APPENDIX B: CONTINGENT REMEDIAL ALTERNATIVES FOOTPRINT DEVELOPMENT

APPENDIX C: COST EVALUATION FOR CONTINGENT REMEDIAL ALTERNATIVES

APPENDIX B: CONTINGENT REMEDIAL ALTERNATIVES FOOTPRINT DEVELOPMENT

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Date:
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APPENDIX B: CONSTITUENT FOOTPRINT DEVELOPMENT METHODS AND FIGURES SUPPORTING THE SUPPLEMENTAL REMEDIAL ALTERNATIVES ANALYSIS

HERRINGTON LAKE, KENTUCKY

RAMBOLL

CONTENTS

FIGURES

ACRONYMS AND ABBREVIATIONS

%	Percent
As	Arsenic
BRN001	BRN stands for Brown (from E.W. Brown Station)
CCR	Coal combustion residuals
CI	Curds Inlet
e.g.	Example
ESL	Ecological screening level
ESV	Ecological screening value
Fe	Symbol for iron
GIS	Geographic Information System
IDW	Inverse Distance Weighting
ISARA	Investigation Source Assessment and Risk Assessment
KAR	Kentucky Administrative Regulation
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
NB	North Bank
PNEC	Predicted no-effect concentrations
RSV	Refined Screening Value
RSL	Refined Screening Level
Se	Selenium
SRAA	Supplemental Remedial Alternatives Analysis
USEPA	United States Environmental Protection Agency
Vs.	Versus

1. OVERVIEW OF FOOTPRINT DEVELOPMENT

This appendix describes the development of the modeled spatial distributions of certain coal combustion residual (CCR) constituents in Curds Inlet in support of the Supplemental Remedial Alternatives Analysis (SRAA). Selenium in sediment and arsenic in sediment pore water were identified for consideration in the SRAA in the Corrective Action Investigation, Source Assessment, and Risk Assessment Report (Corrective Action ISARA Report, Ramboll 2019). Iron in sediment pore water was identified as a constituent for consideration in the SRAA and in the Coal Pile Addendum to the Corrective Action ISARA Report (Ramboll 2020). Each of these three constituents had one or more detected concentrations in sediment (selenium) or sediment pore water (arsenic and iron) that exceeded one or more risk-based screening levels for ecological receptors, as described in the SRAA. This appendix describes the process for defining the three potential sediment remedial Footprints considered in the SRAA. The three remedial Footprints are developed based on risk-based criteria that are protective of the environment. Each Footprint reflects the combination of the three constituents (selenium in sediment and arsenic/iron in sediment porewater), and therefore reflects the cumulative estimated remedial area.

1.1 Physical Footprint Development Methods

The following steps define the process for developing the three cumulative distribution-based Footprints in Curds Inlet:

1. For each of the three constituents (selenium in sediment, and arsenic and iron in pore water) a single physical extent (footprint) was calculated using geographic information service (GIS)-based Inverse Distance Weighting (IDW) interpolation for Curds Inlet, as was initially discussed in the Corrective Action ISARA Report for sediment and arsenic (Ramboll 2019).
2. Each IDW-weighted surface was then further refined to include only regions having a bottom slope of 50 percent (%) or less because where the slope exceeds 50%, sediment deposits are unlikely to be present and remedial options such as capping cannot be successfully implemented. The bottom slope was derived from the Navionics bathymetry data, by calculating the derivative (i.e., slope) of each bathymetric-valued cell relative to its neighboring cells. The Navionics bathymetry is a GIS layer included in the Corrective Action Plan (Ramboll 2017). For Curds Inlet, the bottom slope ranges from 0 to 74%. Most of the steepest slope values are located along the steep shore rock wall that runs laterally along the northeast Curds Inlet. In situ observation from the Phase I and II field sampling efforts indicate that the steep northeast wall retains little or no sediment, and most of the deposited sediment is located throughout the relatively flat bottom region that runs through the deepest points (thalweg) from Upper to Lower Curds Inlet.
3. The slope-refined IDW regions were then further refined using the measured sediment and sediment pore water results presented in the Corrective Action ISARA Report (Ramboll 2019). For arsenic in pore water, for example, the higher modeled concentrations at CI3.1A caused the IDW interpolation to estimate that higher arsenic concentrations (0.15 to 0.34 mg/L) extend west beyond CI3.1C, where the measured concentration was lower than 0.15 mg/L. In such instances, the measured concentration was used to improve the overall accuracy of each of the model(s).
4. For each constituent, three remedial areas were delineated individually based on different risk-based criteria as discussed in Section 1.2 below.

5. The individual remedial areas delineated for each constituent in the appropriate media (sediment and pore water) were then overlaid and combined to create a single Footprint that encompasses the selenium in sediment, arsenic in sediment pore water, and iron in sediment pore water into a single physical extent that are called the Footprints 1, 2, and 3 for consideration in the SRAA.

1.2 Risk-Based Criteria Used to Define Remedial Footprints

The three remedial Footprints are based on risk-based criteria discussed in the Corrective Action ISARA Report and the Coal Pile Addendum (Ramboll 2019, 2020), discussed further below. Each Footprint is considered protective of human health and the environment. Footprints are briefly described below, followed by more detailed description of the risk-based criteria used for the footprints.

- Footprint 1 is the smallest remedial area at 0.75 acres, developed using risk-based criteria of 20 milligrams per kilogram (mg/kg) for selenium in sediment, 0.34 milligrams per liter (mg/L) for arsenic in pore water, and 3.5 mg/L for iron in pore water.
- Footprint 2 is an intermediate area at 1.5 acres, using risk-based criteria of 11 mg/kg for selenium in sediment, 0.15 mg/L for arsenic in pore water, and 1.0 mg/L for iron in pore water.
- Footprint 3 is the Largest area at 2.14 acres using risk-based criteria of 2.9 mg/kg for selenium in sediment, 0.34 mg/L for arsenic in pore water, and 3.5 mg/L for iron in pore water.

1.2.1 Selenium Risk Based Criteria for Sediment

The risk-based selenium criteria used to develop each of the three footprints are described further below.

- **Footprint 1:** Footprint 1 uses the selenium risk-based criterion of 20 mg/kg used by the State of Washington for risk-based remedial decisions (Washington State Department of Ecology 2011, 2013). This remedial value also was used by USEPA from 2015 to 2018 as a refined ecological screening value (RSV) for selenium in sediment. The Washington State Department of Ecology Sediment Management Standards (2013) explains the differences between the 20 mg/kg and 11 mg/kg values. Both the State of Washington RSV and ESVs were determined through studies that used a chronic 28-day growth endpoints for an amphipod (*Hyalella azteca)*. The RSV was determined through studies that used an acute 10-day growth endpoint with the midge *Chironomus dilutus,* and a chronic 28-day mortality endpoint with *Hyalella azteca* (Washington State Department of Ecology 2011); both of these study species are expected to occur in Herrington Lake. Washington State derived the "no adverse effects level" of 11 mg/kg based on a finding of no difference from reference/control in any endpoint and derived the "minor adverse effects level" (20 mg/kg) based on a finding of a difference in only one of the test endpoints from the reference/control (Washington State Department of Ecology 2011; 2013). The State of Washington developed and defined both effects-level criteria in terms of potential impact to the benthic community as a whole but not to individual sediment dwelling organisms.
- **Footprint 2:** Footprint 2 uses the Washington State-derived ESV "no adverse effects level" of 11 mg/kg (Washington State Department of Ecology 2011, 2013).
- **Footprint 3:** Footprint 3 uses the current USEPA Region 4 refined screening level (RSL) of 2.9 mg/kg selenium in sediment. The USEPA cites 2.9 mg/kg as derived from the Netherlands (i.e.,

Dutch Standards derived from Crommentujin et al. (1997; 2000)) but the Netherlands rescinded the 2.9 mg/kg RSL and no longer uses it. This SRAA used the lower RSL for Footprint 3 because the USEPA has not yet rescinded the 2.9 mg/kg criterion[1].

1.3 Arsenic Risk Based Criteria for Sediment Pore Water

The risk-based arsenic criteria used to develop each of the three remedial Footprints are described further below.

- **Footprint 1:** Footprint 1 uses the Kentucky arsenic acute criterion for surface water of 0.340 mg/L (401 KAR 10:031. Surface Water Quality Standards, Table 1).
- **Footprint 2:** Footprint 2 uses the Kentucky arsenic chronic criterion for surface water of 0.150 mg/L. The chronic criterion is "protective of aquatic life based on ninety-six (96) hour exposure that does not exceed the criterion of a given pollutant more than once every three (3) years on the average" (401 KAR 10:031. Surface Water Quality Standards, Table 1).
- **Footprint 3:** Footprint 3 retains the arsenic in surface water chronic criterion of 150 mg/L from Footprint 2. Figure B3-2 provides an illustration of the contribution of each of the three constituents, selenium, arsenic, and iron, to the overall physical shape and extent of Footprint 3. In Figure B3-2, the larger selenium footprint (based on the USEPA 2.9 mg/kg selenium criterion) controls the shape and physical extent of Footprint 3, and not the arsenic 150 mg/L criterion. The SRAA Section 5 and Appendix C provide more information about the relative preliminary costs of the contingent supplemental remedial alternatives.

1.4 Iron Risk-Based Criteria for Sediment Pore Water

The three Footprints are based on the Surface Water Quality Standards chronic criteria for iron. According to the Kentucky standards, the chronic criteria for iron are conditional. Table 1, note #8 for Iron states: "The chronic criterion for iron shall not exceed three and five tenths (3.5) mg/L if aquatic life has not been shown to be adversely affected[2]." Otherwise the chronic criterion is lower, at 1.0 mg/L. The Kentucky acute criterion for iron in surface water (4.0 mg/L) was deemed to be of similar magnitude to the higher of the two chronic criteria (3.5 vs. 1.0 mg/L) but less reflective of the types of any possible chronic exposures to iron in Curds Inlet.

Based on the foregoing, following the risk-based iron criteria were used to develop each of the three Footprints:

- **Footprint 1:** Footprint 1 uses the Kentucky iron in surface water chronic criterion of 3.5 mg/L.
- **Footprint 2:** Footprint 2 uses the Kentucky iron in surface water chronic criterion of 1.0 mg/L.
- **Footprint 3:** Footprint 3 retains the iron in surface water chronic criterion of 1.0 mg/L used in the development of Footprint 2.

[1] As of 2019, the Netherlands defaults to the European Union regulations which derive screening values (predicted no-effect concentrations or PNECs) by evaluating available toxicity data and applying appropriate assessment factors to address uncertainty. No PNEC values are specified; they must be derived based on the appropriate data. The data for Herrington Lake show that a selenium sediment concentration of 2.9 mg/kg is below concentrations occurring well outside the influence of Curds Inlet extending to areas such as Lower Herrington Lake 6 (LHL6), located approximately 3 miles upgradient from Curds Inlet in Herrington Lake. A selenium remedial goal of 2.9 mg/kg would be less than observed background conditions in Herrington Lake.

[2] Table 1, note #8.

2. FOOTPRINT DESCRIPTIONS

2.1 Footprint 1

Footprint 1 is based on the following criteria:

- Selenium in sediment greater than 20 mg/kg.
- Arsenic in sediment pore water greater than 0.34 mg/L - Kentucky acute Surface Water Quality Standard. The arsenic in pore water subregion measures 0.54 Acres.
- Iron in sediment pore water greater than 3.5 mg/L - Kentucky chronic Surface Water Quality Standard for aquatic life.
- Footprint 1 defined using the above criteria measures approximately 0.75 acres and is centered around Middle Curds Inlet from near sampling transect CI2.1 to CI3.2 (Figures B1-4 and B1-5). The Iron concentrations in the pore water define the part of Footprint 1 that extends into Upper Curds Inlet. The arsenic in pore water concentrations define the lower Curds Inlet. Selenium is a smaller portion of this area centered between sampling transects CI3 and CI3.1.

2.2 Footprint 2

Footprint 2 is based on the following criteria:

- Selenium in sediment greater than 11 mg/kg – State of Washington no effects value.
- Arsenic in sediment pore water greater than 0.15 mg/L - Kentucky chronic Surface Water Quality Standard. The Arsenic in pore water subregion measures 0.85 acres
- Iron in sediment pore water greater than 1.0 mg/L - Kentucky chronic Surface Water Quality Standard for aquatic life.

Footprint 2 defined using the above criteria measures approximately 1.5 acres (Figures B2-4 and B2-5). Similar to Footprint 1, the area defined for Footprint 2 is also centered around Middle Curds Inlet but extends farther into Upper Curds Inlet past sampling transect CI2.1 and also farther into Lower Curds Inlet past CI3.2, almost reaching transect CI4.

2.3 Footprint 3

Footprint 3 is based on the following criteria:

- Selenium in sediment greater than 2.9 mg/kg – USEPA Region 4 Ecological RSL.
- Arsenic in sediment pore water greater than 0.15 mg/L - Kentucky chronic Surface Water Quality Standard.
- Iron in sediment pore water greater than 1.0 mg/L - Kentucky chronic Surface Water Quality Standard for aquatic life.

Footprint 3 defined using the above criteria, measures approximately 2.14 acres (Figures B3-2 and B3-3). Like Footprints 1 and 2, Footprint 3 centers around Middle Curds Inlet but extends farther northwest into Upper Curds Inlet, to the Curds North Bank (NB) sampling location, and adjacent to former Outfall BRN001. Like Footprint 2, Footprint 3 also extends into Lower Curds Inlet, past CI3.2, almost reaching sampling transect CI4. The reason for this similarity between Footprint 2 and 3 is that the arsenic in pore water risk-based criterion (0.15 mg/L) and the iron in pore water risk-based criterion (0.1 mg/L) for Footprint 2 and 3 are equal but the selenium in sediment criterion is reduced from 11 mg/kg to 2.9 mg/kg, to reflect the USEPA Region 4 Ecological RSL.

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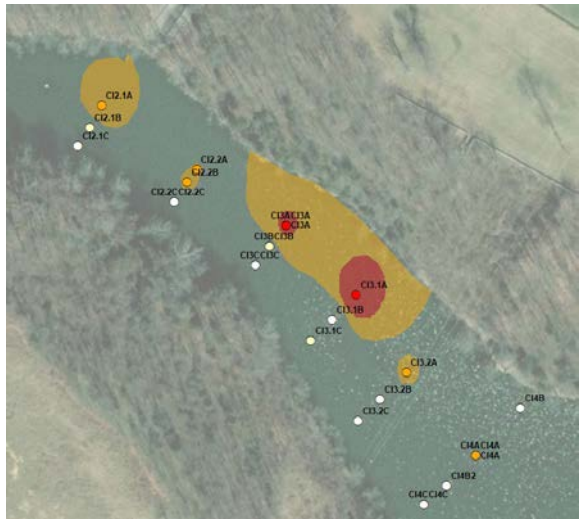
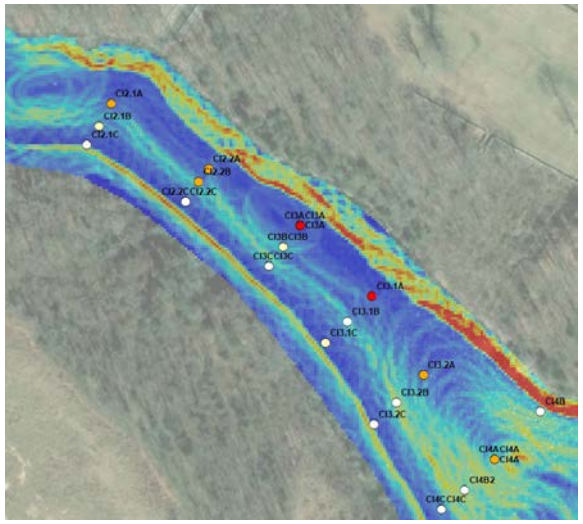
APPENDIX B FIGURES: CONSTITUENT FOOTPRINT DEVELOPMENT METHODS AND FIGURES SUPPORTING THE SUPPLEMENTAL REMEDIAL ALTERNATIVES ANALYSIS HERRINGTON LAKE, KENTUCKY



Selenium in Curds Inlet Sediment - Interpolated

Sampling Locations
Selenium in Sediment (mg/kg)

- >3
- 3-11
- 11-20
- >20

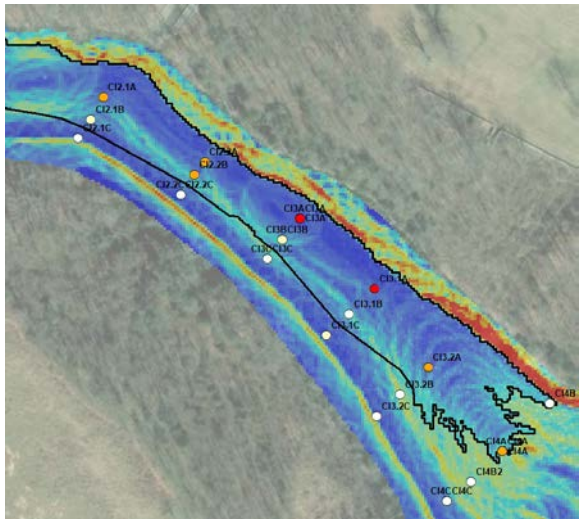


Use Bathymetry to Calculate Slope

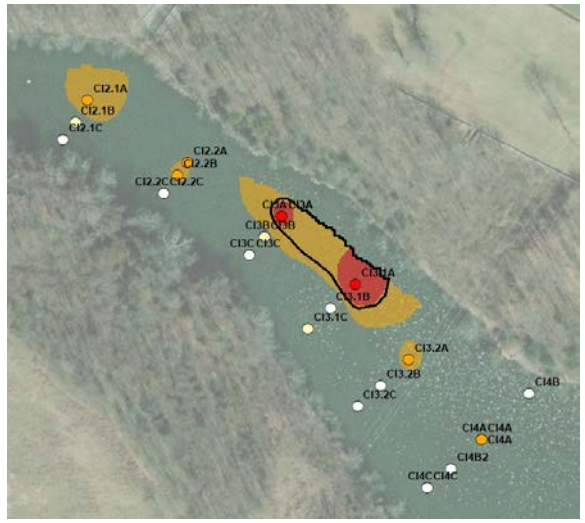
Curds Inlet Bottom Slope in Percent

372% slope

Flat



Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results



Remedial Area for Se >20 mg/kg

~0.2 Acres

- 20 mg/kg – Washington state minor effects value

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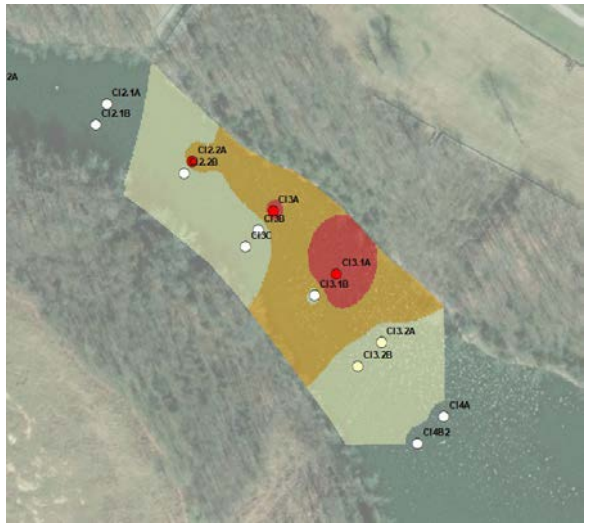
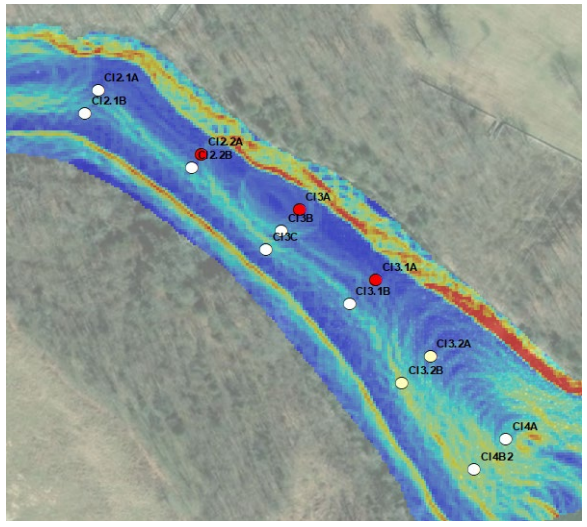
Map Design: AJS Nov 2020

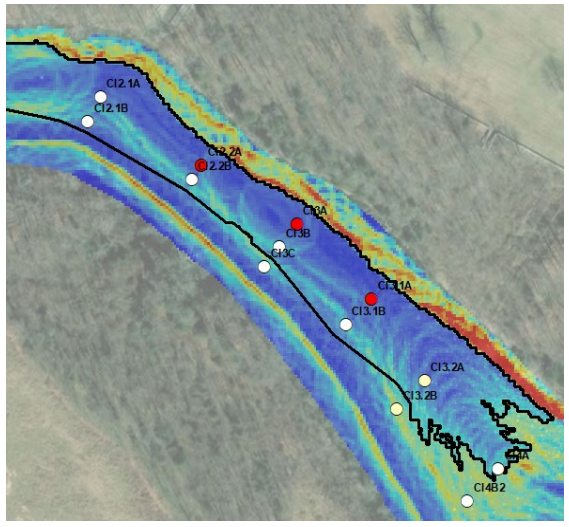
Footprint 1- Selenium in Sediment >20 mg/kg Remedial Area Development

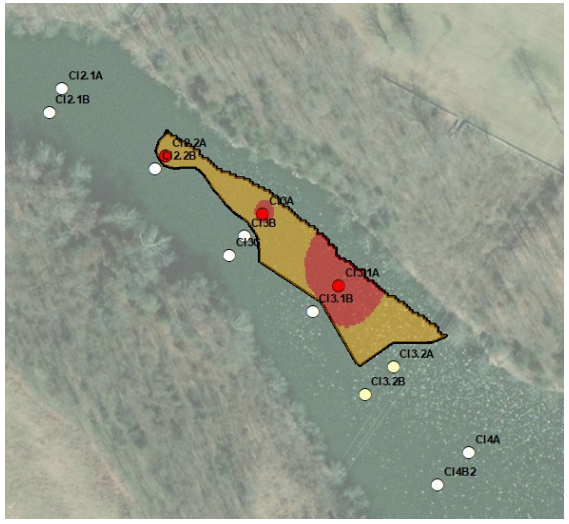
Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B1-1









Arsenic in Curds Inlet Pore Water– Interpolated

Sampling Locations

Arsenic in Pore Water (mg/L)

- <0.15
- 0.15-0.340
- 0.34-0.534
- >0.534

Use Bathymetry to Calculate Slope

Curds Inlet Bottom Slope in Percent

372% slope

Flat

Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results

Remedial Area for >0.34 mg/L

0.54 Acres

- 0.34 mg/L – Kentucky acute surface water criterion

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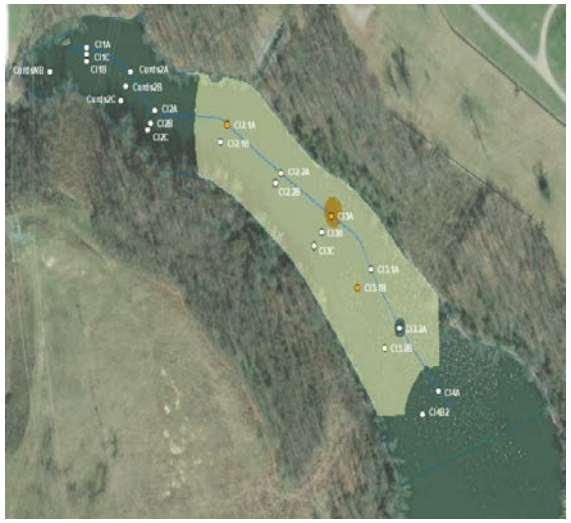
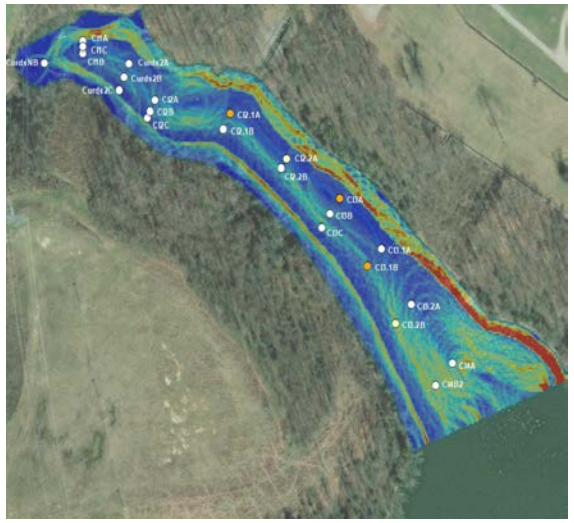
Map Design: AJS Nov 2020

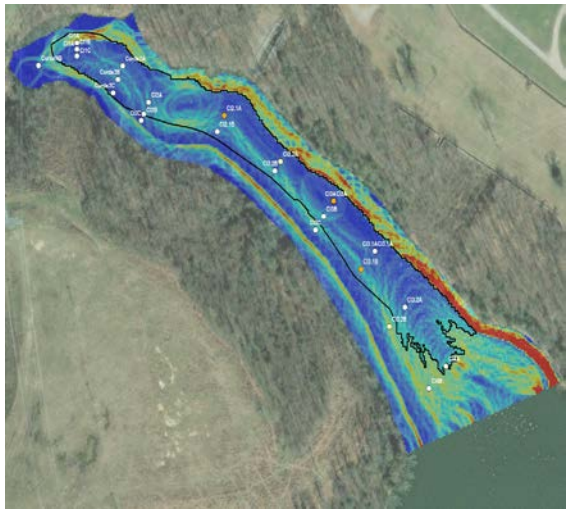
Footprint 1- Arsenic in Sediment Porewater >0.340 mg/L Remedial Area Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B1-2







Iron in Curds Inlet Sediment Pore Water– Interpolated

Iron Porewater Level Estimates for Curds Inlet (mg/L)

Sampling Locations

Iron in Pore Water (mg/L)

- < 1.0
- 1.0-3.5
- >3.5

Inverse Distance Weighting (IDW) Iron in Pore Water (mg/L)

- <1.0
- 1.0-3.5
- >3.5

Use Bathymetry to Calculate Slope

Curds Inlet Bottom Slope in Percent

372% slope

Flat

Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results

Remedial Area for Region for >3.5 mg/L

0.46 Acres

- 3.5 mg/L – Kentucky Chronic Surface Water Standard for Aquatic Life*

*The chronic criterion for iron shall not exceed three and five tenths (3.5) mg/L (thirty-five hundred µg/L) if aquatic life has not been shown to be adversely affected.

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Map Design: AJS Nov 2020

Footprint 1- Iron in Sediment Porewater >0.35 mg/L Remedial Area Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B1-3

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >20 mg/kg – Washington State Minor Effects (Benthic Invertebrate Community) value

Arsenic in Sediment Pore Water >0.340 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >3.5 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CI1B
CURDSNB
CI-1B PW Only
CI1C
Curds-2A
CURDS2
Curds-1C
Curds-28
CURDS2B
Curds-2C
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
28-39ft
(10ft depression)
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
30-36ft
(6ft depression)
CI2.2A Sed,PW, SW
CI-2.2B Sed,PW
CI-2.2C Sed Only
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

Cumulative Estimated Remediation Region for Curds Inlet (mg/L)

- Selenium in Sediment >20 mg/kg – Washington State minor effects (benthic invertebrate community) value
- Arsenic in Sediment Pore Water >0.340 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- Iron in Sediment Pore Water >3.5 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- AMEC Feb 2017 Sediment Sample Locations
- Phase I Sediment and Pore Water Sampling Locations
- Phase II Sediment and Porewater Sampling Locations
- Phase I Surface Water Sample Transects
- Phase II Surface Water Sample Transects
- Gullies - Approximate
- Shoal - Approximate

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Map Design: AJS, Date: Nov, 2020

0 100 Feet N

Footprint 1 - Cumulative Estimated Remediation Region Curds Inlet, Herrington Lake Corrective Action Plan, Mercer County, Kentucky

FIGURE B1-4

Project:

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >20 mg/kg – Washington State Minor Effects (Benthic Invertebrate Community) value

Arsenic in Sediment Pore Water >0.340 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >3.5 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CI1B
CURDSNB
CI-1B PW Only
CI1C
Curds-2A
CURDS2
Curds-1C
Curds-2B
CURDS2B
Curds-2C
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
28-39ft
(10ft depression)
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
CI2.2A Sed,PW, SW
CI-2.2B Sed,PW
CI-2.2C Sed Only
30-36ft
(6ft depression)
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Cumulative Estimated Remedial Area
for Curds Inlet (mg/L)

- Combined Selenium, Arsenic, and Iron AOIs (See
- AMEC Feb 2017 Sediment Sample Locations
- Phase I Sediment and Pore Water Sampling Locations
- Phase II Sediment and Porewater Sampling Locations
- Phase I Surface Water Sample Transects
- Phase II Surface Water Sample Transects
- Gullies - Approximate
- Shoal - Approximate

RAMBOLL

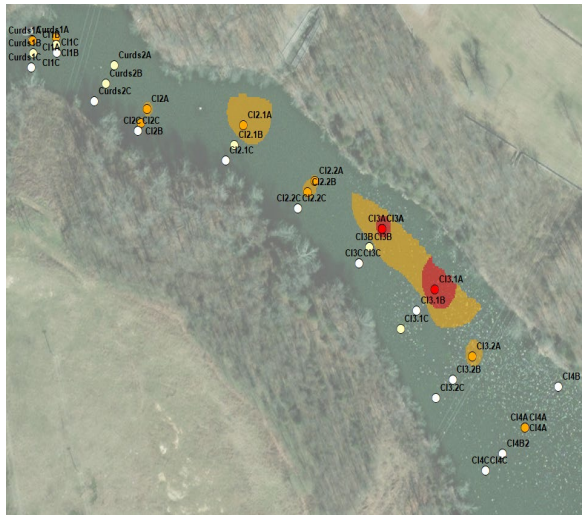
Map Design: AJS, Date: Nov, 2020

0 100 Feet N

Footprint 1 - Combined Cumulative Estimated Remediation Region
Curds Inlet, Herrington Lake Corrective Action Plan,
Mercer County, Kentucky

FIGURE
B1-5

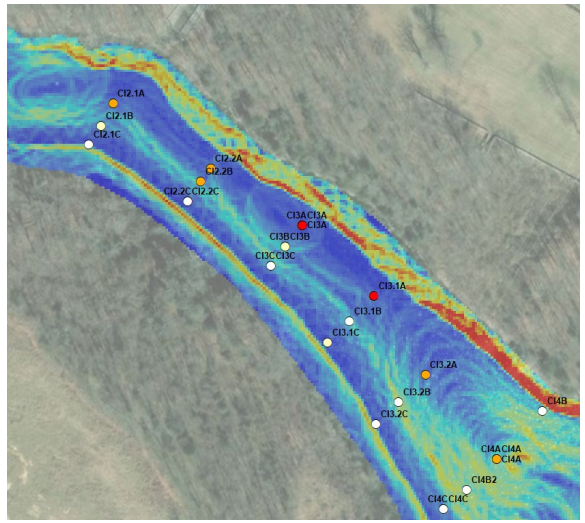
Project:



Selenium in Curds Inlet Sediment - Interpolated

Sampling Locations
Selenium in Sediment (mg/kg)

- < 3
- 3-11
- 11-20
- >20

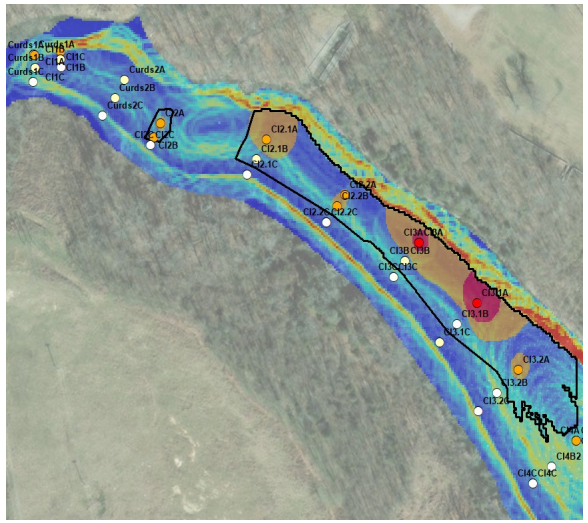


Use Bathymetry to Calculate Slope

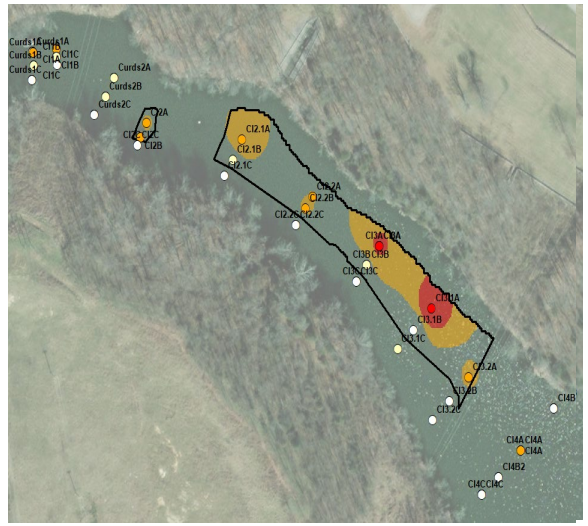
Curds Inlet Bottom Slope in Percent

372% slope

Flat



Refine based on Practical Slope (e.g., <50%), Phase I and Phase II Results



Refined Region for Se >11mg/kg

~1.18 Acres

- 11 mg/kg – Washington state no effects value.

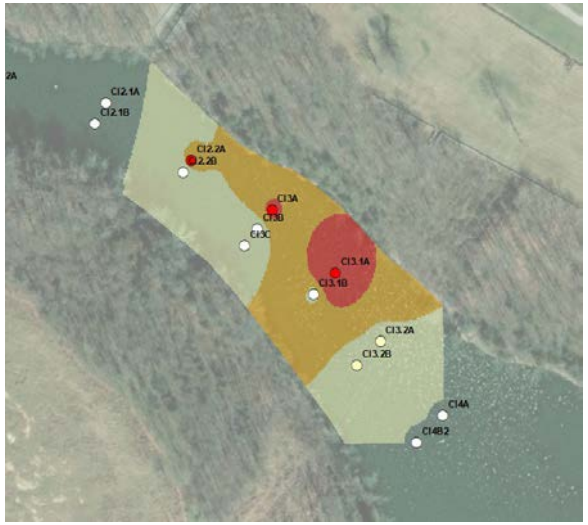
RAMBOLL

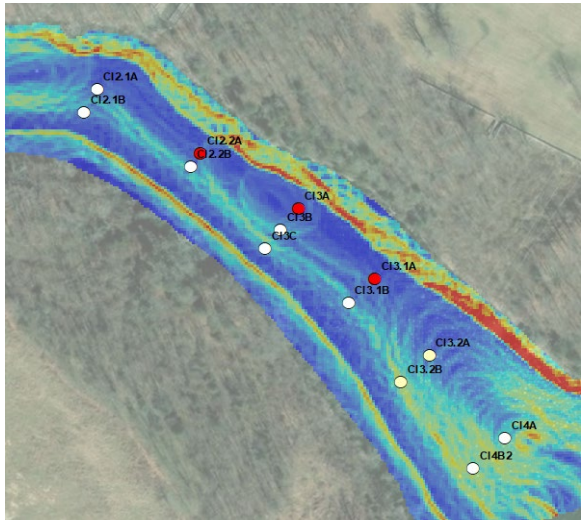
Map Design: AJS Nov 2020

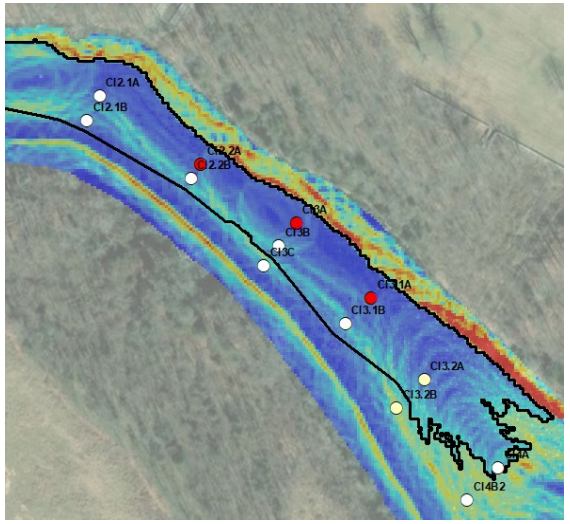
Footprint 2- Selenium in Sediment >11 mg/kg Refined Region Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B2-1







Arsenic in Curds Inlet Pore Water– Interpolated

Sampling Locations

Arsenic in Pore Water (mg/L)

- <0.15
- 0.15-0.340
- 0.34-0.534
- >0.534

Use Bathymetry to Calculate Slope

Curds Inlet Bottom Slope in Percent

372% slope

Flat

Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results

Remedial Area for >150 ug/L

0.85 Acres

- 0.15 - mg/L Kentucky ecological chronic criterion

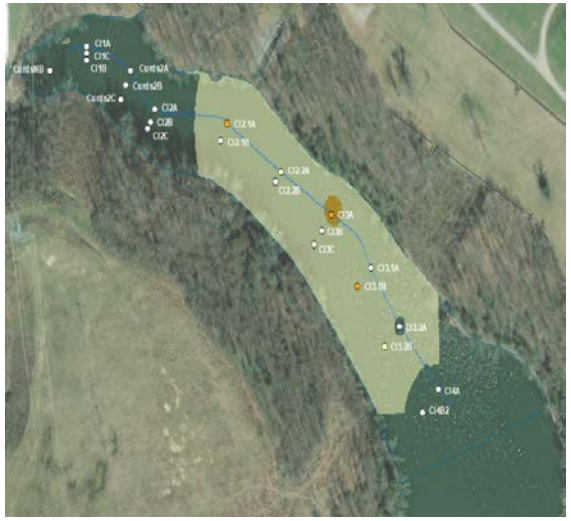
RAMBOLL

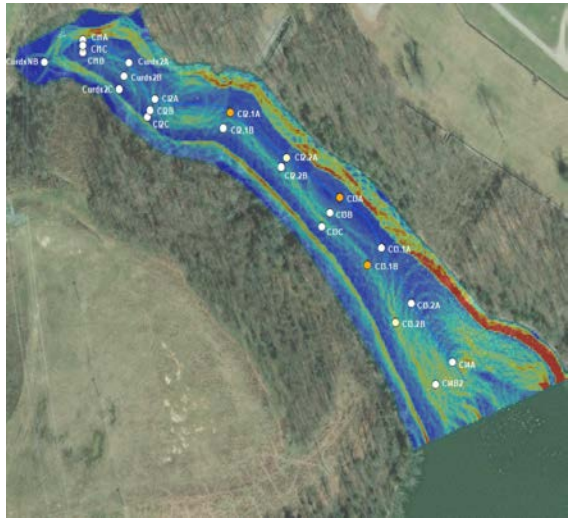
Map Design: AJS Nov 2020

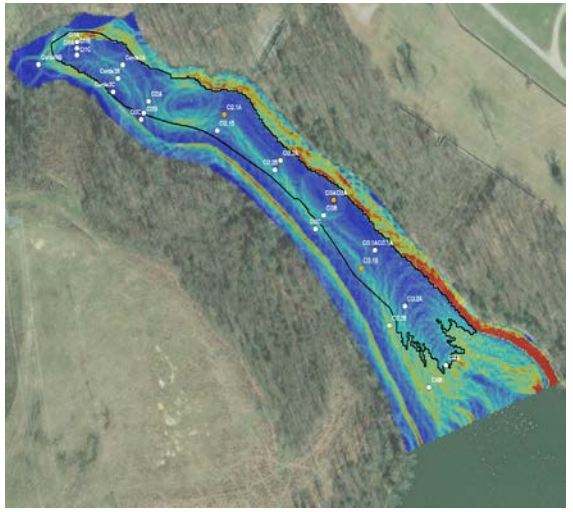
Footprint 2 and 3- Arsenic in Sediment Porewater >0.150 mg/L Remedial Area Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B2-2







Iron in Curds Inlet Sediment Pore Water– Interpolated

Iron Porewater Level Estimates for Curds Inlet (mg/L)

Sampling Locations

Iron in Pore Water (mg/L)

- < 1.0
- 1.0-3.5
- >3.5

Inverse Distance Weighting (IDW) Iron in Pore Water (mg/L)

- <1.0
- 1.0-3.5
- >3.5

Use Bathymetry to Calculate Slope

Curds Inlet Bottom Slope in Percent

372% slope

Flat

Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results

Remedial Area for >1.0 mg/L

0.67 Acres

- 1 mg/L – Kentucky Chronic Surface Water Standard for Aquatic Life

RAMBOLL

Map Design: AJS Nov 2020

Footprint 2 and 3 - Iron in Sediment Porewater >0.1 mg/L Remedial Area Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE B2-3

Note: Selenium in Sediment result from Curds 1A = 14 mg/kg
Washington State No Effects (Benthic Invertebrate Community) Value producing a very small region that is not practically feasible for remediation Note: Location CI1A has a bottom slop of >50% exlcuding it from Footprint 2 for practical remediation methods.

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >11 mg/kg – Washington State No Effects (Benthic Invertebrate Community) Value

Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CURDSNB
CI1B
CI-1B PW Only
CI1C
Curds-28
CURDS2
CURDS2B
Curds-1C
Curds-2C
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
28-39ft
(10ft depression)
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
30-36ft
(6ft depression)
CI-2.2B Sed,PW
CI-2.2C Sed Only
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Cumulative Estimated Remediation Region
for Curds Inlet (mg/L)

- Selenium in Sediment >11 mg/kg – Washington state minor effects
- Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- AMEC Feb 2017 Sediment Sample Locations
- Phase I Sediment and Pore Water Sampling Locations
- Phase II Sediment and Porewater Sampling Locations
- Phase I Surface Water Sample Transects
- Phase II Surface Water Sample Transects
- Gullies - Approximate

RAMBOLL

Map Design: AJS, Date: Nov, 2020

0 100 Feet N

Footprint 2 - Cumulative Estimated Remediation Region
Curds Inlet, Herrington Lake Corrective Action Plan,
Mercer County, Kentucky

FIGURE
B2-4

Project:

Note: Selenium in Sediment result from Curds 1A = 14 mg/kg
Washington State No Effects (Benthic Invertebrate Community) Value producing a very small region that is not practically feasible for remediation Note: Location CI1A has a bottom slop of >50% exlcuding it from Footprint 2 for practical remediation methods.

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >11 mg/kg – Washington State No Effects (Benthic Invertebrate Community) Value

Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CURDSNB
CI1B
CI-1B PW Only
CI1C
Curds-28
Curds-1C
Curds-2C
CURDS2
CURDS2B
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
28-39ft
(10ft depression)
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
30-36ft
(6ft depression)
CI-2.2B Sed,PW
CI-2.2C Sed Only
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Cumulative Estimated Remediation Region for Curds Inlet (mg/L)

- Combined Selenium, Arsenic, and Iron AOIs (See
- AMEC Feb 2017 Sediment Sample
- Phase I Sediment and Pore Water Sampling
- Phase II Sediment and Porewater Sampling
- Phase I Surface Water Sample
- Phase II Surface Water Sample
- Gullies - Approximate

RAMBOLL

Map Design: AJS, Date: Nov, 2020

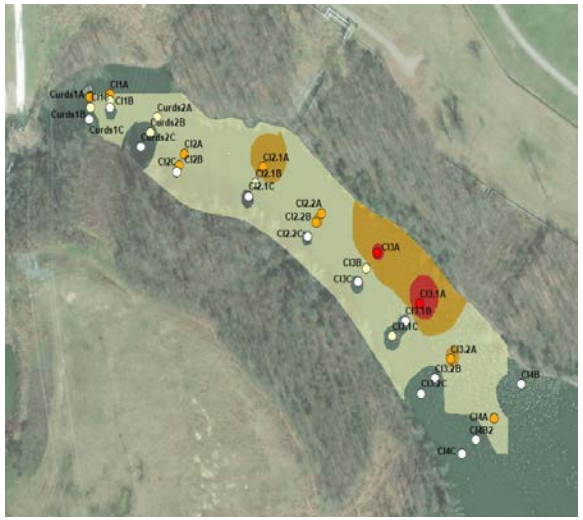
0 100 Feet

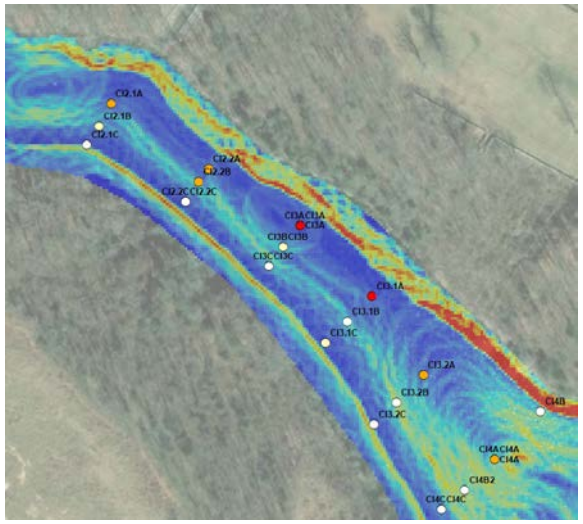
N

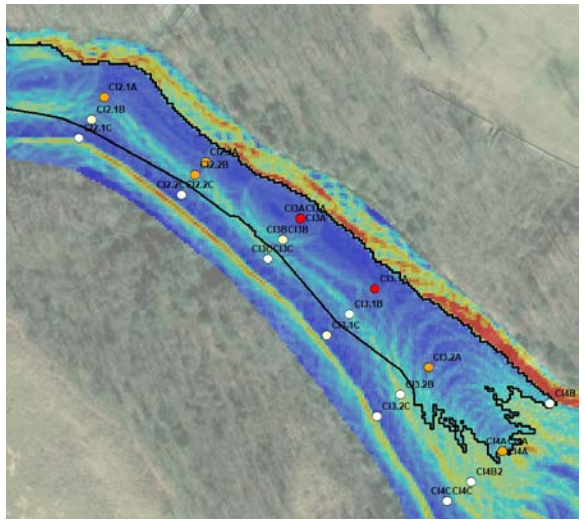
Footprint 2 - Combined Cumulative Estimated Remediation Region - Curds Inlet, Herrington Lake Corrective Action Plan, Mercer County, Kentucky

FIGURE B2-5

Project:







Selenium in Curds Inlet Sediment - Interpolated

Sampling Locations
Selenium in Sediment (mg/kg)
- >3
- 3-11
- 11-20
- >20

Use Bathymetry to Calculate Slope

Curds Inlet Bottom Slope in Percent
372% slope
Flat

Refine based on Practical Slope (e.g. <50%), Phase I and Phase II Results

Remedial Area for Se >2.9 mg/kg

~2.1 Acres

~93,400 cubic ft

~3,460 cubic yards
(assuming 12-inch depth)

~5,190 cubic yards
(assuming 18-inch depth)

- 2.9 mg/kg Region 4 refined screening value, 0.72 mg/kg Region 4 ecological screening value
- 11 mg/kg – Washington state no effects value.
- 20 mg/kg – Washington state minor effects value

RAMBOLL

Map Design: AJS Nov 2020

Footprint 3- Selenium in Sediment >2.9 mg/kg Remedial Area Development

Supplemental Remedial Alternatives Assessment E.W. Brown Station,
Herrington Lake, Mercer County, Kentucky

FIGURE
B3-1

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >2.9 mg/kg – U.S. EPA Ecological Screening Value (ESV)

Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CI1B
CURDSNB
CI-1B PW Only
CI1C
Curds-2A
CURDS2
Curds-1C
Curds-28
CURDS2B
Curds-2C
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
28-39ft
(10ft depression)
30-36ft
(6ft depression)
CI2.2A Sed,PW, SW
CI-2.2B Sed,PW
CI-2.2C Sed Only
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Cumulative Estimated Remediation Region
for Curds Inlet (mg/L)

- Selenium in Sediment >2.9 mg/kg – Washington State minor effects (benthic invertebrate community) value
- Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life
- AMEC Feb 2017 Sediment Sample Locations
- Phase I Sediment and Pore Water Sampling Locations
- Phase II Sediment and Porewater Sampling Locations
- Phase I Surface Water Sample Transects
- Phase II Surface Water Sample Transects
- Gullies - Approximate
- Shoal - Approximate

RAMBOLL

Map Design: AJS, Date: Nov, 2020

0 100 Feet N

Footprint 3 - Cumulative Estimated Remediation Region
Curds Inlet, Herrington Lake Corrective Action Plan,
Mercer County, Kentucky

FIGURE
B3-2

Project:

Combined AOIs for Middle Curds Inlet
Selenium in Sediment >2.9 mg/kg – U.S. EPA Ecological Screening Value (ESV)

Arsenic in Sediment Pore Water >0.150 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

Iron in Sediment Pore Water >1.0 mg/L Kentucky Chronic Surface Water Standard for Aquatic Life

CURDS1
CI1A
CI1B
CURDSNB
CI-1B PW Only
CI1C
Curds-2A
CURDS2
Curds-1C
Curds-28
CURDS2B
Curds-2C
CURDS2C
CI2A
CI2B
CI2C
CI-2C PW Only
CI-2.1A Sed,PW
CI-2.1B Sed,PW
CI2.1C Sed Only
28-39ft
(10ft depression)
30-36ft
(6ft depression)
CI2.2A Sed,PW, SW
CI-2.2B Sed,PW
CI-2.2C Sed Only
CI-3A Sed,PW
CI3A
CI-3B Sed,PW
CI3B
CI-3C Sed Only
CI3C
CI-3.1A Sed,PW, SW
CI-3.1B Sed,PW
CI-3.1C Sed Only
CI-3.2A Sed,PW
CI-3.2B Sed,PW
CI-3.2C Sed Only
CI4B
CI-4A Sed,PW, SW
CI4A
CI-4B2 Sed,PW
CI-4C Sed Only
CI4C

Cumulative Estimated Remedial Area
for Curds Inlet (mg/L)

- Combined Selenium, Arsenic, and Iron AOIs (See
- AMEC Feb 2017 Sediment Sample Locations
- Phase I Sediment and Pore Water Sampling Locations
- Phase II Sediment and Porewater Sampling Locations
- Phase I Surface Water Sample Transects
- Phase II Surface Water Sample Transects
- Gullies - Approximate Locations
- Shoal - Approximate Location

RAMBOLL

Map Design: AJS, Date: Nov, 2020

0 100 Feet N

Footprint 3 - Combined Cumulative Estimated Remediation Region
Curds Inlet, Herrington Lake Corrective Action Plan,
Mercer County, Kentucky

FIGURE
B3-3

Project:

APPENDIX C: COST EVALUATION FOR THE SUPPLEMENTAL REMEDIAL ALTERNATIVES ANALYSIS

Prepared for:
Kentucky Utilities Company

Prepared By:
Ramboll US Consulting, Inc.

Date:
August 2021

APPENDIX C: COST EVALUATION FOR THE SUPPLEMENTAL REMEDIAL ALTERNATIVES ANALYSIS

HERRINGTON LAKE, KENTUCKY

CONTENTS

TABLES

ACRONYMS AND ABBREVIATIONS

%	Percent
cm	Centimeter
EMNR	Enhanced Monitored Natural Recovery
FRTR	US Federal Remediation Round Table
FS	Feasibility Study
ITRC	Interstate Technology and Regulatory Council
ISARA	Investigation, Source Assessment, and Risk Assessment
MW	Monitoring Well
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
O&M	Operation and maintenance
SRAA	Supplemental Remedial Alternatives Analysis
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

1. COST EVALUATION OVERVIEW

Preliminary cost estimates were developed for each of the contingent remedial alternatives discussed in Section 5 of the *Supplemental Remedial Alternatives Assessment* (SRAA Report) for the E.W. Brown Generating Station and nearby Herrington Lake in Mercer County, Kentucky, using standard cost estimating methods and in general conformance with United States Environmental Protection Agency (USEPA) and United States Army Corps of Engineers (USACE) guidelines. For the purpose of this cost evaluation, various assumptions were made regarding means and methods of construction, production rates, and remedial quantities[1]. Many of these assumptions may change during the design and contractor bidding processes. Thus, the cost estimates presented below are intended only to establish a reasonable basis for comparison of alternatives and are not intended to direct the means and methods of construction. This level of feasibility study detail is typically associated with accuracy of +50% to -30% (USEPA 1988; USACE and USEPA 2000). Actual costs will depend on factors such as actual labor and material costs and competitive market conditions.

For this preliminary evaluation, estimated costs were calculated for the following elements:

- Engineering: includes remedial design, permitting, construction and project management, and as-built (post-construction) surveys.
- Pre-Mobilization includes development and review of pre-construction submittals (e.g., clean material certifications) and performing any necessary pre-design and/or pre-remediation site surveys (e.g., sub-bottom profile imagery and side scan sonar).
- Mobilization and Site Preparation: includes construction of temporary site improvements (i.e., access roads and staging areas), setup and maintenance of temporary facilities at the site, deployment of soil erosion and sediment control measures, installation of turbidity controls, and the transportation and setup of construction equipment.
- Thin Layer Cover Placement: includes health and safety measures required to complete this aspect of construction (e.g., air monitoring equipment and associated personnel and laboratory costs, personal protective equipment for contact with contaminated media), operation of temporary site facilities, delivery of thin layer cover material (e.g., sand), and placement of the thin layer cover.
- Capping: includes health and safety measures required to complete this aspect of construction (e.g., air monitoring equipment and associated personnel and laboratory costs, personal protective equipment for contact with contaminated media), operation of temporary site facilities, delivery of capping material (e.g., sand and gravel), and placement of the cap material.
- Sediment Removal: includes health and safety measures required to complete this aspect of construction (e.g., air monitoring equipment and associated personnel and laboratory costs, personal protective equipment for contact with contaminated media), operation of temporary site facilities, mechanical excavation of sediments in deep water areas, turbidity monitoring, separation of sediment from coarse debris (e.g., vegetative material, litter, etc.), sediment mixing

[1] For example, for Contingent Alternatives 1 (Enhanced Monitored Natural Recovery or "EMNR") and 2 (Capping), remedial quantities were increased by 10% to account for material loss, over-placement, and/or overlap during construction. For Contingent Alternative 3 (Sediment Removal), a 6-inch overdredge was added to the target removal volumes based on an assumption that sediment depth does not exceed 3 feet within the footprint to be remediated.

for dewatering and stabilization, water treatment, transportation and offsite disposal, and post-removal confirmation sampling.[2]

- Site Restoration and Demobilization: includes dismantling and disposal of temporary site improvements (i.e., access roads and staging areas), breaking down temporary facilities, decontaminating and removing all construction equipment from the site, and restoring all disturbed upland areas.

The total estimated costs are aggregated based on Total Indirect Costs and Total Direct Construction Costs and are provided in 2020 US dollars.[3] Total Indirect Costs are the non-construction and overhead-related costs and include the engineering and pre-mobilization elements while Total Direct Construction Costs include mobilization and site preparation; thin layer cover, capping, or sediment removal; and site restoration and demobilization. A summary of total estimated costs associated with the contingent remedial alternatives for each of the three remedial footprint footprints is presented in Table C1. The detailed cost estimates for each alternative are presented on separate tables as follows:

- Contingent Alternative 1 (EMNR) – Tables C2-1 through C2-3;
- Contingent Alternative 2 (Capping) – Tables C3-1 through C3-3;
- Contingent Alternative 3 (Sediment Removal) – Tables C4-1 through C4-3.

1.1 Preliminary Cost Estimate Procedures

In many cases, the estimated line item costs developed in this evaluation are based on unit costs (e.g., per volume of sediment to be removed or area to be capped). However, some line items are dependent on different units of measure such as estimated duration or the costs are estimated on a lump sum basis due to the nature of the activity. The procedures used to develop the preliminary cost estimates include the following:

- To allow for more flexibility in considering variations in the amount and scope of remedial work, the unit price method was used for most construction items. The unit price method required that remedial quantities for each of the alternatives evaluated be estimated; estimated quantities are summarized on Table 5-1 in Section 5.1 of the SRAA Report.
- For the capping alternative, preliminary modeling of a conceptual sediment cap design was conducted in accordance with USEPA Guidance for In Situ Subaqueous Capping of Contaminated Sediments (USEPA 1998).
- Modeling is done for this SRAA Report to evaluate the potential cap thickness appropriate to address the flux of selenium and arsenic from sediment/sediment pore water to the water column of Curds Inlet.[4]

---

[2] Delivery and placement of backfill material (sand) has been included as a contingent line item under the Sediment Removal element for Contingent Alternative 3, but the associated line item cost is not included in the total estimated cost for the alternative.

[3] The total estimated costs developed for this evaluation do not include costs for post-construction, long-term operation and maintenance activities that would be required to demonstrate and ensure the continued effective performance of the remedy. If a contingent remedy is necessary, such costs would be included in subsequent evaluations.

[4] As documented in the Corrective Action ISARA Report, mass loading from groundwater to Curds Inlet is *de minimis.* The amount of selenium and arsenic in pore water from Curds Inlet was consistent with flux from sediment and does not indicate mass loading from groundwater upwelling in Curds Inlet.

- For the purpose of this SRAA, the solute transport of selenium and arsenic from the sediment/sediment pore water to the surface water column of Curds Inlet[5] through a cap was simulated using CapSim Version 3.8 (Reible Research Group© 2018, Shen et al. 2018). The CapSim modeling was conducted based on the largest remedy footprint model output (Footprint 3, discussed in Section 2.5.1.3 of the SRAA Report); based on the Kentucky chronic surface water standard for arsenic in sediment porewater (>0.15 mg/L) and the USEPA Region 4 ecological screening level for selenium in sediment (>2.9 mg/kg). For both footprints, the minimum design thickness for the sand layer was increased from 1-foot by 0.5-foot increments, as needed, until the maximum modeled porewater or sediment concentrations in the top 15 cm of sand met these target concentrations. The higher of the two modeled cap thicknesses was selected for this cost estimate.
- The seepage velocity for this model was estimated by assuming that all groundwater traveling between MW-111, MW-112, and MW-113 (Ramboll 2019) flows upward through Curds Inlet. Other model input and output parameters are summarized on Table C5. As presented on Table C5, for areas impacted by selenium only, the preliminary modeling shows that a minimum 12-inch unamended sand cap will be sufficient in establishing an isolation layer for the existing level of sediment contamination. However, a thicker sand layer (i.e., minimum 3.5 to 4.5-foot) is required to establish an isolation layer for the arsenic-impacted areas. This evaluation conservatively assumes that the upper end of the minimum thickness range (i.e., 4.5-foot sand layer) would be installed.

- Unit costs used in this cost evaluation were primarily based on quotes provided by qualified contractors, vendors, and suppliers or invoiced costs from sediment remediation sites in urban areas, primarily in northeast US.[6] Published remedial unit costs (e.g., RSMeans [Gordian 2021), adjusted using location indexes, were also used. In the absence of specific local vendor/contractor estimates or construction cost data, experience with similar projects was relied upon. The unit pricing used in the cost estimates is inclusive of labor, equipment, materials, and contractor overhead and profit, unless otherwise indicated. Production rates for each construction task were also defined and used to estimate construction task durations.
- Costs for certain construction items were estimated using the time and materials method. The duration of such construction items was defined based on production rates obtained from published databases or experience with similar projects.
- The lump sum method was used for construction activities that are readily predictable and quantifiable (e.g., access road and staging area construction), or when little change is anticipated with respect to quantities. The lump sum amount was defined based on past experience with similar projects or as a percent of the total construction costs, in general conformance to USEPA, USACE, and US Federal Remediation Round Table (FRTR) documentation.

[5] As documented in the Corrective Action ISARA Report: Selenium mass flux from sediment to the water column of Curds Inlet is *de minimis*. Arsenic mass flux from sediment to water is likely to occur but the mass transfer between sediment pore water and overlying water is expected to be slow. Moreover, the concentrations of arsenic in all water samples from Curds Inlet were less than the arsenic chronic Kentucky water quality standards protective of human health and the environment.

[6] In addition to the uncertainty inherent to this stage of the project, in some cases, use of unit costs from urban sediment remediation sites may result in an overestimation of costs, especially for costs that are driven by labor due to factors such as higher wages in urban areas and requirements to use unionized labor.

1.2 Cost Estimate Uncertainty and Contingency

This preliminary cost evaluation has multiple sources of uncertainty, including the assumed daily production rates, construction methods, and unit costs. The production rates for the various major construction activities (i.e., thin layer cover, capping, and dredging) are professional estimates based on similar sediment remediation project experience. Factors such as site accessibility and water depth, for example, can greatly affect project-specific production rates, or even from area to area, within larger sites. Also, as discussed above, this cost evaluation is based on certain assumptions about potential means and methods of construction, but final equipment selection, material sources, construction sequence, and other site-specific details would be made by an experienced contractor with knowledge of the site, equipment, and crew availability. The unit costs, in addition to being influenced by the final means and methods of construction, were estimated primarily based on quotes provided by qualified contractors or actual costs from other sediment remediation sites. The size, location, and site-specific requirements and complexities of the sites from which the unit costs were selected may differ at these sites, though professional judgement was used, as appropriate, when applying or adjusting costs.

Construction cost contingency represents costs for unforeseen circumstances, other unknown or unanticipated conditions associated with construction, or remediation activities that could not be evaluated from the available data at the time this cost estimate was developed. Contingency also accounts for small-quantity construction items that may be identified during subsequent remedial design phases. A construction cost contingency of 30% of the total direct construction costs was included in these preliminary cost estimates, consistent with USEPA cost estimating guidance.

2. REFERENCES

Allison, J., and T. Allison. July 2005. Partition Coefficients for Metals in Surface Water, Soil, and Waste. United States Environmental Protection Agency (USEPA) Office of Research and Development. EPA 600-R-05-074.

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TABLES

APPENDIX C: PRELIMINARY COST ESTIMATES FOR CONTINGENT REMEDIAL ALTERNATIVES

Table C1: Summary of Total Estimated Costs for Contingent Remedial Alternatives
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

Alternative	Footprint 1	Footprint 2	Footprint 3
1. EMNR	$2.2	$2.4	$2.5
2. Capping	$2.9	$3.6	$3.9
3. Sediment Removal	$4.0	$5.8	$7.4
All costs are presented in Millions of US dollars.			

Table C2-1: Preliminary Cost Estimate for Footprint 1, Contingent Alternative 1 - Enhanced MNR
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$382,030**	
1.01	Remedial Design			12%	$150,360	As a percent of total capital costs
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$100,240	As a percent of total capital costs
1.04	Project Management			6%	$75,180	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$6,250	$6,250	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$45,060**	
2.01	Pre-Construction Submittals	1	Lump Sum	$25,060	$25,060	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$20,000	$20,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$781,498**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	2	month	$1,587	$3,174	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Thin Layer Capping**				**$146,180**	
4.01	Health and Safety	2	month	$19,850	$39,700	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Thin Layer Cap					
4.02a	Sand (Delivered)	1,065	ton	$33	$34,606	Assumes certified clean material costs and truck delivery to site
4.02b	Thin Layer Cap Placement	666	CY	$108	$71,874	Assumes placement of 6 inches of sand
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$428,000**
Total Direct Construction Costs (Items 3 through 6)	**$1,253,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$1,681,000**
Contingency (30% of Construction Subtotal)	**$505,000**
CONSTRUCTION TOTAL	**$2,186,000**
-30%	**$1,530,200**
+50%	**$3,279,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C2-2: Preliminary Cost Estimate for Footprint 2, Contingent Alternative 1 - Enhanced MNR
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$402,840**	
1.01	Remedial Design				$150,360	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$108,560	As a percent of total capital costs
1.04	Project Management			6%	$81,420	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$12,500	$12,500	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$52,140**	
2.01	Pre-Construction Submittals	1	Lump Sum	$27,140	$27,140	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$25,000	$25,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$781,498**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	2	month	$1,587	$3,174	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Thin Layer Capping**				**$250,425**	
4.01	Health and Safety	2	month	$19,850	$39,700	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Thin Layer Cap					
4.02a	Sand (Delivered)	2,107	ton	$33	$68,486	Assumes certified clean material costs and truck delivery to site
4.02b	Thin Layer Cap Placement	1,317	CY	$108	$142,239	Assumes placement of 6 inches of sand
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$455,000**
Total Direct Construction Costs (Items 3 through 6)	**$1,357,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$1,812,000**
Contingency (30% of Construction Subtotal)	**$544,000**
CONSTRUCTION TOTAL	**$2,356,000**
-30%	**$1,649,200**
+50%	**$3,534,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C2-3: Preliminary Cost Estimate for Footprint 3, Contingent Alternative 1 - Enhanced MNR
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$422,110**	
1.01	Remedial Design				$150,360	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$116,000	As a percent of total capital costs
1.04	Project Management			6%	$87,000	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$18,750	$18,750	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$59,000**	
2.01	Pre-Construction Submittals	1	Lump Sum	$29,000	$29,000	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$30,000	$30,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$781,498**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	2	month	$1,587	$3,174	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Thin Layer Capping**				**$344,088**	
4.01	Health and Safety	2	month	$19,850	$39,700	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Thin Layer Cap					
4.02a	Sand (Delivered)	3,044	ton	$33	$98,926	Assumes certified clean material costs and truck delivery to site
4.02b	Thin Layer Cap Placement	1,902	CY	$108	$205,462	Assumes placement of 6 inches of sand
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$482,000**
Total Direct Construction Costs (Items 3 through 6)	**$1,450,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$1,932,000**
Contingency (30% of Construction Subtotal)	**$580,000**
CONSTRUCTION TOTAL	**$2,512,000**
-30%	**$1,758,400**
+50%	**$3,768,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C3-1: Preliminary Cost Estimate for Footprint 1, Contingent Alternative 2 - Capping
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$498,770**	
1.01	Remedial Design			12%	$204,240	As a percent of total capital costs
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$136,160	As a percent of total capital costs
1.04	Project Management			6%	$102,120	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$6,250	$6,250	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$54,040**	
2.01	Pre-Construction Submittals	1	Lump Sum	$34,040	$34,040	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$20,000	$20,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$781,498**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	2	month	$1,587	$3,174	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Capping**				**$596,164**	
4.01	Health and Safety	2	month	$19,850	$39,700	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Sand Layer					
4.02a	Sand (Delivered)	7,496	ton	$33	$243,626	Assumes certified clean material costs and truck delivery to site
4.02b	Sand Layer Placement	4,685	CY	$47	$220,201	Assumes placement of at least 1 ft of clean sand
4.03	Armor Layer					
4.03a	Armor (Delivered)	865	ton	$24	$20,764	Assumes certified clean material costs and truck delivery to site
4.03b	Armor Cap Placement	666	CY	$108	$71,874	Assumes placement of 6 inches of armor stone
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$553,000**
Total Direct Construction Costs (Items 3 through 6)	**$1,702,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$2,255,000**
Contingency (30% of Construction Subtotal)	**$677,000**
CONSTRUCTION TOTAL	**$2,932,000**
-30%	**$2,052,400**
+50%	**$4,398,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C3-2: Preliminary Cost Estimate for Footprint 2, Contingent Alternative 2 - Capping
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$565,500**	
1.01	Remedial Design				$204,240	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$170,720	As a percent of total capital costs
1.04	Project Management			6%	$128,040	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$12,500	$12,500	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$67,680**	
2.01	Pre-Construction Submittals	1	Lump Sum	$42,680	$42,680	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$25,000	$25,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$783,085**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	3	month	$1,587	$4,762	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Capping**				**$1,026,336**	
4.01	Health and Safety	3	month	$19,850	$59,550	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Sand Layer					
4.02a	Sand (Delivered)	12,662	ton	$33	$411,512	Assumes certified clean material costs and truck delivery to site
4.02b	Sand Layer Placement	7,914	CY	$47	$371,944	Assumes placement of at least 1 ft of clean sand
4.03	Armor Layer					
4.03a	Armor (Delivered)	1,712	ton	$24	$41,091	Assumes certified clean material costs and truck delivery to site
4.03b	Armor Cap Placement	1,317	CY	$108	$142,239	Assumes placement of 6 inches of armor stone
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$634,000**
Total Direct Construction Costs (Items 3 through 6)	**$2,134,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$2,768,000**
Contingency (30% of Construction Subtotal)	**$831,000**
CONSTRUCTION TOTAL	**$3,599,000**
-30%	**$2,519,300**
+50%	**$5,398,500**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C3-3: Preliminary Cost Estimate for Footprint 3, Contingent Alternative 2 - Capping
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$599,470**	
1.01	Remedial Design				$204,240	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$186,560	As a percent of total capital costs
1.04	Project Management			6%	$139,920	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$18,750	$18,750	Assumes post-capping survey
2.0	**Pre-Mobilization**				**$76,640**	
2.01	Pre-Construction Submittals	1	Lump Sum	$46,640	$46,640	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$30,000	$30,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$783,085**	
3.01	Mobilization	1	Lump Sum	$492,800	$492,800	
3.02	Temporary Facilities	3	month	$1,587	$4,762	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$248,800	$248,800	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Capping**				**$1,223,732**	
4.01	Health and Safety	3	month	$19,850	$59,550	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Sand Layer					
4.02a	Sand (Delivered)	14,535	ton	$33	$472,393	Assumes certified clean material costs and truck delivery to site
4.02b	Sand Layer Placement	9,084	CY	$47	$426,971	Assumes placement of at least 1 ft of clean sand
4.03	Armor Layer					
4.03a	Armor (Delivered)	2,473	ton	$24	$59,356	Assumes certified clean material costs and truck delivery to site
4.03b	Armor Cap Placement	1,902	CY	$108	$205,462	Assumes placement of 6 inches of armor stone
5.0	**Site Restoration and Demobilization**				**$324,331**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$50,748	$50,748	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$246,400	$246,400	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$677,000**
Total Direct Construction Costs (Items 3 through 6)	**$2,332,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$3,009,000**
Contingency (30% of Construction Subtotal)	**$903,000**
CONSTRUCTION TOTAL	**$3,912,000**
-30%	**$2,738,400**
+50%	**$5,868,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C4-1: Preliminary Cost Estimate for Footprint 1, Contingent Alternative 3 - Sediment Removal
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$591,070**	
1.01	Remedial Design			8%	$194,480	As a percent of total capital costs
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$194,480	As a percent of total capital costs
1.04	Project Management			6%	$145,860	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$6,250	$6,250	Assumes post-dredge survey
2.0	**Pre-Mobilization**				**$68,620**	
2.01	Pre-Construction Submittals	1	Lump Sum	$48,620	$48,620	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$20,000	$20,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$779,869**	
3.01	Mobilization	1	Lump Sum	$461,025	$461,025	
3.02	Temporary Facilities	3	month	$1,483	$4,449	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$277,671	$277,671	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Removal and Backfill**				**$1,278,530**	
4.01	Health and Safety	3	month	$19,850	$59,550	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Mechanical Removal and Transportation of Sediment to Staging Area	3,378	CY	$164	$553,949	Assumes mechanical excavation of sediments in deep water areas
4.03	Turbidity Monitoring	26	day	$462	$12,001	Includes one oversight engineer for half time during sediment removal operations
4.04	Sediment Dewatering/Stabilization					
4.04a	Sediment Mixing (Dewatering/Stabilization)	2,871	CY	$16	$45,937	Assumes ex-situ mixing using hydraulic excavator; add 5% reagent (Portland cement) by weight
4.04b	Water Treatment	115,969	gallon	$0.47	$54,505	Assumes frac tank system used for temporary storage and treatment of decanted water
4.05	Transportation and Disposal					
4.05a	Waste Characterization Sampling	4	sample	$1,500	$6,000	Assumes 1 sample per 1,000 CY
4.05b	Non-Regulated Sediment	4,307	ton	$115	$495,261	Assumes disposal as non-hazardous material
4.05c	Debris	709	ton	$65	$45,903	Estimated at 15% removal volume, assumes transport and disposal at Mercer County Landfill
4.06	Post-Removal Confirmation Sampling	7	sample	$830	$5,423	Includes surface sample collection (1 sample per 5,000 SF) and analysis
4.07	Backfill Dredged Areas (OPTIONAL)	3,378	CY	$149	$503,283	Line item cost not included in total estimated cost for alternative; assumes 1 ft of backfill
5.0	**Site Restoration and Demobilization**				**$372,182**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$114,487	$114,487	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$230,513	$230,513	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$660,000**
Total Direct Construction Costs (Items 3 through 6)	**$2,431,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$3,091,000**
Contingency (30% of Construction Subtotal)	**$928,000**
CONSTRUCTION TOTAL	**$4,019,000**
-30%	**$2,813,300**
+50%	**$6,028,500**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C4-2: Preliminary Cost Estimate for Footprint 2, Contingent Alternative 3 - Sediment Removal
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$758,180**	
1.01	Remedial Design				$194,480	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$286,400	As a percent of total capital costs
1.04	Project Management			6%	$214,800	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$12,500	$12,500	Assumes post-dredge survey
2.0	**Pre-Mobilization**				**$96,600**	
2.01	Pre-Construction Submittals	1	Lump Sum	$71,600	$71,600	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$25,000	$25,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$781,352**	
3.01	Mobilization	1	Lump Sum	$461,025	$461,025	
3.02	Temporary Facilities	4	month	$1,483	$5,933	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$277,671	$277,671	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Removal and Backfill**				**$2,426,445**	
4.01	Health and Safety	4	month	$19,850	$79,400	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Mechanical Removal and Transportation of Sediment to Staging Area	6,506	CY	$164	$1,066,933	Assumes mechanical excavation of sediments in deep water areas
4.03	Turbidity Monitoring	50	day	$462	$23,114	Includes one oversight engineer for half time during sediment removal operations
4.04	Sediment Dewatering/Stabilization					
4.04a	Sediment Mixing (Dewatering/Stabilization)	5,530	CY	$16	$88,477	Assumes ex-situ mixing using hydraulic excavator; add 5% reagent (Portland cement) by weight
4.04b	Water Treatment	223,361	gallon	$0.47	$104,980	Assumes frac tank system used for temporary storage and treatment of decanted water
4.05	Transportation and Disposal					
4.05a	Waste Characterization Sampling	7	sample	$1,500	$10,500	Assumes 1 sample per 1,000 CY
4.05b	Non-Regulated Sediment	8,295	ton	$115	$953,897	Assumes disposal as non-hazardous material
4.05c	Debris	1,366	ton	$65	$88,412	Estimated at 15% removal volume, assumes transport and disposal at Mercer County Landfill
4.06	Post-Removal Confirmation Sampling	13	sample	$830	$10,733	Includes surface sample collection (1 sample per 5,000 SF) and analysis
4.07	Backfill Dredged Areas (OPTIONAL)	6,506	CY	$149	$969,348	Line item cost not included in total estimated cost for alternative; assumes 2 ft of backfill
5.0	**Site Restoration and Demobilization**				**$372,182**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$114,487	$114,487	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$230,513	$230,513	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$855,000**
Total Direct Construction Costs (Items 3 through 6)	**$3,580,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$4,435,000**
Contingency (30% of Construction Subtotal)	**$1,331,000**
CONSTRUCTION TOTAL	**$5,766,000**
-30%	**$4,036,200**
+50%	**$8,649,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

Work is to be conducted 5 days per week, 10 hours per day. Work is to be conducted 9 months per year.

Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C4-3: Preliminary Cost Estimate for Footprint 3, Contingent Alternative 3 - Sediment Removal
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

INDIRECT COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
1.0	**Engineering, Permitting, and Management**				**$918,430**	
1.01	Remedial Design				$194,480	See Footprint 1
1.02	Permitting	1	Field Season	$50,000	$50,000	
1.03	Construction Management			8%	$374,400	As a percent of total capital costs
1.04	Project Management			6%	$280,800	As a percent of total capital costs
1.05	As-Built Bathymetric Survey	1	each	$18,750	$18,750	Assumes post-dredge survey
2.0	**Pre-Mobilization**				**$123,600**	
2.01	Pre-Construction Submittals	1	Lump Sum	$93,600	$93,600	Assumed at 2% of Direct Construction Costs
2.02	Bonds	0	Lump Sum	$0	$0	Assumed not required
2.03	Sub-Bottom Profile Imagery and Side Scan Sonar	1	Lump Sum	$30,000	$30,000	Assumes survey of extent of work areas (existing conditions)

DIRECT CONSTRUCTION COSTS

Item		Quantity	Units	Unit Cost	Total Cost	Comment
3.0	**Mobilization and Site Preparation**				**$784,319**	
3.01	Mobilization	1	Lump Sum	$461,025	$461,025	
3.02	Temporary Facilities	6	month	$1,483	$8,899	Includes delivery and rental of two contractor trailers
3.03	Site Improvements (Temporary Access Roads and Staging Areas)	1	Lump Sum	$277,671	$277,671	Includes clearing & grubbing, rough grading, geotextile, and compacted fill and gravel
3.04	Soil Erosion and Sediment Control	1	Lump Sum	$27,111	$27,111	Estimated SESC measures installation around staging area and along access road
3.05	Turbidity Curtain Installation	1	Lump Sum	$9,613	$9,613	Assumes one silt curtain across width of inlet with 25% additional material for overlapping and repairs
4.0	**Removal and Backfill**				**$3,522,588**	
4.01	Health and Safety	6	month	$19,850	$119,100	Assumes full time health & safety coverage and air monitoring equipment during construction
4.02	Mechanical Removal and Transportation of Sediment to Staging Area	9,435	CY	$164	$1,547,308	Assumes mechanical excavation of sediments in deep water areas
4.03	Turbidity Monitoring	73	day	$462	$33,521	Includes one oversight engineer for half time during sediment removal operations
4.04	Sediment Dewatering/Stabilization					
4.04a	Sediment Mixing (Dewatering/Stabilization)	8,020	CY	$16	$128,313	Assumes ex-situ mixing using hydraulic excavator; add 5% reagent (Portland cement) by weight
4.04b	Water Treatment	323,927	gallon	$0.47	$152,246	Assumes frac tank system used for temporary storage and treatment of decanted water
4.05	Transportation and Disposal					
4.05a	Waste Characterization Sampling	10	sample	$1,500	$15,000	Assumes 1 sample per 1,000 CY
4.05b	Non-Regulated Sediment	12,029	ton	$115	$1,383,378	Assumes disposal as non-hazardous material
4.05c	Debris	1,981	ton	$65	$128,219	Estimated at 15% removal volume, assumes transport and disposal at Mercer County Landfill
4.06	Post-Removal Confirmation Sampling	19	sample	$830	$15,503	Includes surface sample collection (1 sample per 5,000 SF) and analysis
4.07	Backfill Dredged Areas (OPTIONAL)	9,435	CY	$149	$1,405,786	Line item cost not included in total estimated cost for alternative; assumes 2 ft of backfill
5.0	**Site Restoration and Demobilization**				**$372,182**	
5.01	Dismantling and Disposal of Temporary Staging Areas	1	Lump Sum	$114,487	$114,487	Includes equipment, labor and disposal costs for material used to construct staging area
5.02	Restoration of Disturbed Areas	1	Lump Sum	$26,546	$26,546	Assumes restoration to vegetated area
5.03	Break Down Temporary Facilities	1	Lump Sum	$637	$637	Assumed as 50% of one month rental cost
5.04	Demobilization	1	Lump Sum	$230,513	$230,513	Assumed as 50% of mobilization cost

Total Indirect Costs (Items 1 and 2)	**$1,043,000**
Total Direct Construction Costs (Items 3 through 6)	**$4,680,000**
CONSTRUCTION SUBTOTAL (Includes engineering and construction management)	**$5,723,000**
Contingency (30% of Construction Subtotal)	**$1,717,000**
CONSTRUCTION TOTAL	**$7,440,000**
-30%	**$5,208,000**
+50%	**$11,160,000**

GENERAL NOTES

All costs are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.

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Costs do not include property costs (where applicable), access costs, legal fees, Agency oversight, or public relations efforts.

These costs have been developed using currently available information regarding site characteristics such as site bathymetry and potential debris. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

This estimate was developed using current and generally accepted engineering cost estimation methods. Note that this estimate is based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material.

Table C5: Summary of CapSim Input and Output Parameters
Corrective Action Plan, Supplemental Remedial Alternatives Assessment (SRAA)
E.W. Brown Station, Mercer County, Kentucky

Model Input Parameter	Value	Source
Chemical Specific Inputs		
Initial Concentrations beneath the cap (ug/L)	As: 1500 Se: 8.8	Maximum Curds Inlet Porewater concentration
Partitioning Coefficients (log[L/kg])	As: 2.5 Se: 3.6	Allison and Allison 2005. Partition Coefficients for Metals in Surface Water, Soil, and Waste. June. Median Sediment-Water partitioning value selected.
Molecular Diffusivity (cm^2/s)	As: 1.24E-5 Se: 1.20E-5	USEPA 2004. WATER9. Version 2.0.0. Office of Air Quality Planning and Standards. July.; Calculated from WATER9 empirical relationship Dw = 0.00022 * $(MW)^{-(2/3)}$
Chemical biodegradation rate	0	Assumed no biodegradation or transformation of any contaminants
Buffer Layer		
Thickness [cm]	15	Minimum constructibility thickness
Porosity [-]	0.4	Domenico and Schwarz 1990
Dry bulk density [g/cm^3]	1.5	Based on particle density of 2.5 g/cm^3 and porosity of 0.4.
Fraction of organic carbon, foc (%)	4%	Average value of Curds Inlet concentration
Isolation Layer		
Thickness [cm]	15	Varied to evaluate protectiveness of various construction thicknesses
Porosity [-]	0.4	Domenico and Schwarz 1990
Dry bulk density [g/cm^3]	1.5	Based on particle density of 2.5 g/cm^3 and porosity of 0.4.
Fraction of organic carbon, foc (%)	0.1	ITRC 2015
Mass Transport Properties		
Vertical Dispersivity [cm]	3	10% of total domain thickness as discussed in text.
Boundary layer mass transfer (cm/hr)	0.2	Within range of values in Thibodeaux et al 2001.
Darcy Velocity (cm/yr)	526	See discussion in text
Net sedimentation rate (cm/yr)	0	Conservatively assumed no future sedimentation
Consolidation	N/A	Assumed no consolidation of underlying sediment
Bioturbation zone thickness (cm)	15	Depth of buffer layer
Porewater biodiffusion coefficient (cm^2/yr)	100	Based on particle biodiffusion coefficent in Reible and Lambert 2012.
Particle biodiffusion coefficient (cm^2/yr)	1	Based on median presented in Reible and Lambert 2012 for estuarine systems.
Chemical Specific Outputs and Targets - Arsenic and Selenium		
Cap thickness (ft)	**4.5**	**Design Variable**
Arsenic Porewater Target (ug/L)	150	Kentucky Chronic Surface Water Standard for Aquatic Life
Arsenic Porewater Concentration at 100 years (ug/L)	117	Maximum concentration in 0-15cm below sediment surface
Selenium Sediment Target (mg/kg)	2.9	Kentucky Chronic Surface Water Standard for Aquatic Life
Selenium Sediment Concentration at 100 years (mg/kg)	1.2E-16	Maximum concentration in 0-15cm below sediment surface
Chemical Specific Outputs and Targets - Selenium Only		
Cap thickness (ft)	**1.0**	**Design Variable**
Selenium Sediment Target (mg/kg)	2.9	Washington State No Effects Value
Selenium Sediment Concentration at 100 years (mg/kg)	1.219	Maximum concentration in 0-15cm below sediment surface