	0.01	2.18	87	
	202-01	1990	11	209	0.0286	0.01	2.18	159	
	202-01	1990	9	142	0.0286	0.01	2.18	108	
	203-01	1990	12	902	0.0286	0.01	2.18	[illegible]	
	203-01	1990	10	158	0.0286	0.01	2.18	120	
	203-01	1990	8	82	0.0286	0.01	2.18	63	
	URC-1	2010	11	27	0.017	0.01	2.18	34	
	URC-2	2010	8	27	0.021	0.01	2.18	28	
	URC-3 (12-14)	2010	14	2,156	0.007	0.01	2.18	[illegible]	
	URC-3 (14-16)	2010	16	2,281	0.02	0.01	2.18	[illegible]	
	URC-4 (10-12)	2010	12	10,511	0.02	0.01	2.18	[illegible]	
	URC-4 (13-15)	2010	15	10,796	0.023	0.01	2.18	[illegible]	
	URC-5	2010	10	104	0.014	0.01	2.18	162	
	URC-6	2010	11	1,806	0.019	0.01	2.18	[illegible]	
	URC-7	2010	13	2,545	0.012	0.01	2.18	[illegible]	
	URC-8	2010	11	513	0.0097	0.01	2.18	[illegible]	
	URC-9	2010	4	3	0.0059	0.01	2.18	12	
	URC-10	2010	9	25	0.024	0.01	2.18	23	
Open-Lake Reference Area	AL-1-07b	2007b	SG	96.2	0.0069	0.01	1.48	206	
	AL-2-07b	2007b	SG	88.2	0.003	0.01	1.48	435	TBP invalid (TOC<0.5%)
	AL-3-07b	2007b	SG	62.2	0.0027	0.01	1.48	341	TBP invalid (TOC<0.5%)
	AL-4-07b	2007b	SG	104	0.003	0.01	1.48	513	TBP invalid (TOC<0.5%)
	AL-2-07a	2007a	SG	95.3	0.0217	0.01	1.48	65	
	ALR-1	2009	SG	20.86	0.0171	0.01	1.48	18	
	ALR-2	2009	SG	52.76	0.0126	0.01	1.48	62	
	ALR-3	2009	SG	143.86	0.0293	0.01	1.48	73	
	ALR-4	2009	SG	16.02	0.00894	0.01	1.48	27	
	ALRA-1	2010	SG	16.13	0.013	0.01	0.26	3	
	ALRA-2	2010	SG	68.54	0.016	0.01	0.26	11	
	ALRA-3	2010	SG	135.33	0.017	0.01	0.26	21	
	ALRA-4	2010	SG	51.18	0.009	0.01	0.26	15	
	ALRB-1	2010	SG	209.35	0.013	0.01	0.22	35	
	ALRB-2	2010	SG	174.93	0.011	0.01	0.22	35	
	ALRB-3	2010	SG	120.73	0.0091	0.01	0.22	29	
	ALRB-4	2010	SG	165.19	0.12	0.01	0.22	3	
Open-Lake Placement Area	AD-1-07b	2007b	SG	98.6	0.005	0.01	0.40	30	Marginal TOC level
	AD-2-07b	2007b	SG	109	0.0032	0.01	0.40	135	TBP invalid (TOC<0.5%)
	AD-2-07a	2007a	SG	274	0.0227	0.01	0.40	48	
	AD-1	2009	SG	105.36	0.0163	0.01	0.40	26	
	AD-2	2009	SG	213.59	0.0122	0.01	0.40	69	

TABLE 12: Bulk Pesticides Analyses on Ashtabula Harbor Southern Reach and Open-Lake Reference Area Sediments (USACE, 2010a).

Pesticide - ug/kg	Southern Reach URCMU-1					Southern Reach URCMU-2					Southern Reach URCMU-3				
	URC-1	URC-2	URC-3 (12-14)	URC-3 (14-16)	URCMU-1	URC-4 (10-12)	URC-4 (13-15)	URC-5	URC-6	URCMU-2	URC-7	URC-8	URC-9	URC-10	URCMU-3
4,4-DDD	2.1 U	2.5 U	2.2 U	2.6 U	2.7 U	2.8 U	2.9 U	3.4 U	2.5 U	2.8 U	2.5 U	2.3 U	2.1 U	3.9 U	2.9 U
4,4-DDE	1.0 U	1.2 U	3.2 J	0.77 J	1.3 U	2.7 J	3 J	1.7 U	1.7 J	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
4,4-DDT	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Aldrin	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
alpha-BHC	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
alpha-Chlordane	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Beta-BHC	1.0 U	1.2 U	82 J	100 J	18 J	15 J	220 J	1.7 U	16 J	0.53 J	11 J	1.1 U	4.0 J	1.9 U	4.9 J
Chlordane, total	20.0 U	25 U	21 U	26 U	26 U	27 U	29 U	33 U	24 U	27 U	25 U	23 U	20.0 U	38 U	29 U
delta-BHC	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Dieldrin	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endosulfan I	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endosulfan II	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endosulfan sulfate	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endrin	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endrin aldehyde	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Endrin ketone	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
gamma-BHC (Lindane)	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
gamma-Chlordane	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Heptachlor	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Heptachlor epoxide	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Methoxychlor	1.0 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.4 U	1.7 U	1.2 U	1.3 U	1.2 U	1.1 U	1.0 U	1.9 U	1.4 U
Toxaphene	20.0 U	25 U	21 U	26 U	26 U	27 U	29 U	33 U	24 U	27 U	25 U	23 U	20 U	38 U	29 U

U - Not detected at or above the specified LRL

J - Estimated concentration

Pesticide - ug/kg	Open-Lake Reference Area A (ALRA)					Open-Lake Reference Area B (ALRB)				
	ALRA-1	ALRA-2	ALRA-3	ALRA-4	ALRA-Comp	ALRB-1	ALRB-2	ALRB-3	ALRB-4	ALRB-Comp
4,4-DDD	3.8 U	5.1 U	5.1 U	3.1 U	4.6 U	3.2 U	2.9 U	2.9 U	3.2 U	2.9 U
4,4-DDE	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 J	1.4 U
4,4-DDT	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Aldrin	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
alpha-BHC	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
alpha-Chlordane	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Beta-BHC	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Chlordane, total	37 U	50 U	50 U	31 U	45 U	32 U	29 U	29 U	31 U	29 U
delta-BHC	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Dieldrin	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endosulfan I	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endosulfan II	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endosulfan sulfate	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endrin	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endrin aldehyde	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Endrin ketone	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
gamma-BHC (Lindane)	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
gamma-Chlordane	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Heptachlor	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Heptachlor epoxide	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Methoxychlor	1.9 U	2.5 U	2.5 U	1.5 U	2.3 U	1.6 U	1.4 U	1.4 U	1.5 U	1.4 U
Toxaphene	37 U	50 U	50 U	31 U	45 U	32 U	29 U	29 U	31 U	29 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 13: Metals Analyses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

Analyte (mg/L)	ALR-Site Water		Southern Reach					
			URCMU-1		URCMU-2		URCMU-3	
	Result	Flag	Result	Flag	Result	Flag	Result	Flag
Aluminum	0.03		0.11		0.05		0.14	
Arsenic	0.0016		0.0093		0.007		0.013	
Barium	0.038		0.34		0.18		0.39	
Beryllium	0.0004	U	0.0004	U	0.0004	U	0.0004	U
Cadmium	0.0004	U	0.00017	J	0.0004	U	0.00014	J
Calcium	34		31		33		27	
Chromium	0.0003	J	0.0015		0.00071	J	0.0016	
Cobalt	0.002	U	0.00078	J	0.00081	J	0.0011	J
Copper	0.00096	J	0.0014	J	0.0029		0.0013	J
Iron	0.24		1.9		0.58		1.1	
Lead	0.00019	J	0.001		0.00027	J	0.0023	
Magnesium	8.5		6.9		7.3		6.4	
Manganese	0.049		0.86		0.6		0.37	
Nickel	0.0019	J	0.0036	J	0.005		0.0037	J
Potassium	1.8	J	3.4		3.4		4.4	
Selenium	0.002	U	0.002	U	0.002	U	0.00043	J
Sodium	10		16		14		17	
Thallium	0.0008	U	0.0008	U	0.000034	J	0.0008	U
Vanadium	0.00057	J	0.0031		0.0018		0.0032	
Zinc	0.015	J	0.088		0.048		0.11	
Antimony	0.001	U	0.0002	J	0.0002	J	0.0004	J
Silver	0.0006	U	0.0003	U	0.0006	U	0.0003	U
Mercury	0.0002	U	0.0002	U	0.0002	U	0.0002	U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 14: Inorganic Chemistry Analyses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

			Southern Reach					
Analyte (mg/L)	ALR-Site Water		URCMU-1		URCMU-2		URCMU-3	
	Result	Flag	Result	Flag	Result	Flag	Result	Flag
Total Kjeldahl Nitrogen	0.51		6.5		7.3		10.4	
Ammonia Nitrogen	0.1		6.2		6.9		10.1	
Phosphorus	0.018		0.017		0.14		0.022	
Oil and Grease	5	U	5	U	5	U	5	U
Total Cyanide	0.01	U	0.01	U	0.01	U	0.01	U

U - Not detected at or above the specified LRL

TABLE 15: PAH Analyses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

PAH (ug/L)	ALR-Site Water		Southern Reach					
			URCMU-1		URCMU-2		URCMU-3	
	Result	Flag	Result	Flag	Result	Flag	Result	Flag
2-Methylnaphthalene	**0.35**		**0.49**		**0.54**		**0.90**	
Acenaphthene	0.20	U	0.21	U	0.27	U	0.23	U
Acenaphthylene	0.20	U	0.21	U	0.27	U	**0.72**	
Anthracene	0.20	U	0.21	U	0.27	U	0.23	U
Benzo(a)anthracene	0.20	U	**0.029**	J	0.27	U	0.23	U
Benzo(a) pyrene	0.20	U	0.21	U	0.27	U	0.23	U
Benzo(b) fluoranthene	0.20	U	0.21	U	0.27	U	0.23	U
Benzo(g,h,i) perylene	0.20	U	0.21	U	0.27	U	0.23	U
Benzo(k) fluoranthene	0.20	U	0.21	U	0.27	U	0.23	U
Chrysene	0.20	U	0.21	U	0.27	U	0.23	U
Dibenzo(a,h) anthracene	0.20	U	0.21	U	0.27	U	0.23	U
Fluoranthene	0.20	U	**0.21**		0.27	U	**0.23**	J
Fluorene	0.20	U	**0.052**	J	0.27	U	**0.16**	J
Indeno(1,2,3-cd) pyrene	0.20	U	0.21	U	0.27	U	0.23	U
Naphthalene	**0.23**		**0.21**		0.27	U	0.23	U
Phenanthrene	0.20	U	**0.18**	J	**0.081**	J	**0.20**	J
Pyrene	0.20	U	**0.31**	U	**0.072**	J	**0.30**	

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 16: PCB Aroclor Anaylses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

Aroclor (ug/L)	ALR-Site Water		Southern Reach					
			URCMU-1		URCMU-2		URCMU-3	
	Result	Flag	Result	Flag	Result	Flag	Result	Flag
Aroclor 1016	0.1	U	0.1	U	0.1	U	0.1	U
Aroclor 1221	0.1	U	0.1	U	0.1	U	0.1	U
Aroclor 1232	0.2	U	0.2	U	0.2	U	0.2	U
Aroclor 1242	0.2	U	0.2	U	0.2	U	0.2	U
Aroclor 1248	0.1	U	0.1	U	0.1	U	0.1	U
Aroclor 1254	0.2	U	0.2	U	0.2	U	0.2	U
Aroclor 1260	0.2	U	0.2	U	0.2	U	0.2	U
Aroclor 1262	0.2	U	0.2	U	0.2	U	0.2	U

U - Not detected at or above the specified LRL

TABLE 17: PCB Congener Anaylses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

Site	PCBs (ng/L)
ALR-Site Water	0.21
URCMU-1	62.2
URCMU-2	126.6
URCMU-3	91.4

TABLE 18: Elutriate Congener Distributions (% of total) for Ashtabula Harbor Southern Reach and Open-Lake Reference Areas

		Southern Reach		
Homologue Group	ALR (Lake Water)	URCMU-1	URCMU-2	URCMU-3
Mono-Chlorinated Biphenyls (1)	0%	0%	0%	0%
Di-Chlorinated Biphenyls (2)	14%	1%	1%	2%
Tri-Chlorinated Biphenyls (3)	15%	33%	27%	31%
Tetra-Chlorinated Biphenyls (4)	27%	46%	49%	48%
Penta-Chlorinated Biphenyls (5)	24%	11%	16%	13%
Hexa-Chlorinated Biphenyls (6)	14%	3%	3%	2%
Hepta-Chlorinated Biphenyls (7)	4%	1%	1%	1%
Octa-Chlorinated Biphenyls (8)	0%	1%	0%	0%
Nona-Chlorinated Biphenyls (9)	0%	1%	0%	0%
Deca-Chlorinated Biphenyls (10)	0%	3%	1%	1%
Dioxin-Like (EPA 13)	9%	7%	10%	8%

TABLE 19: Pesticides Analyses on Southern Reach Management Unit Elutriate Samples and Open-Lake Reference Area (ALR) Site Water (USACE, 2010a).

Pesticide (ug/L)	ALR-Site Water		URCMU-1		URCMU-2		URCMU-3	
	Result	Flag	Result	Flag	Result	Flag	Result	Flag
4,4-DDD	0.01	U	0.011	U	0.011	U	0.011	U
4,4-DDE	0.01	U	0.011	U	0.011	U	0.011	U
4,4-DDT	0.01	U	0.011	U	0.011	U	0.011	U
Aldrin	0.01	U	0.011	U	0.011	U	0.011	U
alpha-BHC	0.01	U	0.011	U	0.011	U	0.011	U
alpha-Chlordane	0.01	U	0.011	U	0.011	U	0.011	U
Beta-BHC	0.01	U	0.011	U	0.011	U	0.011	U
Chlordane, total	0.2	U	0.22	U	0.22	U	0.22	U
delta-BHC	0.01	U	0.011	U	0.011	U	0.011	U
Dieldrin	0.01	U	0.011	U	0.011	U	0.011	U
Endosulfan I	0.01	U	0.011	U	0.011	U	0.011	U
Endosulfan II	0.01	U	0.011	U	0.011	U	0.011	U
Endosulfan sulfate	0.01	U	0.011	U	0.011	U	0.011	U
Endrin	0.01	U	0.011	U	0.011	U	0.011	U
Endrin aldehyde	0.01	U	0.011	U	0.011	U	0.011	U
Endrin ketone	0.01	U	0.011	U	0.011	U	0.011	U
gamma-BHC (Lindane)	0.01	U	0.011	U	0.011	U	0.011	U
gamma-Chlordane	0.01	U	0.011	U	0.011	U	0.011	U
Heptachlor	0.01	U	0.011	U	0.011	U	0.011	U
Heptachlor epoxide	0.01	U	0.011	U	0.011	U	0.011	U
Methoxychlor	0.01	U	0.011	U	0.011	U	0.011	U
Toxaphene	0.2	U	0.22	U	0.22	U	0.22	U

U - Not detected at or above the specified LRL

Addendum to Evaluation of Ashtabula Harbor River Channel (Southern Reach) Sediments

1.0 Introduction

Ashtabula Harbor sediments in the River Channel Southern Reach were sampled, analyzed and evaluated in 2011 (U.S. Army Corps of Engineers [USACE] 2011). This investigation included particle size, bulk sediment chemistry, standard elutriate testing (SET), solid phase bioassays and 28-day polychlorinated biphenyl (PCB) bioaccumulation tests employing the aquatic oligochaete *Lumbriculus variegatus*. It concluded that harbor sediments in the River Channel between stations 198+00 and 210+00 are not suitable for open-lake placement, due primarily to the bioaccumulation risk of PCBs in the aquatic environment. Upstream sediments in this channel between stations 210+00 and 213+36 (upstream limit of Federal navigation channel) warranted further investigation with regard to determining suitability for open-lake placement. This addendum serves to address this further evaluation.

River Channel Southern Reach sediments between stations 210+00 and 213+36 were sampled in the Fall of 2011. Figure 1 shows the location of this reach within the Ashtabula River. The objective of the investigation was to characterize sediments with regard to meeting Federal guidelines for open-lake placement based on protocols and guidance contained in the 1998 U.S. Environmental Protection Agency (USEPA)/USACE Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998).

2.0 Background

The 2011 evaluation (USACE 2011) showed widespread PCB contamination within the Southern Reach of River Channel, with limited pesticide, polycyclic aromatic hydrocarbon (PAH) and metals contamination. These sediments were determined to be unsuitable for open-lake placement due to the benthic bioaccumulation of PCBs. However, contamination was not uniform in the reach; contamination was highest between stations 200+00 and 205+00 and generally decreased moving upstream toward the Federal navigation channel limit. Additionally, moving upstream, sediments become coarser grained with the presence of more gravel and cobbles. Given the limited information available on sediments in this upstream extent of the channel, it was concluded that further sediment characterization was required to determine whether material dredged from this reach meets Federal guidelines for open-lake placement.

3.0 Scope of Evaluation

This evaluation is based on the following sediment sampling/testing:

Three locations, ASR-11, ASR-12 and ASR-13, were sampled by core from the surface to project depth (Figure 1). Samples collected from these locations were composited in Management Unit ASRMU-3 between stations 210+00 and 213+36. Sample information is shown in Table 1. While project depth was -17 ft LWD[1], refusal was typically met at -15 ft LWD with the encounter of shale fragments. Poor recovery was encountered (range of 25 to 30% of the penetration depth, 3-4 ft of material), most likely due to compression and plugging of the core by gravel and cobbles. Cobble and gravel layers interspersed within the sediment column may have caused temporary blockages, leading to lower recoveries. Given the poor recovery, discrete sample intervals could not be determined. Vertically discrete layers of physically similar sediments were sampled, representing different sections of the core (upper, middle and lower). Discrete samples were analyzed for bulk chemistry, including the following: metals (23 per TAL including mercury), cyanide (CN), total Kjeldahl nitrogen (TKN), NH_3, total phosphorus (P), PAHs (16 priority pollutants), total organic carbon (TOC), pesticides, oil & grease (O&G) and PCBs (Aroclors), as well as physical analyses (grain size and hydrometer). This suite of tests were also applied to bottom sediment collected from open-lake reference area (ALRB) and open-lake placement areas in Lake Erie (AD) shown in Figure 2. A total of seven discrete surface samples were collected from these two areas. Open-lake area data were used for comparison with the channel data. In addition to the bulk chemistry analyses specified above, analyses of the composite ASRMU-3 sample also included:

- Modified Elutriate Testing (MET) supernatant (total and dissolved): metals (23 per TAL including mercury), CN, TKN, NH_3, total P, PAHs (16 priority pollutants), TOC, pesticides, O&G and PCBs (Aroclors)
- Water column bioassays, including (1) standard 48-hour *Ceriodaphnia dubia* elutriate acute toxicity test, and (2) standard 96-day *Pimephales promelas* elutriate acute toxicity test. Both tests utilized survival as the biological measurement endpoint.

Solid phase bioassays were not applied to these sediments as previous tests on sediments within the reach evidenced no significant acute toxicity (USACE 2011). These included tests on overall more contaminated sediments.

4.0 Sediment Testing Results and Evaluation

Physical Testing

[1] 569.2 feet above mean water level at Rimouski, Quebec, International Great Lakes Datum 1985 (IGLD85)

Table 2 presents the sediment particle size distribution. The River Channel sediments are mainly classified as sand (discrete range of 41.1 to 95.4%; ASRMU-3 composite, 60.7%). These results are generally representative of field conditions; however they do not reflect the substantial amount of cobble and leaf matter that is also present in the sediment and will be encountered as dredged material. The dredged material can be expected to contain a substantial amount of cobble, along with gravel, sand and fine grained sediment.

The open-lake area sediments were mainly silt (27.5 to 75.1%), with sand (11.5 to 70.7%) and clay (1.8 to 21.5%).

Analysis of Sediment Contaminants

Bulk contaminant concentrations in the River Channel sediments were compared to those at the open-lake areas in an effort to identify potential contaminants of concern (COCs).

Metals

The results of bulk metals analyses on the sediments are presented in Table 3. Metal concentrations in the River Channel sediments are generally comparable to those of the open-lake area sediments, and are not of significant toxicological concern.

TOC and Other Inorganic Parameters (CN, TKN, NH_3, total P, TOC and O&G)

Bulk inorganic analyses of the sediments are presented in Table 4. TOC in River Channel sediments range from 0.3 to 6.7%, with the composite sample at 1.1%; however, much of the channel reach is primarily sand with TOC levels below 0.5%. At the two open-lake areas, TOC content ranges from 1.0 (ALRB-3) to 2.7% (AD-1).

Nitrogen (total and ammonia), total P and O&G concentrations are generally similar among the channel and open-lake area sediments. Cyanide was mainly not detected in the sediments, except for in core ASR-11 (Middle) which showed a total concentration of 6 mg/kg. Cyanides are present as free cyanides (the most toxic form) or complexes (relatively nontoxic). Free cyanides are not persistent in the environment; they are volatile, soluble and have a low affinity for sediment adsorption. Therefore, cyanide was not identified as a COC.

PAHs

Table 5 presents bulk PAH analyses of the sediments. The 16 USEPA priority pollutant PAHs and 2-Methylnaphthalene were summed to determine total PAHs. PAH ratios were computed to evaluate whether the PAH profiles showed pyrogenic or petrogenic tendencies. A PAH profile showing a Phenanthrene/Anthracene (PH/AN) ratio less than 10 and a Fluoranthene/Pyrene (FL/PY) ratio of about one are indicative of pyrogenic sources (Brown et al. 2006). A predominantly petrogenic profile would show a PH/AN ratio greater than 15 and a FL/PY ratio significantly less than one (Brown et al., 2006). Neff et al. (2005) states that the FL/PY ratio can approach or exceed a value of one in pyrogenic assemblages.

Total PAH concentrations in the lake sediment samples ranged from 2,845 ug/kg to 4,102 ug/kg. PAH ratios indicate predominantly pyrogenic sources. The channel sediments showed total PAH levels ranging from 1,658 ug/kg to 8,869 ug/kg. PAH ratios indicate predominantly pyrogenic sources.

Sediments typically contain a mixture of both petrogenic (petroleum-related) and pyrogenic (combustion-related) sources. In comparison to petrogenic PAHs, pyrogenic PAH compounds are usually less persistent, mobile and bioavailable in the environment, often resulting in lower toxicities (Gustaffsson *et al.* 1997). The dominant species in PAH mixtures from pyrogenic sources are the parent compounds, while alkyl species dominate petrogenic PAH assemblages. Thus, a pyrogenic assemblage of PAHs characterized by the 16 parent PAHs would be expected to have much less uncertainty associated with the true total PAH concentration in comparison to a petrogenic assemblage. The 16 parent PAH compounds (i.e., USEPA priority pollutants) have been reported as representing about one to two thirds of the actual total PAH concentration in pyrogenic assemblages (Hawthorne et al. 2006). PAH mixtures that arise from pyrogenic sources indicate the presence of black carbon forms that have exhibited an unusually strong partitioning behavior. Such PAHs strongly adsorb to this black carbon, limiting their concentration in interstitial water, and thus reducing mobility, bioavailability and toxicity (on a bulk sediment concentration basis) (e.g., Pastorok *et al.* 1994).

The risk to benthic macroinvertebrates associated with complex mixtures of PAHs can be estimated using hydrocarbon narcosis and equilibrium partitioning (EqP) models (USEPA 2003). This approach assumes that the risk of PAH mixtures to benthic organisms is attributable to the number of PAH toxic units that are freely dissolved in sediment pore water, and is used to calculate EqP Sediment Benchmark Toxic Units, Final Chronic Value ($\sum ESBTU_{FCV}$) (USEPA 2003). TOC is an important partitioning parameter as it acts to sequester PAHs in the sediment phase, thus lowering the amount of PAHs available in the water phase. $ESBTU_{FCV}$s were calculated as follows:

Equation 1

$$ESBTU_{FCV} = \frac{C/f_{OC}}{C_{OC,\,PAHi,\,FCVi}}$$

Where:
$C_{OC,\ PAHi,\ FCVi}$ = Final chronic value (FCV) concentration in sediment (µg/g_{OC}) (see USEPA 2003)
C = Concentration of PAH compound in sediment (µg/g dry weight)
f_{OC} = Decimal fraction of TOC in sediment (TOC) (µg/g_{OC} dry weight)

Freshwater sediments containing $\sum ESBTU_{FAV} < 1.0$ for a mixture of 34 or more PAH compounds are predicted to be acceptable for the protection of benthic organisms. Conversely, $\sum ESBTU_{FAV} \geq 1.0$ suggest that sensitive benthic organisms may be affected by the PAH mixture. USACE guidelines (USEPA/USACE 1998) emphasize acute toxicity tests for dredged material evaluations. This model employed $C_{OC,\ PAHi,\ FAVi}$ specific to *Hyalella azteca*, which is one of two recommended test species used for standard acute toxicity tests in dredged material toxicity evaluations (USEPA/USACE 1998), and is anticipated to be more sensitive to PAHs than most other freshwater organisms (including the midge *Chironomus dilutus*). The $C_{OC\ PAHi,FAVi}$ values for *H. azteca* are based on an acute toxicity critical body burden of 13.9 µmol/g lipid, which is the geometric mean of the acute value for fluoranthene within the genus (GMAV) based on data originally published by Spehar *et al.* (1999) (see Appendix C of USEPA 2003). Use of this single critical body burden in the model is assumed to be valid because hydrophobicity-normalized toxicity is considered to be equivalent among Type I narcotic chemicals. The 13.9 µmol/g octanol GMAV for *H. azteca* has been confirmed in the literature. Hawthorn *et al.* (2007) predicted a critical body burden of 15 µmol/g lipid (lower 95% confidence interval) for 85% or greater survival when 97 field collected sediments were evaluated in 28-day laboratory tests and the dissolved PAH concentration in sediment porewater was determined by ASTM D7363 (Hawthorne *et al.* 2007). In addition, the lethal residue (LR_{50}) value of 33.0 µmol/g lipid determined by Hawthorne *et al.* (2007) using these 97 field samples was in very good agreement with the LR_{50} value of 32 µmol/g lipid determined in water only laboratory exposures using radio-labeled fluoranthene (Schuler *et al.* 2006).

The calculation of $C_{OC\ PAHi,FAVi}$ for individual PAH compounds was based on the following equation:

Equation 2

$$C_{OC\ PAHi,FAVi} = K_{oc} * MW * [10^{-0.945*\log(Kow)+\log(GMAV)}]$$

Where:
K_{OC} = Organic carbon-water partition coefficient for PAH compound
K_{OW} = Octanol-water partition coefficient for PAH compound
MW = Molecular weight of PAH compound, g/mol

GMAV = Geometric mean of acute toxicity (critical body burden) values for fluoranthene within the genus, 13.9 μmol/g lipid

Since sediments were only analyzed primarily for 16 parent PAH compounds, an uncertainty factor had to be applied to account for the unmeasured mostly alkyl PAHs. USEPA recommends the use of an uncertainty factor of 11.5 at 95% confidence for 13 parent PAHs (USEPA 2003). Hawthorne et al. (2006) concludes that this uncertainty can be substantially reduced when sediments are contaminated with primarily pyrogenic PAHs, and calculated a toxic unit uncertainty factor of 4.0 for the 16 parent PAHs at a confidence limit of 99% for sediments primarily impacted by pyrogenic sources.

Table 6 presents the final toxic units for samples ASR-11(Lower) and ASR-12 (Upper) which were slightly elevated compared to open-lake area sediments. Sample ASR-11 (Lower) had $\sum ESBTU_{FAV,34}<1.0$, suggesting the sediments are not acutely toxic to *H. azteca* with respect to PAH contamination. Although the ASR-12 (Upper) fine to medium sands sample with a $\sum ESBTU_{FAV,34}$ of 1.86 suggests the potential for unacceptable PAH-associated acute toxicity, this result is not believed to be predictive or representative of actual conditions, as EqP-based ESB for nonionic organic chemicals are not intended for use with largely sandy sediments with low TOC. The sediment PAH mixture show pyrogenic tendencies, thus PAHs are believed to be strongly associated with the particulate phase and largely not bioavailable. Further, previous biological effects testing did not show reduced growth or survival associated with a total PAH concentration of 6,310 ug/kg for these sediments (USACE 2011). Based on this information, PAHs were not identified as a COC in these samples.

PCBs

Table 7 presents the results of PCB analysis on the sediments. Aroclors were mainly not detectable at laboratory reporting limits (LRLs) ranging from 37 to 130 ug/kg. Aroclor 1248 was measured at 87 ug/kg in sample ASR-1 (Lower). These results are consistent with past data on this section of the channel, which indicate low levels of PCBs at the upstream limit of the Federal navigation channel comparable to open-lake area sediments.

To evaluate bioaccumulation of PCBs from sample ASR-1 (Lower), the theoretical (or thermodynamically-defined) bioaccumulation potential (TBP) model was employed. TBP is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, in sediments into benthic organisms (McFarland and Clarke 1986). This model is expressed as:

Equation 3

$$TBP = BSAF\ (L)\ (C_s/TOC)$$

Where:

TBP = Predicted whole body tissue concentration of the neutral organic compound (µg/kg wet weight)
BSAF = Biota-sediment accumulation factor
L = Concentration of lipid in target animals (percent of wet weight)
C_s = Concentration of neutral organic compound in sediment (µg/kg dry weight)
TOC = Total organic carbon concentration in sediment (percent of dry weight)

TBP is a screening tool that tends to err on the conservative side. The target animal used in this case is an oligochaete worm. In this model, 1% lipid content, an average characteristically representative of oligochaete worms (e.g., Ankley *et al.* 1992, Pickard *et al.* 2001) was used. Previous 28-day bioaccumulation tests have established a total PCB BSAF of 1.7 for these sediments (USACE 2011). With a measured TOC of 1.7%, the TBP result is 87 ug/kg. This is less than a previously established maximum TBP for the open-lake sediments of 206 ug/kg (USACE 2011). Therefore, PCBs were not identified as a COC in this sample.

Pesticides

Table 8 presents the results of bulk pesticides analyses on the sediments. Most pesticides in the channel and open-lake area sediments were non-detectable. 4,4-DDE was detected at similar levels in the open-lake area and channel sediments, with a maximum of 2 ug/kg at ASR-11 (Lower). These concentrations are not of toxicological concern.

Elutriate Testing

Tables 9 through 13 present the results of the MET performed on the ASRMU-3 sediments. Elutriate data are presented as dissolved concentrations. Open-water discharge of the dredged material would consist of a series of discrete, almost instantaneous discharges, resulting in short-term, intermittent and unsteady impacts on the water column. The release of contaminants are determined through elutriate testing, the results of which are compared to acute water quality criteria for the protection of aquatic life to evaluate compliance with water quality standards.

Inorganics (CN, TKN, NH_3, total P, TOC and O&G)

The inorganic chemistry elutriate results are presented in Table 9. Low releases were noted for TKN and ammonia, none of which indicate a violation of water quality standards.

Metals

The metal elutriate results are shown in Table 10. Metals in the elutriate are comparable to site water.

PAHs

The PAH elutriate results are shown in Table 11. Releases of PAHs were non-detectable at LRLs ranging from 1.1 to 5.7 ug/L.

PCBs

The PCB elutriate results are shown in Table 12. No releases of Aroclors were detected at LRLs ranging from 0.1 to 0.2 ug/L.

Pesticides

The pesticide elutriate results are shown in Table 13. No releases of pesticides were detected at LRLs ranging from 0.012 to 0.25 ug/L.

Water Column Bioassays

Both elutriate toxicity tests performed on the ASRMU-3 sediment sample determined lethal responses to elutriate and involved exposures to five elutriate treatments (100%, 50%, 25%, 12.5% and 6.25%) and a performance control. Water column bioassays compliment the elutriate data by considering contaminant interactive effects (synergistic and antagonistic) as well as the effects of unmeasured contaminants or those without promulgated standards for comparison or screening purposes. The results of these bioassays on the ASRMU-3 sediment elutriate are summarized in Table 14 and described as follows:

C. dubia—Survival of this test species across all dilutions was 100%.

P. promelas—Survival of this test species was generally equivalent to the laboratory control (92.0%) with survival ranging from 84% (100% treatment) to 96% (12.5% treatment).

Conclusions

Sediments in the Southern Reach of River Channel between stations 210+00 and 213+36 in Ashtabula Harbor have been determined to meet Federal guidelines for open-lake placement. Bulk sediment contaminant concentrations, toxicity and bioaccumulation modeling, and bioassays have not indicated unacceptable water column and benthic impacts associated with open-water placement of the dredged material. The primary sediment COC in downstream areas of the harbor is total PCBs due to increased bioaccumulation relative to open-lake area sediments. This increased risk with respect to PCB contamination has not been identified in sediments near upstream limit of the Federal navigation channel. Elutriate data indicate that contaminant releases to the water column during placement of the dredged material in the lake would not violate water quality standards.

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Figure 1
Ashtabula Harbor
Southern Reach
Sample Locations
Aerial Photo
0
175
350
Feet
2011 Sample Locations
Federal Navigation Channel
Management Units
ASRMU-1
ASRMU-2
ASRMU-3
US Army Corps of Engineers
Buffalo District
ASR-1
ASR-2
ASR-3
ASR-4
ASR-5
ASR-6
ASR-7
ASR-8
ASR-9
ASR-10
ASR-11
ASR-12
ASR-13
ASRMU-1
ASRMU-2
ASRMU-3
200+00
205+00
210+00
213+00
213+38
Great Lakes Ave
E 19th St
E 21st St
E 22nd St
E 23rd St
Laurel Ct
Glannel Ave
Hawthorne Ave
Marine Ave
Pearl Rd

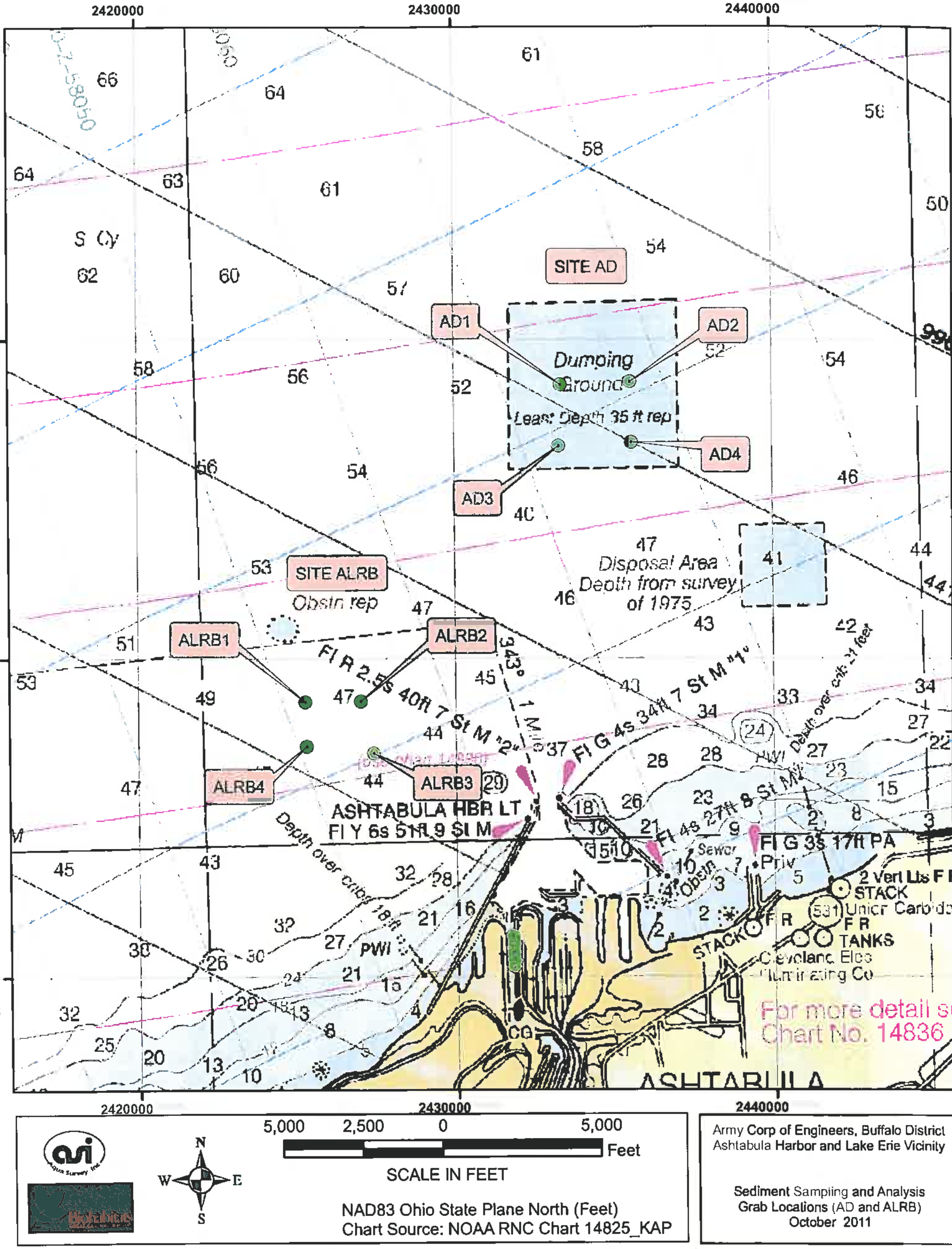
2420000
2430000
2440000
840000
830000
820000
SITE AD
AD1
AD2
AD3
AD4
Dumping Ground
Least Depth 35 ft rep
Disposal Area
Depth from survey of 1975
SITE ALRB
ALRB1
ALRB2
ALRB3
ALRB4
Obstn rep
Fl R 2.5s 40ft 7 St M "2"
Fl G 4s 34ft 7 St M "1"
343° 1 Mile
ASHTABULA HBR LT
Fl Y 6s 51ft 9 St M
Fl 4s 27ft 8 St M
Fl G 3s 17ft PA
Depth over crib 18 ft
Depth over crib 21 feet
PWI
2 Vert Lts F R
STACK
Union Carbide
F R
TANKS
Cleveland Elec Illuminating Co
CG
For more detail see Chart No. 14836
ASHTABULA
5,000
2,500
0
5,000
Feet
SCALE IN FEET
NAD83 Ohio State Plane North (Feet)
Chart Source: NOAA RNC Chart 14825_KAP
N
S
E
W
Army Corp of Engineers, Buffalo District
Ashtabula Harbor and Lake Erie Vicinity
Sediment Sampling and Analysis
Grab Locations (AD and ALRB)
October 2011

Figure 2

TABLE 1: ASRMU-3 2011 Sample Information (Biohabitats 2012).

Management Unit/Lake Area	Date/Time	Sample ID	Latitude	Longitude	Type	Surface Elevation (-LWD)	Study Elevation (-LWD)	Penetration Elevation (-LWD)	Core Recovery (ft)
ASRMU-3	10/7/11 - 1220	ASR-11	41.88633701	-80.79785951	Core	1.2	17	11	2.6
	10/7/11 - 1120	ASR-12	41.88611078	-80.79788067	Core	1.5	17	12	3.7
	10/7/11 - 1030	ASR-13	41.88577342	-80.79779512	Core	2.6	17	12	3
ALRB	10/6/11 - 1110	ALRB1	41.92891697	-80.82149106	Grab	48.33			
	10/6/11 - 1120	ALRB2	41.92887472	-80.81507786	Grab	47.53			
	10/6/11 - 1130	ALRB3	41.92438703	-80.81373406	Grab	44.23			
	10/6/11 - 1140	ALRB4	41.92509761	-80.82147058	Grab	46.33			
AD	10/6/11 - 925	AD1	41.95578889	-80.79090639	Grab	51.63			
	10/6/11 - 1030	AD3	41.95052472	-80.79126139	Grab	50.63			
	10/6/11 - 1015	AD4	41.95070319	-80.78292875	Grab	51.63			

TABLE 2: Particle Size Distribution of Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

Particle Size Distribution (%)	ASR-11			ASR-12			ASR-13		ASRMU-3
	Upper (Sands and Gravel)	Middle (Silty Clay W/ Fine Sands)	Lower (Silty Clay)	Upper (Fine to Medium Sands)	Middle (Sands and Gravel)	Lower (Silty Clay)	Upper (Sands and Gravel)	Lower (Silty Clay W/ Sands)	
Silt	23.2	7.5	50.6	8.3	7.6	16.1	4.6	18.5	31
Clay	3	4	8.3	1.8	0.1	7.8	0	8.4	8.3
Gravel	0	0	0	0	0	0	0	0	0
Coarse Sand	19.2	17.3	8.2	20.3	18.2	16.1	19.3	17.3	0
Medium Sand	36.4	52.2	20.4	45	61.3	31.7	64.1	42.1	45.1
Fine Sand	18.2	19	12.5	24.6	12.8	28.3	12	13.7	15.6
Total Sand	73.8	88.5	41.1	89.9	92.3	76.1	95.4	73.1	60.7

Particle Size Distribution (%)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area (AD)		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
Silt	68.5	75.1	55.5	67	63.6	27.5	43.5
Clay	10.8	6	2.5	21.5	19.2	1.8	8.2
Gravel	0	0	0	0	0	0	0
Coarse Sand	1	0	0	0	0	41.2	6.7
Medium Sand	1.4	1.2	2.2	2.5	0	11.3	2.3
Fine Sand	18.3	17.7	39.8	9	17.2	18.2	39.3
Total Sand	**20.7**	**18.9**	**42**	**11.5**	17.2	70.7	48.3

TABLE 3: Bulk Metals Analyses on Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

Metal - (mg/kg)	ASR-11			ASR-12			ASR-13		ASRMU-3
	Upper (Sands and Gravel)	Middle (Silty Clay W/ Fine Sands)	Lower (Silty Clay)	Upper (Fine to Medium Sands)	Middle (Sands and Gravel)	Lower (Silty Clay)	Upper (Sands and Gravel)	Lower (Silty Clay W/ Sands)	
Aluminum	8100	7500	11000	6900	6800	8600	7100	7300	6400
Antimony	0.26J	0.26	0.47	0.25	0.16J	0.31	0.31	0.19J	0.18J
Arsenic	8.4	7.3	11	8.8	6.7	11	9.5	6.3	7.2
Barium	38	29	82	35	31	65	28	28	39
Beryllium	0.39	0.39	0.66	0.39	0.42	0.6	0.37J	0.36	0.42
Cadmium	0.33	0.53	1.5	0.38	0.6	0.95	0.51	0.48	0.72
Calcium	1500	1600	4100	1400	1300	2400	2400	1200	2000
Chromium	15	14	29	15	14	30	15	16	17
Cobalt	9.3	9.9	14	8.1	8.5	13	9.6	8	8.7
Copper	24	19	32	24	21	26	26	18	20
Iron	28000	24000	30000	26000	23000	25000	24000	24000	21000
Lead	18	18	68	16	15	44	20	17	31
Magnesium	3300	3300	4600	2400	2900	3300	3400	2700	3000
Manganese	200	220	430	210	150	190	210	160	170
Mercury	0.016J	0.025J	0.086	0.013J	0.014J	0.057	0.0075J	0.026J	0.022J
Nickel	23	22	33	20	21	28	24	21	23
Potassium	1000	1100	1600	810	860	1300	910	930	1000
Selenium	0.97U	0.91U	0.65J	0.85U	0.89U	0.58J	0.93U	0.83U	0.31J
Silver	0.17	0.075J	0.31	0.13U	0.12U	0.11J	0.13U	0.14U	0.14J
Sodium	57J	52J	91J	44J	38J	70J	69J	51J	56J
Thallium	0.11J	0.24J	0.26J	0.091J	0.098J	0.17J	0.11J	0.12J	0.13J
Vanadium	11	10	20	10	9.3	20	9.3	9.4	12
Zinc	82	69	160	78	78	110	72	79	84

U - Not detected at or above the specified LRL

J - Estimated concentration

Metal - (mg/kg)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area (AD)		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
Aluminum	9200	9200	9600	9800	20000	13000	10000
Antimony	0.47	0.36	0.4	0.43	0.64J	0.43	0.47
Arsenic	7.4	8.2	9.5	12	11	12	11
Barium	50	49	48	64	110	95	49
Beryllium	0.62	0.53	0.63	0.76	0.91J	0.86	0.53
Cadmium	1.4	1.4	1	2.1	1.8	2	0.93
Calcium	13000	13000	16000	13000	35000	25000	17000
Chromium	25	24	21	29	39	36	19
Cobalt	10	10	10	13	14	13	11
Copper	31	30	31	44	40	36	27
Iron	30000	31000	34000	31000	47000	31000	35000
Lead	28	28	25	35	40	37	20
Magnesium	7900	7500	8000	7100	7600	6600	6300
Manganese	440	460	530	530	1300	770	610
Mercury	0.1	0.092	0.076	0.12	0.14	0.14	0.065
Nickel	31	30	30	39	45	40	27
Potassium	2000	1800	1900	2100	3900	3000	1600
Selenium	0.67J	0.34J	0.62J	0.53J	1.5J	0.95J	0.6J
Silver	0.26	0.17J	0.21	0.43	0.35J	0.28	0.23
Sodium	85J	80J	86J	85J	240J	190	77J
Thallium	0.29J	0.3J	0.28J	0.35J	0.47J	0.43J	0.26J
Vanadium	21	20	19	25	38	34	19
Zinc	140	140	130	170	180	180	120

TABLE 4: Bulk Inorganic Chemistry Analyses on Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

Parameter - (mg/kg)	ASR-11			ASR-12			ASR-13		ASRMU-3
	Upper (Sands and Gravel)	Middle (Silty Clay W/ Fine Sands)	Lower (Silty Clay)	Upper (Fine to Medium Sands)	Middle (Sands and Gravel)	Lower (Silty Clay)	Upper (Sands and Gravel)	Lower (Silty Clay W/Sands)	
Oil and Grease	620	260	490	270	240	3100	370	730	220
Nitrogen, ammonia	98B	28UJ	220	24UJ	22UJ	81B	10UJ	39UJ	55B
Phosphorus, total	130	72	210	73	66	130	63	96	100
Nitrogen, total kjeldahl	890	430	1800	340	310	1800	370	370	650
Cyanide, total	1.4U	6	1 6U	1.2U	1.1U	1.5U	1.2U	1.2U	1.3U
Percent moisture	26	17	38	19	12	32	16	19	22
Total Organic Carbon	11000	4000	17000	4000	5900	67000	3800	3000	11000

Parameter - (mg/kg)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
Oil and Grease	460	540	310	480	740	1600	270
Nitrogen, ammonia	91	88	73	97	960	580	64
Phosphorus, total	320	300	310	290	580	420	260
Nitrogen, total kjeldahl	1100	1100	1200	1500	5000	2700	1100
Cyanide, total	1.8U	1 7U	1.7U	2U	3.8U	2.8U	1.5U
Percent moisture	45	42	40	50	74	64	35
Total Organic Carbon	13000	12000	10000	18000	27000	23000	13000

U - Not detected at or above the specified LRL

J - Estimated concentration

B = parameter also detected in laboratory blank

TABLE 5: Bulk Polycyclic Aromatic Hydrocarbon (PAH) Analyses on Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

PAH - (ug/kg)	ASR-11			ASR-12			ASR-13		ASRMU-3
	Upper (Sands and Gravel)	Middle (Silty Clay W/ Fine Sands)	Lower (Silty Clay)	Upper (Fine to Medium Sands)	Middle (Sands and Gravel)	Lower (Silty Clay)	Upper (Sands and Gravel)	Lower (Silty Clay W/ Sands)	
2-methylnaphthalene	220 U	190 U	51 J	200 U	180 U	130 J	12 J	13 J	13 J
Acenaphthene	14 J	9 1 J	96 J	39 J	28 J	270 J	36 J	49 J	36 J
Acenaphthylene	12 J	190 U	250 U	200 J	7 9 J	63 J	9.9 J	200 U	200 U
Anthracene	31 J	18 J	160 J	270 J	64 J	170 J	84 J	54 J	66 J
Benzo(a)anthracene	150 J	50 J	420 J	930 J	92 J	170 J	180 J	68 J	110 J
Benzo(a)pyrene	150 J	40 J	380 J	740 J	55 J	120 J	160 J	52 J	76 J
Benzo(b)fluoranthene	200 J	54 J	590 J	1100 J	85 J	200 J	230 J	82 J	130 J
Benzo(ghi)perylene	63 J	18 J	190 J	170 J	21 J	47 J	70 J	29 J	43 J
Benzo(k)fluoranthene	130 J	33 J	290 J	350 J	38 J	81 J	100 J	38 J	71 J
Chrysene	140 J	47 J	470 J	720 J	61 J	150 J	160 J	69 J	110 J
Dibenz(a,h)anthracene	220 U	190 U	63 J	50 J	180 U	240 U	190 U	200 U	200 U
Dibenzofuran	220 U	190 U	250 U	16 J	180 U	240 U	14 J	200 U	14 J
Fluoranthene	300 J	91 J	930 J	1400 J	150 J	660 J	290 J	210 J	220 J
Fluorene	19 J	8.3 J	140 J	64 J	17 J	190 J	28 J	33 J	30 J
Indeno(1,2,3-cd)pyrene	53 J	190 U	190 J	190 J	180 U	240 U	70 J	200 U	36 J
Naphthalene	220 U	190 U	23 J	200 U	180 U	36 J	13 J	200 U	200 U
Phenanthrene	32 J	50 J	740 J	630 J	120 J	1100 J	200 J	220 J	180 J
Pyrene	310 J	100 J	870 J	1600 J	170 J	500 J	370 J	200 J	230 J
Total	**2,484**	**1,658**	**6,103**	**8,869**	**1,809**	**4,607**	**2,217**	**2,117**	**1,965**
PH/AN	1 0	2.8	4.6	2.3	1.9	6.5	2.4	4.1	2.7
FL/PY	0.97	0.91	1.07	0.88	0.88	1.32	0.78	1.05	0.96

U - Not detected at or above the specified LRL

J - Estimated concentration

Parameter -(ug/kg)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
2-methylnaphthalene	290 U	280 U	270 U	320 U	3100 U	450 UJ	240 U
acenaphthene	31 J	26 J	20 J	26 J	3100 U	450 UJ	20 J
acenaphthylene	32 J	21 J	14 J	27 J	3100 U	450 UJ	14 J
anthracene	97 J	84 J	59 J	72 J	3100 U	450 UJ	58 J
benzo(a)anthracene	330 J	270 J	210 J	270 J	170 J	59 J	170 J
benzo(a)pyrene	300 J	240 J	180 J	250 J	3100 U	56 J	140 J
benzo(b)fluoranthene	470 J	370 J	310 J	370 J	180 J	88 J	250 J
benzo(ghi)perylene	140 J	140 J	110 J	130 J	3100 U	450 UJ	67 J
benzo(k)fluoranthene	210 J	160 J	110 J	160 J	3100 U	45 J	110 J
chrysene	350 J	320 J	240 J	300 J	3100 U	72 J	200 J
dibenz(a,h)anthracene	48 J	280 U	270 U	320 U	3100 U	450 UJ	240 U
dibenzofuran	22 J	21 J	18 J	19 J	3100 U	450 UJ	240 U
fluoranthene	570 J	520 J	430 J	510 J	170 J	100 J	350 J
fluorene	39 J	37 J	30 J	31 J	3100 U	450 UJ	36 J
indeno(1,2,3-cd)pyrene	140 J	140 J	110 J	130 J	3100 U	450 UJ	67 J
naphthalene	23 J	26 J	19 J	21 J	3100 U	450 UJ	13 J
phenanthrene	300 J	250 J	210 J	240 J	3100 U	62 J	230 J
pyrene	710 J	500 J	400 J	490 J	220 J	130 J	400 J
Total	**4,102**	**3,685**	**3,010**	**3,686**			**2,845**
PH/AN	3.1	3.0	3 6	3.3			4.0
FL/PY	0 80	1.04	1.08	1.04	0.77	0 77	0.88

TABLE 6: Acute Equilibrium Partitioning-Based Sediment Benchmark Toxic Units (ESBTUs) Specific to *Hyalella azteca* for PAH Compound Mixture in Select Ashtabula Harbor Sediment Samples.

PAH compound	$C_{oc,PAHi,FAVi}$ (μg/g$_{oc}$)*	ASR 12 (Upper) (Fine to Medium Sands)			
		PAH (μg/g)	f_{oc}	C_{oc} (μg/g$_{oc}$)	$ESBTU_{FAVi}$
Acenaphthene	3042	0.039	0.004	9.75	0.0032049
Acenapnthylene	2800	0.2	0.004	50.00	0.0178586
Anthracene	3680	0.27	0.004	67.50	0.0183442
Benzo(a)Anthracene	5212	0.93	0.004	232.50	0.0446127
Benzo(a)Pyrene	5974	0.74	0.004	185.00	0.030965
Benzo(b)Fluoranthene	6068	1.1	0.004	275.00	0.0453197
Benzo(ghi)Perylene	6789	0.17	0.004	42.50	0.0062601
Benzo(k)Fluoranthene	6073	0.35	0.004	87.50	0.0144075
Chrysene	5226	0.72	0.004	180.00	0.0344435
Dibenzo(a,h)Anthracene	6955	0.05	0.004	12.50	0.0017974
Fluoranthene	4385	1.4	0.004	350.00	0.0798145
Fluorene	3339	0.064	0.004	16.00	0.0047924
Indeno(1,2,3-cd)Pyrene	6912	0.19	0.004	47.50	0.0068716
Naphthalene	2387	0.2	0.004	50.00	0.0209491
Phenanthrene	3697	0.63	0.004	157.50	0.0426031
Pyrene	4326	1.6	0.004	400.00	0.0924664
Total PAHs (16)		8.65			
$\sum ESBTU_{FAV,16}$					0.4647106
Uncertainty factor					4
$\sum ESBTU_{FAV,34}$					**1.8588426**

PAH compound	$C_{oc,PAHi,FAVi}$ (μg/g$_{oc}$)*	ASR 11 (Lower) (Silty Clay)			
		PAH (μg/g)	f_{oc}	C_{oc} (μg/g$_{oc}$)	$ESBTU_{FAVi}$
Acenaphthene	3042	0.096	0.017	5.65	0.0018562
Acenaphthylene	2800	0.25	0.017	14.71	0.0052525
Anthracene	3680	0.16	0.017	9.41	0.0025578
Benzo(a)Anthracene	5212	0.42	0.017	24.71	0.0047406
Benzo(a)Pyrene	5974	0.38	0.017	22.35	0.0037414
Benzo(b)Fluoranthene	6068	0.59	0.017	34.71	0.0057195
Benzo(ghi)Perylene	6789	0.19	0.017	11.18	0.0016463
Benzo(k)Fluoranthene	6073	0.29	0.017	17.06	0.0028089
Chrysene	5226	0.47	0.017	27.65	0.0052903
Dibenzo(a,h)Anthracene	6955	0.063	0.017	3.71	0.0005329
Fluoranthene	4385	0.93	0.017	54.71	0.0124752
Fluorene	3339	0.14	0.017	8.24	0.0024667
Indeno(1,2,3-cd)Pyrene	6912	0.19	0.017	11.18	0.0016169
Naphthalene	2387	0.023	0.017	1.35	0.0005669
Phenanthrene	3697	0.74	0.017	43.53	0.0117745
Pyrene	4326	0.87	0.017	51.18	0.0118303
Total PAHs (16)		5.80			
$\sum ESBTU_{FAV,16}$					0.0748768
Uncertainty factor					4
$\sum ESBTU_{FAV,34}$					**0.299507**

*Based on acute critical body burden of 13.9 μmol/g lipid for *Hyalella azteca*

TABLE 7: Bulk PCB Analyses on Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

Aroclor (ug/kg)	ASR-11			ASR-12			ASR-13		ASRMU-3
	Upper (Sands and Gravel)	Middle (Silty Clay W/ Fine Sands)	Lower (Silty Clay)	Upper (Fine to Medium Sands)	Middle (Sands and Gravel)	Lower (Silty Clay)	Upper (Sands and Gravel)	Lower (Silty Clay W/ Sands)	
Aroclor 1016	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1221	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1232	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1242	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1248	45 U	40 U	**87**	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1254	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U
Aroclor 1260	45 U	40 U	53 U	40 U	37 U	49 U	39 U	41 U	42 U

Aroclor (ug/kg)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
Aroclor 1016	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1221	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1232	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1242	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1248	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1254	59 U	57 U	55 U	67 U	130 U	92 U	50 U
Aroclor 1260	59 U	57 U	55 U	67 U	130 U	92 U	50 U

U - Not detected at or above the specified LRL

TABLE 8: Bulk Pesticides Analyses on Ashtabula Harbor and Open-Lake Area Sediments (Biohabitats 2012).

Pesticide - (ug/kg)	ASR-11 Upper (Sands and Gravel)	ASR-11 Middle (Silty Clay W/ Fine Sands)	ASR-11 Lower (Silty Clay)	ASR-12 Upper (Fine to Medium Sands)	ASR-12 Middle (Sands and Gravel)	ASR-12 Lower (Silty Clay)	ASR-13 Upper (Sands and Gravel)	ASR-13 Lower (Silty Clay W/ Sands)	ASRMU-3
4,4-DDD	2.3 U	2 U	2.7 U	2.1 U	1.9 U	2.5 U	2 U	2.1 U	2.2 U
4,4-DDE	1.1 U	1 U	2	1 U	0.93 U	1.2	0.99 U	1 U	0.65 J
4,4-DDT	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Aldrin	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Alpha-BHC	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Alpha-Chlordane	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Beta-BHC	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Chlordane (total)	23 U	20 U	27 U	20 U	19 U	25 U	20 U	20 U	21 U
Delta-BHC	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.45 J	1 U	1.1 U
Dieldrin	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endosulfan I	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endosulfan II	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endosulfan sulfate	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endrin	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endrin aldehyde	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Endrin ketone	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Gamma-BHC (lindane)	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Gamma-Chlordane	1.1 U	1 U	1 J	1 U	0.93 U	0.56 J	0.99 U	1 U	1.1 U
Heptachlor	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Heptachlor epoxide	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Methoxychlor	1.1 U	1 U	1.3 U	1 U	0.93 U	1.2 U	0.99 U	1 U	1.1 U
Toxaphene	23 U	20 U	27 U	20 U	19 U	25 U	20 U	20 U	21 U

U - Not detected at or above the specified LRL

J - Estimated concentration

Pesticide - (ug/kg)	Open-Lake Reference Area B (ALRB)				Open-Lake Placement Area		
	ALRB-1	ALRB-2	ALRB-3	ALRB-4	AD-1	AD-3	AD-4
4,4-DDD	3.1 U	2.9 U	2.8 U	3.4 U	6.5 U	4.8 U	2.6 U
4,4-DDE	0.83 J	0.9 J	1.4 U	1.7 U	3.2 U	2.3 U	0.91 J
4,4-DDT	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Aldrin	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Alpha-BHC	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Alpha-Chlordane	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Beta-BHC	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Chlordane (total)	30 U	29 U	28 U	34 U	64 U	47 U	26 U
Delta-BHC	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Dieldrin	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endosulfan I	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endosulfan II	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endosulfan sulfate	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endrin	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endrin aldehyde	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Endrin ketone	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Gamma-BHC (lindane)	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Gamma-Chlordane	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Heptachlor	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Heptachlor epoxide	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Methoxychlor	1.5 U	1.4 U	1.4 U	1.7 U	3.2 U	2.3 U	1.3 U
Toxaphene	30 U	29 U	28 U	34 U	64 U	47 U	26 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 9: Inorganic Chemistry Analyses on ASRMU-3 Elutriate Sample and Open-Lake Placement Area (AD) Site Water (Biohabitats 2012).

Analyte (mg/L)	AD SITE WATER	ASRMU-3
	Total	Dissolved
Oil and Grease	**0.7 J**	**1.7 J**
Nitrogen, ammonia	**0.034 J**	**2.1**
Phosphorus, total	0.023 UJ	0.01 J
Nitrogen, total kjeldahl	0.58 UJ	**1.8**
Cyanide, total	0.01 U	0.01 U
Total Suspended Solids	1 UJ	
Total Organic Carbon	**2.3**	**2.9**

U - Not detected at or above the specified LRL
J - Estimated concentration

TABLE 10: Metals Analyses on ASRMU-3 Elutriate Sample and Open-Lake Placement Area (AD) Site Water (Biohabitats 2012).

Analyte (mg/L)	AD SITE WATER	ASRMU-3
	Total	Dissolved
Aluminum	0.07	0.046
Antimony	0.00052 J	0.001 U
Arsenic	0.0011	0.0028
Barium	0.022	0.18
Beryllium	0.0004 U	0.0004 U
Cadmium	0.0004 U	0.0004 U
Calcium	39	29
Chromium	0.00056 J	0.0012 J
Cobalt	0.00012 J	0.00018 J
Copper	0.0014 J	0.00055 J
Iron	0.23	0.14
Lead	0.0004 J	0.00023 J
Magnesium	8.8	6.5
Manganese	0.0072	0.081
Mercury	0.0002 U	0.0002 U
Nickel	0.0016 J	0.004 U
Potassium	1.6	2.1
Selenium	0.00066 J	0.002 U
Silver	0.0015 U	0.0006 U
Sodium	9.4	11
Thallium	0.00017 J	0.002 U
Vanadium	0.0005 J	0.0013 J
Zinc	0.075	0.036

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 11: Polycyclic Aromatic Hydrocarbon (PAH) Analyses on ASRMU-3 Elutriate Sample and Open-Lake Placement Area (AD) Site Water (Biohabitats 2012).

PAH (ug/L)	AD SITE WATER	ASRMU-3
	Total	Dissolved
2-methylnaphthalene	4.5 UJ	5.7 U
Acenaphthene	4.5 UJ	5.7 U
Acenaphthylene	4.5 UJ	5.7 U
Anthracene	4.5 UJ	5.7 U
Benzo(a)anthracene	0.91 UJ	1.1 U
Benzo(a)pyrene	0.91 UJ	1.1 U
Benzo(b)fluoranthene	0.91 UJ	1.1 U
Benzo(ghi)perylene	1.8 UJ	2.3 U
Benzo(k)fluoranthene	0.91 UJ	1.1 U
Chrysene	0.91 UJ	1.1 U
Dibenz(a,h)anthracene	1.8 UJ	2.3 U
Dibenzofuran	3.6 UJ	4.6 U
Fluoranthene	1.8 UJ	2.3 U
Fluorene	4.5 UJ	5.7 U
Indeno(1,2,3-cd)pyrene	1.8 UJ	2.3 U
Naphthalene	4.5 UJ	5.7 U
Phenanthrene	1.8 UJ	2.3 U
Pyrene	4.5 UJ	5.7 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 12: PCB Anaylses on ASRMU-3 Elutriate Sample and Open-Lake Reference Area (AD) Site Water (Biohabitats 2012).

PCB (ug/L)	AD SITE WATER	ASRMU-3
	Total	Dissolved
Aroclor 1016	0.1 U	0.1 U
Aroclor 1221	0.1 U	0.1 U
Aroclor 1232	0.2 U	0.2 U
Aroclor 1242	0.2 U	0.2 U
Aroclor 1248	0.1 U	0.1 U
Aroclor 1254	0.2 U	0.2 U
Aroclor 1260	0.2 U	0.2 U

U - Not detected at or above the specified LRL

TABLE 13: Pesticides Analyses on ASRMU-3 Elutriate Sample and Open-Lake Placement Area (AD) Site Water (Biohabitats 2012).

Pesticide (ug/L)	AD SITE WATER	ASRMU-3
	Total	Dissolved
4,4-DDD	0.01 U	0.012 U
4,4-DDE	0.01 U	0.012 U
4,4-DDT	0.01 U	0.012 U
Aldrin	0.01 U	0.012 U
Alpha-BHC	0.01 U	0.012 U
Alpha-Chlordane	0.01 U	0.012 U
Beta-BHC	0.01 U	0.012 U
Chlordane (total)	0.21 U	0.25 U
Delta-BHC	0.01 U	0.012 U
Dieldrin	0.01 U	0.012 U
Endosulfan I	0.01 U	0.012 U
Endosulfan II	0.01 U	0.012 U
Endosulfan sulfate	0.01 U	0.012 U
Endrin	0.01 U	0.012 U
Endrin aldehyde	0.01 U	0.012 U
Endrin ketone	0.01 U	0.012 U
Gamma-BHC (lindane)	0.01 U	0.012 U
Gamma-Chlordane	0.01 U	0.012 U
Heptachlor	0.01 U	0.012 U
Heptachlor epoxide	0.01 U	0.012 U
Methoxychlor	0.01 U	0.012 U
Toxaphene	0.21 U	0.25 U

U - Not detected at or above the specified LRL

J - Estimated concentration

TABLE 14: Water Column Bioassay Results on ASRMU-3 Elutriate Sample (Biohabitats 2012).

Management Unit/Sample	Elutriate Treatment Concentration	Percent Survival	
		48 hour *Ceriodaphnia dubia*	**96 hour** *Pimephales promelas*
Laboratory **Control**	0.0%	100.0%	92.0%
ASRMU-3	6.25%	100.0%	96.0%
ASRMU-3	12.5%	100.0%	96.0%
ASRMU-3	25.0%	100.0%	92.0%
ASRMU-3	50.0%	100.0%	88.0%
ASRMU-3	100.0%	100.0%	84.0%

ENCLOSURE 4. Results of PCB and TSS analyses on Ashtabula Harbor management unit sediment elutriate and open-lake reference area (AD) site water (Biohabitats 2012).

PCB (µg/L)	AD site water	Ashtabula Harbor management unit									
		Lower River Channel		Southern Reach							
		LRRMU		ASRMU-1B		ASRMU-2A		ASRMU-2B		ASRMU-3	
	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aroclor 1016	0.1 U*	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1221	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1232	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1242	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1248	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Aroclor 1254	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Aroclor 1260	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Total suspended solids (mg/L)		32		47		130		120		130	

*Not detected at or above the specified LRL.

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ENCLOSURE 5. Acute water column toxicity test results on Ashtabula Harbor management unit sediment elutriate treatments (Biohabitats 2012).

Mangement unit/ control	Harbor area	Elutriate concentration	Percent survival		Ammonia concentration (mg/L)
			48-hour *Ceriodaphnia dubia*	96-hour *Pimephales promelas*	
Laboratory control		0.0%	100.0%	92.0%	0.3
LRRMU	Lower River Channel	6.25%	96.0%	98.0%	
LRRMU		12.5%	88.0%	92.0%	
LRRMU		25.0%	100.0%	96.0%	
LRRMU		50.0%	100.0%	66.0%	8.7
LRRMU		100.0%	92.0%	0.0%	17.0
ASRMU-1B	Southern Reach	6.25%	100.0%	80.0%	
ASRMU-1B		12.5%	100.0%	90.0%	
ASRMU-1B		25.0%	100.0%	96.0%	
ASRMU-1B		50.0%	92.0%	68.0%	7.2
ASRMU-1B		100.0%	100.0%	0.0%	14.0
ASRMU-2A		6.25%	96.0%	84.0%	
ASRMU-2A		12.5%	100.0%	90.0%	
ASRMU-2A		25.0%	96.0%	90.0%	
ASRMU-2A		50.0%	100.0%	90.0%	5.6
ASRMU-2A		100.0%	100.0%	20.0%	11.0
ASRMU-2B		6.25%	100.0%	94.0%	
ASRMU-2B		12.5%	100.0%	92.0%	
ASRMU-2B		25.0%	100.0%	84.0%	
ASRMU-2B		50.0%	100.0%	68.0%	8.6
ASRMU-2B		100.0%	100.0%	0.0%	18.0
ASRMU-3		6.25%	100.0%	96.0%	
ASRMU-3		12.5%	100.0%	96.0%	
ASRMU-3		25.0%	100.0%	92.0%	
ASRMU-3		50.0%	100.0%	88.0%	2.6
ASRMU-3		100.0%	100.0%	84.0%	5.1

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MINNESOTA SLIP
PINNEY DOCK
Material Offloading Area
PINNEY DOCK MAIN GATE
Parkgate Ave.
HAUL ROUTE
SR 531
Runoff Pipeline
ELKEM LAGOON 5C
NOTES
1 HORIZONTAL CONTROL IS IN NAD 1983 STATE PLANE COORDINATES OHIO NORTH FEET
2 THE ORTHOPHOTOS SHOWN ARE FROM 2009
3 FEATURES SHOWN INCLUDING POWER LINES POLES AND TOWERS AND RAIL ROADS ARE BASED ON THE 2009 ORTHOPHOTOS SHOWN. EXISTING CONDITIONS MAY VARY
PLAN
SCALE 1" = 500'-0"
LEGEND
CREEK
HAUL ROUTE, EXISTING ROAD
POWER LINES
POWER POLE
POWER TOWER
RAILROAD
STAGING AREA BOUNDARY
REAL ESTATE PLAN
U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207
ASHTABULA HARBOR
ASHTABULA, OHIO
KINDER MORGAN PINNEY DOCK TO ELKEM
Sheet

Enclosure 6

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