Prepared for
**Greenfield Environmental Multistate Trust LLC**
**Trustee of the Multistate Environmental Response Trust**

Project Number
**1690019547**

Prepared by
**Ramboll**
**Atlanta, Georgia**

Date
**Final September 2021**

# OU2 ECOLOGICAL RISK ASSESSMENT TECHNICAL MEMORANDUM

## Kerr-McGee Chemical Corp – Navassa Superfund Site
## Navassa, North Carolina

# CONTENTS



# LIST OF EXHIBITS

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF APPENDICES

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| % | percent |
| ADW | Animal Diversity Web |
| AhR | AhR-1 aryl hydrocarbon |
| ARC GIS | Aeronautical Reconnaissance Coverage Geographic Information System |
| ASTM | American Society for Testing and Materials |
| AUF | area use factor |
| bgs | belowground surface |
| DL | detection limit |
| EarthCon | EarthCon Consultants of North Carolina, PC |
| EcoSSL | ecological soil screening level |
| EPC | exposure point concentration |
| EQuIS | Environmental Quality and Information System |
| ERA | ecological risk assessment |
| ESV | ecological screening value |
| HMW | high molecular weight |
| HQ | hazard quotient |
| Integral | Integral Engineering, PC |
| LOAEL | lowest observed adverse effect level |
| LMW | low molecular weight |
| mg/kg | milligram(s) per kilogram |
| Multistate Trust | Multistate Environmental Response Trust |
| NCDEQ | North Carolina Department of Environmental Quality |
| ND | not detected |
| ng/kg | nanogram(s) per kilogram |
| OU1 | Operable Unit 1 |
| OU2 | Operable Unit 2 |
| PAH | polycyclic aromatic hydrocarbon |
| PCDD/Fs | polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans |
| PCDD/F TEQs | PCDDs and PCDFs TEQ (based on TCDD) |
| Ramboll | Ramboll US Consulting, Inc. |
| SIM | selective ion monitoring |
| Site | Navassa Superfund Site |
| SOP | standard operating procedure |
| SWAC | surface weighted average concentration |
| TCDD | 2,3,7,8-tetrachlorodibenzo-*p*-dioxin |
| TDI | total daily intake |
| TEQ | toxic equivalency quotient |
| TOC | total organic carbon |
| TRV | toxicity reference value |
| UCL | upper confidence limit |
| USEPA | United States Environmental Protection Agency |
| USEPA R4 | United States Environmental Protection Agency Region 4 |
| WW | wet weight |

# EXECUTIVE SUMMARY

Ramboll US Consulting, Inc. (Ramboll), Integral Engineering, PC (Integral), and EarthCon Consultants of North Carolina, PC (EarthCon), on behalf of Greenfield Environmental Multistate Trust, LLC, present this Ecological Risk Assessment (ERA) Technical Memorandum for Operable Unit 2 (OU2) of the Kerr-McGee Chemical Corp – Navassa Superfund Site (the Site), located in Navassa, North Carolina. This memorandum documents the June 2020 field investigation for soil invertebrates and co-located soil samples and the calculation of site-specific uptake for polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDD/Fs), in accordance with the "Invertebrate and Soil Sampling Work Plan for Operable Unit 2" (Ramboll and EarthCon, 2020). The ERA provided herein follows the approach agreed upon with United States Environmental Protection Agency (USEPA) and North Carolina Department of Environmental Quality (NCDEQ) in the "White Paper on Addressing Human Health and Ecological Risks from Exposures to Impacted Soils in OU2 and OU4" (Risk Strategy White Paper) (Integral, Ramboll, and EarthCon, 2021) and approved on September 23, 2021. The ERA for OU2 provided herein is also consistent with the "Revised Semi-Screening Level ERA Calculations for OU1" (USEPA R4, 2020).

The purpose of the ERA is to evaluate potential risks for birds and mammals related to high molecular weight (HMW) PAHs, low molecular weight (LMW) PAHs, and PCDD/F toxicity equivalence (TEQ) concentrations in soils to determine if unacceptable ecological risks are potentially present at OU2. Based on discussions with the USEPA and NCDEQ, the following avian and mammalian species were identified as potential receptors for consideration in the OU2 ERA based on their prevalence in the area and potential to be highly exposed to OU2 soil contaminants through the diet:

- American Robin – The robin has a home range of 0.11 to 2 acres (USEPA, 1993; Pitts, 1984) and was selected as the representative small home range avian receptor.
- American Woodcock – The woodcock has a home range of 0.3 to 171.2 acres (USEPA, 1993) and was selected as the representative large home range avian receptor.
- Short-Tailed Shrew – The shrew has a home range of 0.25 to 6 acres (USEPA, 1993; DeGraaf, 2000; University of Michigan Animal Diversity Web [ADW] query, 2021) and was selected as the representative small home range mammalian receptor.
- Raccoon – The raccoon has a home range of 5.3 to 4,946 acres (USEPA, 1993) and was selected as the representative large home range mammalian receptor.

The ERA considers a range of potential land uses, including residential, industrial/commercial, recreational with minimal development (e.g., nature trails), and recreational with development (e.g., sports fields), as indicated in Exhibit ES-1.[1] Consistent with the ERA for Operable Unit 1 (OU1), this ERA evaluates risks to songbirds (robin and woodcock) under future land uses that would result in redevelopment of OU2. Songbirds were selected because of their ability to tolerate a range of human development and their potential to be exposed to OU2 soil contaminants while foraging. Because the OU2 land uses that involve redevelopment (residential, commercial/industrial, and/or recreational – sport field) would limit the quality and amount of wildlife habitat in OU2, the OU2 ERA does not address resident ecological function (e.g., soil invertebrates, mammals) for these land uses. The existing site habitat would not be significantly disturbed from the current conditions under a recreational nature trail land use for OU2. Therefore, the evaluation of risks for the current conditions and for the recreational nature trail land use scenario included a broader range of species, including

[1] Exhibit ES-1 shown here is Table 1B from the June 2021 version of the Risk Strategy White Paper.

small- and large-home range songbirds, small- and large-home range mammals, and soil invertebrates.

**Exhibit ES-1. Summary of Ecological Receptors in OU2 ERA Based on Land Use**

| Land Use Scenarios | Potential Ecological Receptors | Ecological Exposure Area | Basis of Ecological Exposure Point Concentration |
|---|---|---|---|
| Future Residential, Industrial/Commercial, Recreational - Sports Field | Small home range bird species | 2-acre exposure areas drawn around highest concentrations | Surface Weighted Average Concentrations (SWAC) |
| | Large home range songbird species | All of OU2 - 15.6 acres | SWAC |
| Current Conditions<br><br>Future Recreational - Nature Trails | Small home range bird and mammal species | 2-acre exposure areas drawn around highest concentrations | SWAC |
| | Large home range songbird and mammal species | All of OU2 - 15.6 acres | SWAC |
| | Invertebrates | Each individual polygon is considered | Composite Sample Result or 95% Upper Confidence Limit (UCL) or Maximum of Discrete Sample Results if no Composite Sample Result Available |

**OU2 Soil Invertebrate and Soil Investigation to Support the ERA**

The soil invertebrate and soil sampling for OU2 was conducted in June 2020 in support of calculating Site-specific uptake factors. Sampling was completed at 15 locations, representing a range of HMW PAHs within OU2. Samples included belowground (soil-dwelling) invertebrates and aboveground (surface-dwelling) invertebrates. Most of the soil-dwelling invertebrate samples were comprised of earthworms. Aboveground invertebrate samples were composites of a number of different types of invertebrates that were present at OU2 at the time of sampling. In addition, three larval wasp samples were collected opportunistically during sampling. Co-located surface soil composites from 0 to 6 inches belowground surface were concurrently collected along with the belowground invertebrates. Tissue and soil samples were analyzed for alkylated and nonalkylated PAHs, PCDD/Fs, percent (%) lipid (in tissue), total organic carbon (in soil), and % moisture.

Site-specific uptake equations for HMW and LMW PAHs and PCDD/F TEQs were calculated using the soil and adult invertebrate data collected in June 2020.[2] The analysis of the invertebrate data focused on soil data below 250 milligrams per kilogram (mg/kg) HMW PAHs and the co-located samples, where

[2] Since there was sufficient mass of adult aboveground invertebrates for laboratory analysis, larval wasp samples were not used in the risk characterization of OU2.

the relationship between soil invertebrates and soil was strongest and most consistent, and therefore provides for more pertinent data for decision-making. As a consequence, four samples dominated by adult wasps, which had the highest HMW PAH concentrations, were not included in the uptake evaluation. For PAHs and PCDD/Fs, best fit regression lines were evaluated to determine which equation provided the best fit between the soil PAH data and the corresponding tissue PAH concentration. A linear uptake was determined to provide the best fit for PAHs and PCDD/F TEQs for aboveground and belowground invertebrates. The uptake equations were used to estimate soil invertebrate tissue concentrations in the ERA food web modeling based on site-specific soil data. The site-specific soil invertebrate data contributed to the understanding of site-specific ecological risks because the data show that the actual concentrations of PAHs and PCDD/Fs detected in OU2 soil invertebrates were lower than might be predicted from default literature values.

**OU2 Ecological Risk Assessment**

OU2 was segregated into 92 polygons that were ¼-acre or less in size to support human health and ecological risk assessment. Representative PAH and PCDD/F TEQ concentration data for each of these polygons were used in a food web model to characterize potential risks to birds and mammals. The songbirds considered in this OU2 ERA are the same as those considered for OU1, which include a large home range species (American woodcock) and a small home range species (American robin). This OU2 ERA also considers potential exposures and potential risks to a large home range mammal (raccoon), a small home range mammal (short tailed shrew) and soil invertebrates.

**ERA Approach and Results for Birds and Mammals**

The ERA is based on consideration of risks to wildlife estimated using hazard quotients (HQs), which are the ratio of concentration exposures and lowest observed adverse effect level (LOAEL) toxicity reference values (TRVs) protective of birds and mammals. LOAEL HQs were calculated for each receptor for the HMW and LMW PAHs and for bird and mammal PCDD/F TEQs. A food web model was developed to estimate exposure based on species-specific ecological exposure parameters and estimated total daily intake (TDI) calculations. USEPA Region 4 (R4) TRVs were used as estimates of safe levels for the HQ calculation.

Exposure areas are 15.6 acres (all of OU2) for large home range species and 2 acres for small home range species. EPCs are SWACs for each exposure area and were calculated as follows:

1. Large home range bird and mammal receptors (American woodcock and raccoon):
   To address ecological risk to large home birds and mammals, PAH and PCDD/F TEQ exposure concentrations for soil were based on the SWACs for all of OU2. The SWAC was based on a representative concentration established for each polygon based on the available OU2 data from 2004 to 2020. The OU2 SWAC is calculated using the following formula:

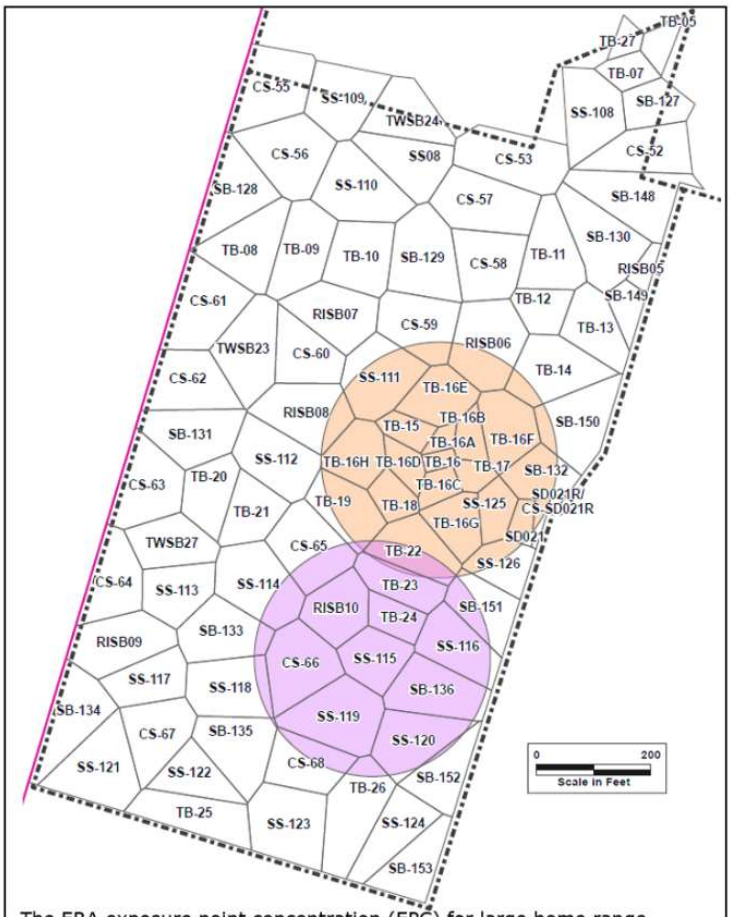
$$SWAC = \frac{(Area_{Parcel\,1} \times Concentration_{Parcel\,1}) + (Area_{Parcel\,2} \times Concentration_{Parcel\,2}) + \ldots}{Area_{Parcel\,1} + Area_{Parcel\,2} + \ldots}$$

   For polygons that are truncated by the OU2 boundary, only those portions of the polygons that fall within the OU2 boundary were used in the calculation of the SWAC. The ERA included two exposure considerations for species that have natural home ranges larger than the spatial scale of OU2. The first exposure consideration assumes that these species live exclusively at

OU2 (i.e., area use factor [AUF] = 1). The second exposure consideration is based on the estimated home range of the woodcock and raccoon relative to the size of OU2 (i.e., the animals move into and out of OU2 as they naturally move around their home ranges).

2. Small home range bird and mammal receptors (American robin and shrew):
   To address ecological risk to small home range birds and mammals, a 2-acre exposure area was used and an EPC was calculated based on the SWAC for 2-acre circular area centered around the highest concentrations of PAHs and PCDD/F TEQ in surface soil (as shown in Exhibit ES-2).

   The 2-acre SWACs are based on the HMW PAHs, LMW PAHs, avian PCDD/F TEQ, and mammal PCDD/F TEQ concentrations for parcels wholly or partially in these 2-acre areas—taking into consideration the spatial proportion of the polygons within the 2-acre area. The food web model assumes that small home range birds and mammals live only within this 2-acre area, which is the highest small home range bird and mammal exposure that would be expected for OU2.




The ERA exposure point concentration (EPC) for large home range species is a SWAC based on the polygons within OU2. The ERA EPC for small home range species are based on SWACs for the 2-acre circular areas centered on the polygon with the highest HMW PAHs (TB-16) and PCDD/F TEQ (SS-115).

**Exhibit ES-2. OU2 Polygons Considered for the OU2 SWACs for Large Home Range Species and the 2-Acre SWACs for Small Home Range Species**

The OU2 SWAC or 2-acre SWAC was used in a food web model to evaluate potential risks to birds and mammals. The food web model was conducted for LMW PAHs, HMW PAHs, and PCDD/F TEQ, with results reflected in terms of the HQ. The food web model for birds and mammals used dietary exposure scenarios that range from high exposure diet scenarios (i.e., diets that would lead to greater exposure than expected under true Site conditions) to diet scenarios that more realistically represent the mix of food sources that the receptor is likely to eat from OU2. As agreed with the USEPA and NCDEQ on a conference call dated May 10, 2021, the diet scenarios considered are comprised of the following[3]:

[3] Four dietary scenarios are used for the American robin and 2 dietary scenarios are used for each of the other ecological receptors (woodcock, raccoons, and shrews). The diets for the robin include ingestion of invertebrates and plants. As indicated in the OU1 Semi-Screening ERA, "plant material is expected to contain very little PAH, as plants have in general not been observed to accumulate lipophilic compounds such as PAHs into their fruits to an appreciable extent. It is expected that incorporation of plant material into the diet of robins would likely serve to decrease the estimated PAH dose the birds are receiving, and thereby lower the estimated risks".

**American robin**

- Scenario 1: A diet consisting of solely belowground invertebrates (i.e., earthworms), which reflects the high exposure diet for the robin.
- Scenario 2: A diet split 50/50 between plants and belowground invertebrates.
- Scenario 3: A diet consisting of 50% aboveground and 50% belowground invertebrates.
- Scenario 4: A diet consisting of 30% plants, 35% aboveground and 35% belowground invertebrates which is a more realistic representation of the robin's diet at OU2.

**American woodcock**

- Scenario 1: A diet consisting of solely belowground invertebrates (i.e., earthworms), which reflects the high exposure diet for the woodcock.
- Scenario 2: A diet consisting of 50% aboveground and 50% belowground invertebrates, which is a more realistic representation of the woodcock's diet at OU2.

**For mammals (raccoons):**

- Scenario 1: 20% plants and 80% belowground invertebrates (i.e., earthworms), which reflects the high exposure diet.
- Scenario 2: 20% plants, 40% aboveground invertebrates, and 40% belowground invertebrates, which is a more realistic representation of the raccoon's diet at OU2.

**For mammals (shrews):**

- Scenario 1: 100% belowground invertebrates, (i.e., earthworms), which reflects the high exposure diet.
- Scenario 2: 50% belowground invertebrates and 50% aboveground invertebrates, which is a more realistic representation of the shrew's diet at OU2.

The food web model for birds and mammals considers uptake from soil to dietary prey items based on the site-specific uptake factors derived from the June 2020 soil and soil invertebrate PAH and PCDD/F study. The ERA food web HQ results for birds and mammals are summarized in Exhibit ES-3, with blue and green highlighted cells showing HQs greater than 1. Exhibit ES-3 summarizes the HQs for birds and mammals for each of the diet scenarios, considering SWACs and AUFs based on the size of the home range of the species.

| Exhibit ES-3. Summary of LOAEL SWAC HQs | | | | | |
|---|---|---|---|---|---|
| **Receptor** | **Chemical** | **LOAEL SWAC HQ (unitless)** | | | |
| | | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** |
| **American Robin** | | | | | |
| American Robin (AUF=1) | Σ10 HMW PAHs | **20** | **10** | **9** | **7** |
| | Σ7 LMW PAHs | 0.2 | 0.09 | 0.09 | 0.07 |
| | PCDD/F Avian TEQ | 0.1 | 0.07 | 0.09 | 0.07 |
| **American Woodcock** | | | | | |
| | | **Conservative Scenario** | | **Realistic Scenario** | |
| American Woodcock (AUF=1) | Σ10 HMW PAHs | **6** | | **3** | |
| | Σ7 LMW PAHs | 0.03 | | 0.02 | |
| | PCDD/F Avian TEQ | 0.04 | | 0.02 | |
| American Woodcock (AUF=0.63) | Σ10 HMW PAHs | **4** | | **2** | |
| | Σ7 LMW PAHs | 0.02 | | 0.01 | |
| | PCDD/F Avian TEQ | 0.03 | | 0.01 | |
| **Shrew and Raccoon** | | | | | |
| | | **Conservative Scenario** | | **Realistic Scenario** | |
| Short-tailed Shrew (AUF = 1) | Σ10 HMW PAHs | **3** | | 1 | |
| | Σ7 LMW PAHs | 0.02 | | 0.01 | |
| | PCDD/F Mammal TEQ | 0.8 | | 0.5 | |
| Raccoon (AUF = 1) | Σ10 HMW PAHs | 0.3 | | 0.2 | |
| | Σ7 LMW PAHs | 0.002 | | 0.0009 | |
| | PCDD/F Mammal TEQ | 0.07 | | 0.04 | |

The following HQ results from the food web model were observed for the birds and mammals (Exhibit ES-3):

- **LMW PAHs and PCDD/F TEQ HQs:** The HQs for LMW PAHs and PCDD/F TEQ were less than 1 for each of the birds and mammals considered in the food web modeling, whether based on a diet consisting solely of belowground invertebrates that would lead to higher exposure than expected under true site conditions or a more realistic diet consisting of a mixed food sources. HQs of less than 1 indicate an acceptable risk.
- **HMW PAH HQs**: The HMW PAH HQs for the raccoon are less than 1 for both the high exposure and the more realistic diet scenarios—indicating no unacceptable risk to raccoons. The HMW PAH HQs for the robin, woodcock, and shrew varied based on the species and species-specific diet, and, in the case of the woodcock, the AUF, as listed below. For these species, the lower HQ end of the range reflects the most likely species-specific mixed diet, and the upper end of the range reflects the highly exposed diet (i.e., diets comprised of all belowground invertebrates).

    - Robin: HQs range from 7 to 20
    - Woodcock: HQs range from 3 to 6 when the AUF is based on 100% use of OU2 and HQs range from 2 to 4 when the AUF reflects species-specific home ranges
    - Raccoon: HQs range from 0.2 to 0.3 (i.e., the HQs are less than 1)
    - Shrew: HQs range from 1 to 3.

The HMW PAH HQs for the woodcock and the shrew are within or close to the HQ range of 2 to 4 which may be considered acceptable, as stated in the Risk Strategy White Paper. The HQs for the robin range from 7 to 20. The HMW PAH HQs for the robin are based on a 2-acre exposure area centered on the area of OU2 with the highest concentrations of HMW PAHs. It can be reasonably expected that these HQs are not representative of robin exposure to HMW PAHs in other areas of OU2 where HMW PAH concentrations are lower.

**ERA Approach and Results for Soil Invertebrates**

This OU2 ERA considers potential risks for soil invertebrates exposed to PAHs in OU2 soils. Soil invertebrates exposure to PCDD/Fs was not considered because invertebrates lack the 1 aryl hydrocarbon (AhR) receptor where PCDD/F binding occurs and therefore, are not sensitive to PCDD/F toxicity. The evaluation of ecological risk due to soil invertebrates exposure to PAHs in OU2 soils is based on a comparison of OU2 HMW and LMW PAH soil concentrations to the USEPA PAH Ecological Soil Screening Levels (EcoSSLs) for soil invertebrates. HQs are calculated as the ratio of concentration in each less than ¼-acre polygon to the USEPA PAH EcoSSLs. The USEPA PAH EcoSSLs for soil invertebrates used to calculate HQs are based on studies including 10% reduction of reproduction and growth. This means that HQs exceeding 1 may indicate a 10% reduction of reproduction and growth.

The ERA for soil invertebrates indicates that the majority of OU2 soils have HMW and LMW PAH concentrations less than the USEPA PAH EcoSSLs for soil invertebrates (i.e., HQs less than 1):

- For HMW PAHs, 56 of 88 polygons had HQs of 1 or below. The HMW PAH concentrations for 29 polygons yielded HQs of 2 to 10. The remaining three polygons (SS-117, TB-12, and TB-16) had HMW PAH HQs of 20, 20, and 100, respectively.
- For LMW PAHs, 85 of 88 polygons had HQs below 1. The three remaining polygons (TB-12, TB16-F, and TB-16) had HQs of 2, 8, and 20, respectively.
- The June 2020 soil invertebrate survey involved collection of soil invertebrates from polygons at OU2 with soil concentrations that yielded HMW PAH HQs that ranged from 0.03 to 20 and LMW PAH HQs that ranged from 0.003 to 8. Six of the polygons where soil invertebrates were collected had HMW PAH HQs ranging from 2 to 20 and one LMW PAH HQ of 8. Soil invertebrates were present in these polygons.

**ERA Conclusions**

The following conclusions can be drawn based on the ERA for birds, mammals, and soil invertebrates.

**Birds and Mammals**

- LMW PAHs and PCDD/Fs: HQs were less than 1 for LMW PAHs and PCDD/Fs for songbirds and mammals, indicating these chemicals in OU2 soils would not likely pose unacceptable risks to wildlife.
- HMW PAHs
    - HQs were less than 1 for HMW PAHs for the raccoon, indicating that omnivorous large home range mammals that may inhabit OU2 are not likely to experience unacceptable risks.

- The HQs for HMW PAHs for the woodcock range from 2 to 6 based on the range of diet and AUFs considered. If it is conservatively assumed that the woodcock has a diet consisting solely of belowground invertebrates, the HQ for HMW PAHs ranges from 4 to 6—with the lower HQ based on consideration of the woodcock's home range. However, when a more realistic diet for the woodcock is considered, the HQ ranges from 2 to 3. Consistent with the Risk Strategy White Paper and the OU1 ERA (USEPA, 2020), the HQs calculated for the woodcock and other birds like woodcock may be considered acceptable for OU2 given 1) the uncertainty in the risk estimates that, if accounted for, would tend to lower the risk, and 2) the knowledge that all or a large portion of OU2 will likely be redeveloped in the future.
- The HQs for HMW PAHs for the robin range from 7 to 20.

**Soil Invertebrates**

- The risk characterization indicates HQs less than 1 across the majority (approximately 70% for HMW PAHs and approximately 98% for LMW PAHs) of OU2 (HQs are less than or equal to 1).
- The analysis suggests potential risks to invertebrates in polygons with PAH HQs >1 based on the EPA EcoSSLs, which reflects a 10% reduction in soil invertebrate growth rates and reproduction; which, in turn, suggests a potential that PAH concentrations may locally impact the availability of invertebrates as a food source in the food web or reduce other soil functions. This is particularly true of polygon TB-16, which had an HQ = 100. Polygon TB-16 coincides with the area of highest HQs for robins. All other polygons had an HQ ≤ 20. Field observations suggest that invertebrates were present in polygons with HQs as high as 20.

# 1. INTRODUCTION

This Technical Memorandum presents information supporting the evaluation of potential ecological risks at the Kerr-McGee Chemical Corp – Navassa Superfund Site [U.S. Environmental Protection Agency (USEPA) ID# NCD980557805], referred to herein as the Site, located in Navassa, North Carolina (Figure 1-1). This Technical Memorandum presents an ecological risk assessment (ERA) for Operable Unit 2 (OU2) of the Site (Figure 1-2A and Figure 1-2B), referred to herein as the OU2 ERA Technical Memorandum, and is submitted by Ramboll US Consulting, Inc. (Ramboll), Integral Engineering, PC. (Integral), and EarthCon Consultants of North Carolina, PC. (EarthCon) on behalf of Greenfield Environmental Multistate Trust LLC, not individually but solely in its representative capacity as Trustee of the Multistate Environmental Response Trust (the Multistate Trust). This ERA was completed following the approach agreed upon with USEPA and North Carolina Department of Environmental Quality (NCDEQ) in the "*White Paper on Addressing Human Health and Ecological Risks from Exposures to Impacted Soils in OU2 and OU4*" (Risk Strategy White Paper), and approved on September 23, 2021 (Integral, Ramboll, and EarthCon, 2021).

The purpose of the ERA is to evaluate potential risks for birds and mammals related to high molecular weight (HMW) polycyclic aromatic hydrocarbons (PAHs), low molecular weight (LMW) PAHs, and polychlorinated dibenzo-p-dioxins/polychlorinated dibenzo furans (PCDD/F) toxic equivalency quotient (TEQ) concentrations in soils to determine if unacceptable ecological risks are potentially present at OU2.

Based on discussions with the USEPA and NCDEQ, the following avian and mammalian species were identified as potential receptors for consideration in the OU2 ERA based on their prevalence in the area and potential to be highly exposed to OU2 soil contaminants through the diet:

- American Robin – The robin has a home range of 0.11 to 2 acres (USEPA, 1993; Pitts, 1984) and was selected as the representative small home range avian receptor.
- American Woodcock – The woodcock has a home range of 0.3 to 171.2 acres (USEPA, 1993) and was selected as the representative large home range avian receptor.
- Short-Tailed Shrew – The shrew has a home range of 0.25 to 6 acres (USEPA, 1993; DeGraaf, 2000; University of Michigan Animal Diversity Web [ADW] query, 2021) and was selected as the representative small home range mammalian receptor.
- Raccoon - The raccoon has a home range of 5.3 to 4,946 acres (USEPA, 1993) and was selected as the representative large home range mammalian receptor.

This memorandum documents the June 2020 field data collection completed to calculate site-specific uptake for PAHs and PCDD/Fs. The June 2020 field event included collection and analyses of soil invertebrates and co-located soil samples in accordance with the "*Invertebrate and Soil Sampling Work Plan for Operable Unit 2*" (the OU2 Soil and Soil Invertebrate Work Plan) approved by the USEPA and North Carolina Department of Environmental Quality in May 2020 (Ramboll and EarthCon, 2020).

The ERA estimates risks to wildlife using hazard quotients (HQs), which are the ratio of exposure concentrations to toxicity reference values (TRVs) protective of birds and mammals. Lowest observed adverse effect level (LOAEL) HQs were calculated for each receptor for the HMW and LMW PAHs and for bird and mammal PCDD/F TEQs. A food web model was developed to estimate exposure based on species-specific ecological exposure parameters and estimated total daily intake (TDI) calculations. The site-specific uptake factors derived from the June 2020 field event and surface soil PAH and

PCDD/F data for OU2 were used in the ERA food web model to estimate HQs based on USEPA Region 4 (R4) TRVs.

The remainder of the OU2 ERA Technical Memorandum is organized as follows:

- Section 2.0 – 2020 ERA-Related OU2 Investigation and Results
- Section 3.0 – OU2 ERA
- Section 4.0 – Discussion and Conclusions
- Section 5.0 – References

# 2. 2020 ERA-RELATED OU2 INVESTIGATION AND RESULTS

This ERA relies on soil and tissue data collected in June 2020 to estimate representative ecological exposures. This section summarizes the June 2020 investigation and results.

## 2.1 June 2020 Field Collection and Laboratory Analysis Summary

The purpose of the June 2020 investigation was to collect co-located samples of soils and invertebrate tissues to calculate Site-specific uptake factors for PAHs and PCDD/Fs from soils to invertebrate tissue and, in turn, support the development of a food web model for OU2.

As part of the characterization and evaluation of human health risks, OU2 was segregated into 92 polygons of ¼-acre or less. The 92 polygons for OU2 are illustrated on Figure 2-1, as Thiessen polygons developed using Aeronautical Reconnaissance Coverage Geographic Information System (ARC GIS) tools. Previously collected data were evaluated to identify 15 polygons (Figure 2-1) for the June 2020 sampling event to provide a data set that is representative of the range in HMW PAH concentration in OU2 soils for the calculation of Site-specific uptake factors. Ramboll completed the OU2 soil invertebrate survey June 15 to 20, 2020. Field activities were consistent with the OU2 Soil and Soil Invertebrate Work Plan (Ramboll and EarthCon, 2020). Samples included co-located surface soil and terrestrial invertebrates, including surface-dwelling (or aboveground) invertebrates and soil-dwelling (or belowground) invertebrates (primarily earthworms). In addition, depurated earthworms were collected. Larval aboveground invertebrates (i.e., wasp larvae) were collected opportunistically at three locations and analyzed for PAHs. Ultimately the wasp larval data were not used for the ERA in Section 3 because there was sufficient adult aboveground invertebrate mass for the ERA. In addition, four samples dominated by adult wasps were excluded from the ERA as the analysis of the invertebrate data focused on data below 250 milligrams per kilogram (mg/kg), where the relationship between soil invertebrates and soil was strongest and most consistent, which provides more pertinent data for decision-making. The larval wasp PAHs results and the adult wasps PAHs and PCDD/Fs results are provided in appendices along with other tissue sample results for reference, if warranted. Field data sheets are presented in Appendix A, and a photolog is presented in Appendix B.

The invertebrate samples were composites of multiple individual organisms and were collected as described in the OU2 Soil and Soil Invertebrate Work Plan, and as follows:

- Aliquots of surface soil were collected from locations where belowground invertebrates were collected (co-located) at a depth between 0 to 6 inches belowground surface (bgs).
- The contribution of each aliquot to a composite surface soil sample was qualitatively weighted towards how many belowground invertebrates were collected from any area, with more belowground invertebrates present having a greater contribution of soil in the composite sample so the most accurate uptake relationships between soil and belowground invertebrates could be identified for use in the ERA of OU2.

The samples collected from each polygon[4] (belowground invertebrates, aboveground invertebrates, depurated earthworms, and soil samples) are summarized on Table 2-1. Belowground invertebrates

[4] Each polygon sampled was assigned a sequential identification number (e.g., P01, P02). This identification number along with the historical sample soil sample identification used to select the polygon based on HMW PAH concentration was used to identify a sample from the June 2020 investigation.

were primarily non-depurated earthworms with some locations also being a mixture of non-depurated earthworms, grubs, and mealworms[5]. Table 2-1 also includes information about each sample, such as sample weight, soil description, and if a polygon was expanded to another polygon with a similar PAH concentration range to collect the minimum required invertebrate mass for analysis.

In December 2020, the USEPA, NCDEQ and the Multistate Trust decided to analyze for PCDD/Fs in samples where there was sufficient remaining soil and tissue mass to support calculation of site-specific uptake factors for PCDD/Fs. The samples analyzed for PCDD/Fs are presented in Table 2-2A.

### 2.1.1 Setting

The habitat of OU2 consists of a wooded mix of deciduous and coniferous trees with an understory consisting of occasional shrubs in areas with significant canopy, and grasses and small plants in more open areas. Appendix B contains a photolog of the sampling area. In general, there was a thick covering of pine needles on the ground.

The soils in the majority of polygons sampled were wet from recent rainfall with many isolated and interspersed areas of standing water, from a few to several inches deep. These areas of standing water varied in width from several feet to encompassing approximately half of the polygon area. In areas with trees that had fallen, small patches of grasses and other small vegetation, such as privet, have colonized the area due to increased sunlight. The growth of grass and other small vegetation may have been aided by the trenching activities occurring in various parts of OU2, which exposed the soil beneath the thick pine needle cover.

Each of the OU2 polygons that was sampled for soil invertebrates appeared to have a diverse and robust invertebrate community that consisted primarily of organisms such as earthworms, centipedes, ants, snails, slugs, pill bugs, spiders, beetles, wasps, grasshoppers, and crickets. Appendix B contains representative photos of some of the observed invertebrate species. In addition, various wildlife was observed during the sampling activities, including birds, turtles, snakes, lizards, salamanders, frogs, deer, and skunk.

### 2.1.2 Laboratory Analysis Methods

Tissue and soil samples for alkylated and nonalkylated PAH, percent (%) lipid, and % moisture analysis were shipped under chain of custody to SGS Axys Canada on June 23, 2020 and received in good condition on June 25, 2020 (Appendix C1). Soil samples for total organic carbon (TOC) analysis were shipped to SGS Dayton on June 23, 2020 and received in good condition on June 25, 2020 (Appendix C1). For tissue samples, contents were homogenized in their respective sample jars to minimize tissue loss due to transfer before analysis. Extra soil and tissue samples not used up during the analyses were frozen by the laboratory and placed in storage. The USEPA, NCDEQ, and the Multistate Trust decided to analyze any remaining soil and tissue samples in cold storage for PCDD/Fs in December 2020. The remaining tissue and soil samples with a mass of 2 grams or greater were analyzed. The samples analyzed for PCDD/Fs are presented in Table 2-2A. Laboratory detection limits were verified prior to the PCDD/F tissue analyses (Table 2-2B).

Soil and tissue samples were analyzed using the following methods summarized in Exhibit 2-1:

[5] Five polygons—P01(SS-121), P03(SS-123), P07(TWSB-23), P09(TB-16F), and P10(TB-14) included earthworms with either grubs or meal worms.

| Exhibit 2-1. Soil and Tissue Analytical Methods | |
|---|---|
| **Analyte** | **Laboratory Method** |
| **Soil Samples** | |
| Alkylated PAHs | USEPA 8270D-SIM |
| Nonalkylated PAHs | USEPA 8270D |
| Moisture content | ASTM D2974 |
| TOC | USEPA 9060 |
| PCDD/F | USEPA 8290 |
| **Tissue Samples** | |
| Alkylated PAHs | USEPA 8270-PAH-ALK-SIM |
| Nonalkylated PAHs | USEPA 8270-PAH-SIM |
| Moisture content | Axys SOP SLA-015 |
| Lipids | Axys SOP SLA-020 |
| PCDD/F | USEPA 8290 |
| ASTM – American Society for Testing and Materials<br>SIM – Selected ion monitoring<br>SOP – Standard operating procedure | |

The soil and tissue laboratory reports for PAH and PCDD/Fs analyses are presented in Appendix C, with 20% of the samples reported as a Level IV data package and 80% of the samples reported as a Level II data package. Data were validated by a third-party validator, and the validation reports are presented in Appendix D. The third-party validation confirmed the quality of the data are appropriate for use in this OU2 ERA Technical Memorandum. Validated data in tabular format are presented in Appendix E. The soil and tissue data for PAHs were provided to the USEPA and NCDEQ in the electronic Environmental Quality and Information System (EQuIS) database format in January 2021, and PCDD/Fs were provided in May 2021 (EarthCon, 2020; 2021).

## 2.2 Analytical Results

This section summarizes the soil and invertebrate PAH and PCDD/F TEQ concentration results. These data provide a basis for the site-specific PAH and PCDD/F TEQ uptake equations and the ERA presented in Section 4.

The sum of concentration was calculated for each of the following PAH mixtures:

- Alkylated PAHs – A sum of 15 PAHs (∑15 Alkylated PAHs) based on C1-Benzo[a]anthracenes/Chrysenes, C1-Fluoranthenes/Pyrenes, C1-Fluorenes, C1-Phenanthrenes/Anthracenes, C2-Benzo[a]anthracenes/Chrysenes, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Benzo[a]anthracenes/Chrysenes, C3-Fluorenes, C3-Naphthalenes, C3-Phenanthrenes/Anthracenes, C4-Benzo[a]anthracenes/Chrysenes, C4-Naphthalenes, and C4-Phenanthrenes/Anthracenes.
- HMW (nonalkylated) PAHs – A sum of 12 PAHs (Σ12 HMW PAHs) based on Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[e]pyrene, Benzo[g,h,i]perylene, Benzo[j,k]fluoranthenes, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Indeno[1,2,3-cd]pyrene, Perylene, and Pyrene.

- LMW weight (nonalkylated) – A sum of 8 PAHs (∑8 LMW PAHs) based on 1-Methylnaphthalene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluorene, Naphthalene, and Phenanthrene.
- Total (alkylated and nonalkylated combined) PAHs – A sum of alkylated and nonalkylated (HMW and LMW) PAHs (Total ∑35 PAHs).

For any individual PAH that is not detected (ND), a concentration of one-half the laboratory detection limit (DL) was used for the purpose of calculating each of the above sums. PCDD/F mixtures are addressed using the TEQ approach for birds and mammals based on the World Health Organization equivalency factors and in a manner consistent with USEPA guidance on TEQs (Van den Berg et al., 1998). The PCDD/F TEQ was calculated by multiplying the soil or tissue concentration of each dioxin and dioxin-like compound by its corresponding avian or mammalian toxic equivalent factor and then summing the results to reflect potential exposures to soil or tissue for birds or mammals in terms of TEQ. Any non-detected concentrations are conservatively treated as equal to the laboratory DL for the purpose of calculating the sum.

### 2.2.1 June 2020 Soil Concentrations

The OU2 soil concentrations are provided in Table 2-3A for the PAH sums and the PCDD/F TEQs (avian and mammal). The HMW PAHs and PCDD/F mammal TEQ soil concentrations are illustrated on Figures 2-2 and 2-3, respectively. A summary of the OU2 soil concentrations is provided in Exhibit 2-2, showing the maximum concentrations, the upper confidence limit (UCL)[6], and the average concentrations. The data supporting the sum of PAHs and the PCDD/F TEQs are provided as follows:

- Validated PAH analytical data for individual PAHs are provided in Appendix E1-A.
- Validated PCDD/F analytical data for individual PCDD/Fs are provided in Appendix E2-A.
- Calculation of PAH sums (Total ∑35 PAHs, ∑15 Alkylated PAHs, ∑12 HMW PAHs, ∑8 LMW PAHs) is provided in Appendix E1-B.
- The calculation of PCDD/F TEQ (avian and mammal) soil and tissue concentrations is provided in Appendix E2-B1 and Appendix E2-B2, respectively.
- Table 2-2A presents the analytical soil concentrations of PAHs, in milligrams per kilogram (mg/kg), and PCDD/F TEQs, in nanograms per kilogram (ng/kg), by polygon.
- Figure 2-2 and Figure 2-3 present PAH and PCDD/F TEQ soil concentrations.
- ProUCL output is provided in Appendix F.
- The analytical data for individual PAHs and individual PCDD/F congeners is provided in Appendix H.

[6] The 95% UCLs are calculated by USEPA ProUCL Software.

A summary of soil concentration data by PAH and PCDD/F TEQ type is presented in Table 2-3B, and highlighted in Exhibit 2-2. Alkylated HMW and LMW PAHs are presented in the uncertainty section in Section 3.3.

| Exhibit 2-2. Summary for June 2020 Soil Concentrations | | | |
|---|---|---|---|
| **ΣPAH and PCDD/F TEQ** | **Soil Concentration for Uptake Evaluation for OU2 (mg/kg PAHs and ng/kg TEQ)** | | |
| | **Average** | **95% UCL** | **Maximum** |
| Total Σ35 PAH – Alkylated and nonalkylated | 227 | 325 | 718 |
| Σ15 Alkylated PAHs | 70.1 | 100 | 211 |
| Σ12 HMW PAHs – Nonalkylated | 149 | 215 | 501 |
| Σ8 LMW PAHs – Nonalkylated | 8.67 | 12.1 | 32.8 |
| Avian PCDD/F TEQ | 6.35 | 9.81 | 18.3 |
| Mammal PCDD/F TEQ | 9.15 | 15.1 | 27.9 |

### 2.2.2 June 2020 Tissue Residue Concentrations

The tissue residue concentrations for the soil invertebrate samples from the June 2020 OU2 investigation are summarized in Exhibits 2-3A, 2-3B, and 2-3C. The data sets are provided in Appendix E. Appendices E1-A, E1-B, E2-A and E2-B present the tissue data and calculations for each PAH sum and PCDD/F TEQ for the June 2020 field event. Table 2-4A presents the analytical tissue residue concentrations of PAHs, in mg/kg of wet weight (WW), and PCDD/F TEQs by polygon for aboveground invertebrates, belowground invertebrates[7], and depurated earthworms. Depurated earthworms were not used in the food web model or to calculate site-specific uptake factors.

As discussed in Section 2.1, larval aboveground invertebrate tissue data were not used in the ERA as there was sufficient tissue data for belowground and aboveground invertebrates to calculate site-specific uptake equations. A comparison of larval PAH tissue results to adult aboveground invertebrates and belowground invertebrates indicated that larval concentrations were lower than the adult aboveground or belowground invertebrates (Table 2-4B).[8] In addition, adult wasp samples were not used in the ERA as the analysis of invertebrate data was focused on soil data below 250 mg/kg HMW PAHs. Samples dominated by wasps were associated with soil samples above 250 mg/kg HMW PAHs.

Figure 2-4A presents the measured invertebrate PAH tissue concentrations organized by polygon. The relationship between HMW PAH concentrations in soil versus HMW PAH concentration in the invertebrate tissues is presented in Figures 2-4B and 2-4C. The avian and mammal PCDD/F TEQs for the soil invertebrate tissues are illustrated by polygon on Figures 2-5A and 2-5B, respectively. A summary of tissue concentration data by PAH and PCDD/F TEQ type is presented in Table 2-4B, and highlighted in Exhibits 2-3A, 2-3B, and 2-3C. Alkylated HMW and LMW PAHs are presented in the uncertainty section in Section 3.3.

[7] The belowground invertebrate tissues were not depurated.
[8] Larval aboveground invertebrate samples were not analyzed for PCDD/Fs.

| Exhibit 2-3A. Summary of Aboveground Invertebrate Tissue Concentrations | | | |
|---|---|---|---|
| **Aboveground Invertebrates** | **WW Tissue Residue Concentrations (mg/kg PAHs and ng/kg TEQ)** | | |
| | **Average** | **95% UCL** | **Maximum** |
| Total Σ35 PAH – Alkylated and nonalkylated | 6.81 | 30.2 | 81.3 |
| Σ15 Alkylated PAHs | 2.05 | 9.37 | 25.4 |
| Σ12 HMW PAH – Nonalkylated | 4.10 | 17.5 | 46.3 |
| Σ8 LMW PAH – Nonalkylated | 0.665 | 3.44 | 9.57 |
| Avian PCDD/F TEQ | 0.605 | 0.736 | 0.892 |
| Mammal PCDD/F TEQ | 0.491 | 0.640 | 0.831 |

| Exhibit 2-3B. Summary of Belowground Invertebrate Tissue Concentrations | | | |
|---|---|---|---|
| **Belowground Invertebrates** | **WW Tissue Residue Concentrations (mg/kg PAHs and ng/kg TEQ)** | | |
| | **Average** | **95% UCL** | **Maximum** |
| Total Σ35 PAH – Alkylated and nonalkylated | 20.9 | 35.3 | 86.9 |
| Σ15 Alkylated PAHs | 5.26 | 8.66 | 23.7 |
| Σ12 HMW PAH – Nonalkylated | 15.0 | 25.9 | 60.8 |
| Σ8 LMW PAH – Nonalkylated | 0.645 | 0.876 | 2.38 |
| Avian PCDD/F TEQ | 1.07 | 1.59 | 2.87 |
| Mammal PCDD/F TEQ | 1.42 | 2.32 | 4.38 |

| Exhibit 2-3C. Summary of Depurated Earthworm Tissue Concentrations | | | |
|---|---|---|---|
| **Depurated Earthworms** | **WW Tissue Residue Concentrations (mg/kg PAHs and ng/kg TEQ)** | | |
| | **Average** | **95% UCL** | **Maximum** |
| Total Σ35 PAH – Alkylated and nonalkylated | 7.28 | 12.1 | 10.5 |
| Σ15 Alkylated PAHs | 1.95 | 3.24 | 2.87 |
| Σ12 HMW PAH – Nonalkylated | 5.07 | 8.53 | 7.45 |
| Σ8 LMW PAH – Nonalkylated | 0.263 | 0.413 | 0.425 |
| Avian PCDD/F TEQ | 1.00 | 1.59 | 1.69 |
| Mammal PCDD/F TEQ | 1.09 | 2.09 | 2.30 |

Blue highlights indicate that the 95% UCL exceeds the maximum value. Where the 95% UCLs exceed the maximum concentration, the maximum concentration is used for the ERA instead of the 95% UCL.

## 2.3 Site-Specific PAH and PCDD/F Uptake Equations

Site-specific uptake equations were developed to estimate concentrations in prey in areas of the site where invertebrate samples were not collected. For ERAs where site-specific uptake equations are not available, tissue concentrations are typically modeled using literature-sourced equations. For PAHs, the default equation typically used is a linear uptake equation from USEPA (2007) Ecological Soil Screening Levels (Eco-SSL). For PCDD/F TEQs, a logarithmic equation from Sample et al. (1998) is typically used. Modeled equations can overestimate tissue concentrations as the environment and organisms can be different than what is present at the site.

For OU2, measured concentrations in invertebrate tissues from the June 2020 were typically much lower than the concentrations estimated by applying the default models to the Site-specific soil concentrations. For HMW and LMW PAHs, measured concentrations were 4 to 12 times lower than the modeled concentrations for belowground invertebrates, but the difference between measured and modeled for aboveground invertebrates was in orders of magnitude. For PCDD/F TEQs, measured concentrations were approximately 2 to 6 times lower than modeled concentrations for belowground invertebrates, but were 2 to 37 times lower for aboveground invertebrates when compared to modeled tissue concentrations using the default Sample et al. (1998) equation. Appendix G provides a more detailed comparison of measured versus modeled data.

Data from the June 2020 field investigation were used to develop several site-specific uptake equations for HMW and LMW PAHs and PCDD/F TEQs including power, exponential, linear, and logarithmic equations. Samples containing wasps were not used to determine site-specific uptake equations. The uptake equations are presented in Appendix G.

For PAHs, the $R^2$ of best fit regression lines for these equations were compared to determine which equation provided the best fit between the soil PAH data and the corresponding invertebrate tissue PAH concentration following the methods outlined in the USEPA R4 evaluation of Operable Unit 1 (OU1) (USEPA R4, 2020) with the equation with the highest $R^2$ having the best fit. As detailed in Table G2-1A in Appendix G, the observed uptake using the best fit uptake equation for HMW PAHs yielded concentrations approximately 4.5 times lower than the default equation from USEPA Eco-SSL for belowground invertebrates but approximately 150-200 times lower for aboveground invertebrates.

For the OU2 PCDD/F TEQ uptake calculations, a linear equation was selected for use in estimating tissue concentrations in belowground and aboveground invertebrates for PCDD/Fs, with linear regression equations and $R^2$ values provided in Exhibit 2-4. For consistency with the OU1 ERA analysis, USEPA stated a preference for the linear equation on a conference call on May 10, 2021, unless the best fit was unsuitable compared to other best fit approaches considered in Appendix G. Appendix G provides a summary of the best fit approaches considered (i.e., power, exponential, linear, and logarithmic equations).

**Exhibit 2-4. Summary of Site-Specific Linear Uptake Equations for PAHs and PCDD/F TEQs for Aboveground and Belowground Invertebrates**

| Analyte | Invertebrate Type | Best Fit Regression Equation for HMW PAH Concentration in Tissue | $R^2$ | Equation Type |
|---|---|---|---|---|
| Σ12 HMW PAHs | Aboveground | $C_{AG} = 0.003 * C_s$ | 0.6441 | Linear |
| | Belowground | $C_{EU} = 0.1222 * C_s$ | 0.9469 | Linear |
| Σ8 LMW PAHs | Aboveground | $C_{AG} = 0.0023*C_s$ | 0.6362 | Linear |
| | Belowground | $C_{EU} = 0.083*C_s$ | 0.953 | Linear |
| Avian PCDD/F TEQ | Aboveground | $C_{AG} = 0.0411 * C_s$ | 0.5418 | Linear |
| | Belowground | $C_{EU} = 0.168 * C_s$ | 0.8616 | Linear |
| Mammal PCDD/F TEQ | Aboveground | $C_{AG} = 0.0221 * C_s$ | 0.6737 | Linear |
| | Belowground | $C_{EU} = 0.1669 * C_s$ | 0.8243 | Linear |

Note: The equations were developed in Excel using all available numerical digits; therefore, the equations differ slightly from those developed for OU1, which used rounded values.

- For example, the equation for HMW PAHs for belowground invertebrates presented in USEPA (2020) was $C_{EU} = 0.1225 * C_s$ with a $R^2$ of 0.86.
- The CEU = 0.1222* Cs using all available numerical digits has an $R^2$ of 0.9469.
- $C_{AG}$ = PAH or PCDD/F TEQ concentration in wet weight aboveground invertebrate tissue (mg/kg WW or ng/kg WW, respectively).
- $C_{EU}$ = PAH or PCDD/F TEQ concentration in wet weight belowground invertebrate tissue, primarily earthworms (mg/kg WW or ng/kg WW, respectively).
- $C_s$= PAH or PCDD/F TEQ concentration in soil (mg/kg DW or ng/kg DW, respectively).

# 3. OU2 ERA

OU2 soil concentrations for PAHs and PCDD/F TEQs were used in an ERA to characterize potential risk to ecological receptors at OU2. As described in the Risk Strategy White Paper, the OU2 ERA builds on the approach used by the USEPA for OU1 (USEPA R4, 2020).

It is anticipated that OU2 will be redeveloped for some form of human use, including residential, industrial/commercial, and/or recreational use. The ERA considers a range of potential land uses, including residential, industrial/commercial, recreational with minimal development (e.g., nature trails), and recreational with development (e.g., sports fields). With the exception of development of recreational nature trails, these uses would limit the extent of ecological habitat/function. Songbirds are considered the most at-risk receptor from this type of exposure scenario. If all or a portion of OU2 is designated for use as a recreational nature trail system, these areas may remain in a natural state and support a broader ecological habitat/function. Therefore, the OU2 ERA includes an evaluation of receptors indicative of ecological function (including soil invertebrates and mammals) in addition to songbirds when evaluating the nature trail land use scenario.

The following subsections describe the selection of the representative data for each polygon for use the ERA (Section 3.1), describes the approach to characterizing ecological risks (Section 3.2), and discusses uncertainties in the ERA results (Section 3.3).

## 3.1 Soil Data Available for the OU2 ERA

The ERA considered the available data for PAHs and PCDD/Fs in surface soils for OU2 from multiple investigations (EarthCon, 2019a; EarthCon, 2019b; Integral, in draft). The available data were used for the Thiessen polygons shown on Figure 2-1, developed using ARC GIS tools.[9] The full data set is provided in Appendix H. The OU2 data set includes discrete surface soil samples, as well as 5-point composite surface soil samples for individual polygons. For the purposes of establishing exposure point concentrations (EPCs) for the ERA (Section 3.2.1), a single representative concentration was established for each polygon based on the following considerations:

- Where available, the 5-point composite soil sample result was used to establish the representative concentration for the polygon.
- For those polygons with no composite soil samples but where there were more than one discrete sample collected, the representative concentration for the polygon was established based on a 95% UCL calculated using USEPA ProUCL software (Version 5.1.00). ProUCL documentation is presented in Appendix F.
- For those polygons where either there was insufficient data to calculate a 95% UCL or where the 95% UCL exceeds the maximum value, the maximum concentration was used to represent the polygon.

[9] The soil data from June 2020 soil and soil invertebrate study were not considered in the selection of representative data for the OU2 polygons, as these data were collected from a different depth interval (0-6 inches) than the other data sets (0-12 inches) and consisted of composite samples that were not intended to be representative of the full area of the polygon from which the samples were collected.

The outcome was that there was one representative concentration per polygon for the ERA, with 92 polygons for PAHs and 91 polygons for PCDD/F TEQs (Table 3-1A and Table 3-1B, with polygons identified on Figure 2-1).[10] The representative data for the polygons were used to generate a surface weighted average concentrations (SWACs) for use in the OU2 ERA, as detailed in Section 3.2. Section 3.1.1 and Section 3.1.2 describe the data available for calculating SWACs.

### 3.1.1 PAH Soil Data Characterization

The PAHs consistently available for the majority of the OU2 soil dataset for samples collected from 2004 to 2020 are the USEPA's 16 priority pollutant PAHs along with 2-methylnapthalene (i.e., ∑17 PAHs). The following PAHs are included in the OU2 SWACs for HMW and LMW PAHs for 88 of the 92 OU2 polygons:

- Σ10 HMW (nonalkylated) PAHs –Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[e]pyrene, Benzo[g,h,i]perylene, Benzo[j,k]fluoranthenes, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Indeno[1,2,3-cd]pyrene, Perylene, and Pyrene.
- ∑7 LMW weight (nonalkylated) –Acenaphthene, Acenaphthylene, Anthracene, Fluorene, Naphthalene, Phenanthrene, and 2-Methylnaphthalene.

Data for only 13 PAHs was available for 4 of the polygons (RISB05, RISB06, RISB07, and RISB08), while the remaining 88 polygons have data for 17 PAHs. Rather than reduce the data set for all 92 polygons to calculate a consistent sum of 13 PAHs, which could potentially underestimate PAH concentrations at the Site, the data for the 4 polygons with 13 PAHs were excluded from the SWAC calculations for use in the ERA. For HMW PAHs, the sum for the available HMW PAHs (Σ9 HMW) for the 4 polygons is low and ranged from 0.0885 to 10.2 mg/kg. By comparison, the SWAC for the Σ10 HMW PAH sum in Table 3-1A is 35.3 mg/kg. The exclusion of these four polygons from the ERA is discussed in Section 3.3.

As was discussed in Section 2, the soil and soil invertebrate study included analysis of 35 PAHs, which include USEPA's 16 priority pollutant PAHs, along with additional PAHs that comprise the 35 PAHs identified by USEPA in consideration of narcosis toxicity to invertebrates (USEPA 2003, Hawthorne et al. 2006). Because 35 PAHs are not consistently available for the OU2 soil dataset given the past focus on USEPA priority pollutant PAHs, this is addressed as an uncertainty in Section 3.3.

The summary of the available Σ10 HMW PAH and Σ7 LMW PAH data collected for OU2 is presented in Table 3-1A, and HMW PAH concentrations are shown in Figure 3-1A and Figure 3-2. Figure 3-1A illustrates the HMW PAH detected concentrations, oriented from highest concentration to lowest concentration for OU2. The full soil dataset for PAHs is provided in Appendix H. As indicated on Figures 3-1A and 3-2, the highest HMW PAH concentration (2,020 mg/kg) was detected from polygon TB-16. TB-16 also had the highest LMW PAH concentration (659 mg/kg).

### 3.1.2 PCDD/F TEQ Soil Data Characterization

PCDD/F mixtures for soil were considered using the avian and mammal TEQ approach. A summary of the soil PCDD/F TEQs used in this ERA is provided in Table 3-1B and shown in Figure 3-1B and Figure

[10] The total number of polygons for PCDD/F TEQs differs slightly from the total number of polygons for PAHs because parcels SD021 and SD021R were sampled as a single parcel during the PCDD/F sampling due to the small size of the parcels. Benzo(e)pyrene, perylene, and 1-methylnaphthalene were not used in the sums of HMW and LMW PAHs because they are not consistently available for the soil dataset. These constituents were analyzed as part of the June 2020 soil and soil invertebrate investigation and are included in the estimate of uptake from soil to soil invertebrates.

3-2. Figure 3-1B illustrates the PCDD/F bird and mammal TEQ detected concentrations, oriented from highest concentration to lowest concentration for OU2. Polygon SS-115 had the highest avian and mammal PCDD/F TEQ at 206 ng/kg and 275 ng/kg, respectively.

## 3.2 OU2 ERA Approach and Ecological Risk Characterization

This section summarizes the ERA approach and ecological risk characterization, as described in the Risk Strategy White Paper.

### 3.2.1 Ecological Receptors Evaluated

Bird and mammal ecological receptors were evaluated based on home range. Small home range receptors are those species with a home range that would be contained entirely within OU2. Large home range species are those species whose home range is greater than the size of OU2 and, therefore, would only be expected to spend a portion of their time within OU2. As detailed in the Risk Strategy White Paper (Integral, Ramboll, and EarthCon, 2021) and summarized below, the rationale for the selection of the four bird and mammal species includes:

- These species are omnivorous, but their diets can be dominated by the ingestion of belowground and aboveground soil invertebrates, so they have a potential for high exposure to soil contaminants from their diets.
- Each species forages within the soil and soil litter and can have incidental ingestion of soil via foraging methods that is greater than other species.
- There is habitat present in OU2 for each of these species.

Exposure parameters for each species are identified by USEPA (USEPA, 2020; USEPA R4, 2016) and agreed upon by NCDEQ. The following summarizes the ecological receptors selected as representative species for the OU2 ERA:

- Songbirds
  - American robin (*Turdus migratorius*), a small home range omnivorous songbird that is known to eat a large percentage of soil invertebrates depending on season.
    - American woodcock (*Scolopax minor*), a large home range invertebrate-eating bird.

- Mammals
  - Short-tailed shrew (*Blarina brevicauda*), a small home range invertebrate-eating mammal.
    - Raccoon (*Procyon lotor*), a large home range omnivorous mammal.

- Soil invertebrates

### 3.2.2 Exposure Areas and EPCs

The following describes the exposure areas used in the ERA and the calculation of EPCs for each exposure area.

#### 3.2.2.1 Birds and Mammals

The food web model for birds and mammals considered exposure areas and estimates the EPCs for the exposure areas based on SWACs according to the following formula:

$$SWAC = \frac{(Area_{Parcel\,1} \times Concentration_{Parcel\,1}) + (Area_{Parcel\,2} \times Concentration_{Parcel\,2}) + \ldots}{Area_{Parcel\,1} + Area_{Parcel\,2} + \ldots}$$

**Large home range bird and mammal receptors (American woodcock and raccoon)**

- To address ecological risk to large home birds and mammals, PAH and PCDD/F TEQ EPCs for soil were based on the SWACs for all of OU2. The SWAC was based on a representative concentration established for each polygon as described in Section 3.1.
- The areas used in the SWAC is based on the portions of the polygons that fall within the OU2 boundary. The ERA considered two exposure area scenarios for the woodcocks and raccoons. The first scenario conservatively assumes that these species live exclusively at OU2 (i.e., area use factor [AUF] = 1). The second scenario considers an AUF based on the estimated home range of the woodcock and raccoon relative to the size of OU2, with AUFs of 0.63 and 0.12, respectively (Table 3-2A).

    - The area of OU2 used for the SWAC is based on the polygons with sufficient available data.
    - There are six polygons located along the northern OU2 boundary where small portions of the polygons from OU1 extend into OU2 (Figure 2-1). These 6 polygons were evaluated in the OU1 ERA (USEPA R4, 2020); therefore, they are not included in the overall OU2 SWAC calculation. Excluding these polygons reduces the OU2 area from 15.6 acres by 0.2 acres for the purposes of the SWAC calculation (does not apply to the 2-acre SWAC calculation).
    - In addition, as mentioned in Section 3.1, there are four polygons where there is insufficient PAHs to fully calculate the HMW and LMW PAH sums (Table 3-1A and Figure 2-1). If the partial PAH sum for these polygons were used, the SWAC would be artificially low. Therefore, data from these polygons were excluded from the SWAC calculations. In doing so, the SWAC acreage used to derive the SWAC for large home range birds and mammals was reduced to 14.7 acres and the count of polygons used in the soil invertebrate evaluation is 88 polygons rather than the 92 polygons initially mentioned for PAHs (Table 3-1A).
    - The SWACs for bird and mammal PCDD/F TEQs are provided in Table 3-1B. The total acreage for the PCDD/F TEQ SWACs was 15.4 acres.
        - The acreage used for SWACs (14.7 acres, 15.4 acres, vs 15.6 acres) is discussed in the uncertainty analysis.

The OU2 SWAC for large home range birds and mammals are detailed in Table 3-1A and 3-1B, and summarized in Exhibit 3-1A:

**Exhibit 3-1A. OU2 SWAC Concentrations for Food Web Model for Large Home Range Birds and Mammals**

| Analyte | Soil Units | SWAC Concentrations |
|---|---|---|
| Σ10 HMW PAH | mg/kg | 35.3 |
| Σ7 LMW PAH | mg/kg | 7.73 |
| Avian PCDD/F TEQ | ng/kg | 10.5 |
| Mammal PCDD/F TEQ | ng/kg | 17.7 |

**Small home range bird and mammal receptors (American robin and shrew)**

- To address ecological risk to small home range birds and mammals, a 2-acre exposure area was used and an EPC calculated based on the SWAC for a 2-acre circular area centered around the highest concentrations of PAHs and PCDD/F TEQ in surface soil (as shown in Figures 3-2).
- As documented in the Risk Strategy White Paper, the 2-acre home range was selected for the robin and the shrew, in collaboration with EPA and NCDEQ, based on a review published literature on the species home range.
- The 2-acre SWACs are based on the calculated SWACs for HMW PAHs, LMW PAHs, avian PCCD/F TEQ, and mammal PCDD/F TEQ for these 2-acre areas, which take into consideration the spatial proportion of the polygons wholly within the 2-acre area.
- For those polygons that intersect the 2-acre area, the SWAC only includes that portion that is contained within the 2-acre area.
- The food web model assumes that small home range birds and mammals live only within this 2-acre area, which is the highest small home range bird and mammal exposure that would be expected for OU2.

The contribution of each polygon on the overall SWAC is shown quantitatively on Tables 3-3A and 3-3B for PAHs and PCDD/F TEQs, respectively, for small home range birds and mammals. The SWAC calculations address the spatial contributions from polygon areas that are not equally spaced in OU2. SWACs for the 2-acre area of highest concentrations are presented in Exhibit 3-1B.

**Exhibit 3-1B. 2-Acre SWAC Concentrations for Food Web Model for Small Home Range Birds and Mammals**

| Analyte | Soil Units | SWAC Concentrations |
|---|---|---|
| Σ10 HMW PAHs | mg/kg | 80.3 |
| Σ7 LMW PAH | mg/kg | 34.2 |
| Avian PCDD/F TEQ | ng/kg | 33.1 |
| Mammal PCDD/F TEQ | ng/kg | 58.2 |

## 3.3 Soil Invertebrates

Risks were evaluated for soil invertebrates in each individual polygon and the representative concentration established for each polygon (as discussed in Section 3.1) was used as the EPC.

### 3.3.1 Assessment/Measurement Endpoints

The assessment endpoints for the OU2 ERA are the following:

- Survival, growth, and reproductive ability for bird populations and mammal populations at OU2.
- Maintenance of community function for soil invertebrates at OU2.

This ERA for soil invertebrates is based on:

- PAH soil concentrations in each OU2 polygon compared to the USEPA PAH Ecological Soil Screening Level (EcoSSL) for soil invertebrates.
- Consideration of the basis of the USEPA PAH EcoSSL for soil invertebrates exposed to PAHs.

- Field observations regarding the presence of invertebrates from the June 2020 OU2 soil invertebrate survey.

### 3.3.2 Risk Characterization Approach for Birds and Mammals

A food web model was used to evaluate potential exposures to birds and mammals due to PAHs and PCDD/F TEQ in soils. The food web model is based on consideration of species-specific ecological exposure parameters, as summarized in Table 3-2A, and estimated TDI calculations. The TDI formula is used to estimate uptake from soil to dietary prey items and ultimately to the food eaten by the wildlife species.

$$Exposure\ (TDI) = AUF \times \left[\frac{IR_{soil} \times C_{soil} + IR_{food} \times \sum(FIR_{food\ item} \times C_{food\ item})}{BW}\right]$$

Where: Exposure (TDI) = Total daily intake (mg/kg-d or ng/kg-d)

- AUF = Area use factor (unitless percentage) (literature)
- $IR_{soil}$ = Ingestion rate of soil (kg weight of soil/individual/day) (literature)
- $C_{soil}$ = Concentration of constituent in soil (measured)
- $IR_{food}$ = Ingestion rate of food (kg fresh weight of food/individual/day) (literature)
- $FIR_{food\ item}$ = Fractional ingestion rate of food item (unitless percentage) (literature)
- $C_{food}$ item = Concentration of constituent in a food item (mg/kg or ng/kg fresh weight) (modeled)
- BW = Body weight (kg) (literature)

The food web model for birds and mammals considers uptake from soil to dietary prey items. The uptake approach is based on site-specific uptake factors derived from the June soil and soil invertebrate PAH and PCDD/F study using the uptake approaches detailed in Appendix G and summarized in Section 2.3 of this report. For plants, the uptake approach is modeled due to the lack of site-specific data.

The food web model considered two dietary exposure scenarios for each receptor: a high exposure scenario and a realistic exposure scenario. The dietary scenarios for the American robin and the American woodcock include the same scenarios as those used in the OU1 Semi-Screening ERA. The diet scenarios for the robin in the OU1 ERA did not include consumption of plants, which are expected to make up a part of the robin's diet, as stated in the OU1 ERA and documented in the USEPA (1993) Wildlife Exposure Factors Handbook. The OU1 Semi-Screening ERA states that "plant material is expected to contain very little PAHs, as plants have in general not been observed to accumulate lipophilic compounds such as PAHs into their fruits to an appreciable extent. It is expected that incorporation of plant material into the diet of robins would likely serve to decrease the estimated PAH dose the birds are receiving, and thereby lower the estimated risks." To account for this, the OU2 ERA included two additional dietary exposure scenarios for the robin that include consumption of plants.

The diet scenarios for the birds and mammals are summarized below:

- American robin:
  - Scenario 1: A diet consisting of solely belowground invertebrates (i.e., earthworms), which reflects the most highly exposed diet

  - Scenario 2: A diet split 50/50 between plants and belowground invertebrates for the robins that eat plants
  - Scenario 3: A diet consisting of aboveground and belowground invertebrates
  - Scenario 4: A diet consisting of 30% plants,35% aboveground and 35% belowground invertebrates which is representative of the likely robin diet at OU2

- American woodcock:
  - Scenario 1: A diet consisting of solely belowground invertebrates (i.e., earthworms), which reflects the most highly exposed diet
  - Scenario 2: A diet consisting of 50% aboveground and 50% belowground invertebrates, which is representative of the likely woodcock diet at OU2

- Raccoons:
  - Scenario 1: 20% plants and 80% belowground invertebrates (i.e., earthworms), which reflects the most highly exposed raccoon diet
  - Scenario 2: 20% plants, 40% aboveground invertebrates, and 40% belowground invertebrates, which representative of the likely raccoon diet at OU2

- Shrews:
  - Scenario 1: 100% belowground invertebrates, (i.e., earthworms), which reflects the most highly exposed shrew diet
  - Scenario 2: 50% belowground invertebrates and 50% aboveground invertebrates, which is representative of the likely shrew diet at OU2.

HQs were calculated for songbirds and mammals for HMW PAHs, LMW PAHs, avian PCDD/F TEQ, and mammal PCDD/F TEQ to determine if unacceptable ecological risks are potentially present for these animals. HQs are the ratio of TDI to TRV. As identified in the Risk Strategy White Paper and discussed in a conference call with USEPA and NCDEQ on May 10, 2021, HQs were calculated using the LOAEL TRV, summarized on Table 3-2B, and consistent with the approach used by USEPA for OU1 (USEPA R4, 2020). HQs greater than a value of 1 based on LOAEL TRVs indicate the potential risk for ecological receptors via the food web.

#### 3.3.2.1 Food Web Model Results for Large Home Range Birds and Mammals

The OU2 SWAC concentrations for PAHs and PCDD/F TEQs presented in Section 3.2.2 and the site-specific uptake equations for aboveground and belowground invertebrates presented in Section 2.3 were used in the food web model for large home range species (woodcock and raccoon). A detailed summary of food web calculations is presented in Appendix I1. A summary of the LOAEL SWAC HQs is presented in Exhibit 3-2A and Exhibit 3-2B for the woodcock and raccoon, respectively.

| Exhibit 3-2A. Summary of LOAEL HQs for American Woodcock | | | |
|---|---|---|---|
| **Receptor** | **Chemical** | **LOAEL HQ (unitless)** | |
| | | **Scenario 1** | **Scenario 2** |
| American Woodcock (AUF=1) | Σ10 HMW PAHs | **6** | **3** |
| | Σ7 LMW PAHs | 0.03 | 0.02 |
| | PCDD/F Avian TEQ | 0.04 | 0.02 |
| American Woodcock (AUF=0.63) | Σ10 HMW PAHs | **4** | **2** |
| | Σ7 LMW PAHs | 0.02 | 0.01 |
| | PCDD/F Avian TEQ | 0.03 | 0.01 |

Blue shading = HQs between 2 and 10
Scenario 1 = 100% belowground invertebrates (High Exposure Diet)
Scenario 2 = 50% belowground invertebrates and 50% aboveground invertebrates (Realistic Exposure Diet)

| Exhibit 3-2B. Summary of LOAEL HQs for Raccoon | | | |
|---|---|---|---|
| **Receptor** | **Chemical** | **LOAEL HQ (unitless)** | |
| | | **Scenario 1** | **Scenario 2** |
| Raccoon (AUF = 1) | Σ10 HMW PAHs | 0.3 | 0.2 |
| | Σ7 LMW PAHs | 0.002 | 0.0009 |
| | PCDD/F Mammal TEQ | 0.07 | 0.04 |
| Raccoon (AUF = 0.12) | Σ10 HMW PAHs | 0.04 | 0.02 |
| | Σ7 LMW PAHs | 0.0002 | 0.0001 |
| | PCDD/F Mammal TEQ | 0.008 | 0.005 |

Scenario 1 = 20% Plants and 80% Belowground Invertebrates (High Exposure Diet)
Scenario 2 = 20% Plants, 40% Belowground Invertebrates, and 40% Aboveground Invertebrates (Realistic Exposure Diet)

The ERA considered AUFs of 1 and a species-specific AUF calculated using 15.6 acres (total size of OU2) for woodcock and raccoon. An AUF is the ratio of the animal's home range compared to the area of the Site. An AUF value of 1 is a conservative estimate of risk as it assumes that wildlife receptors obtain all their food from OU2. Woodcocks and raccoons have a much larger home range than that of OU2 indicating that they do not spend all their time within OU2 and their species-specific AUF decreases to 0.63 and 0.12, respectively, when their home ranges are considered.

As can be seen in Exhibits 3-2A and 3-2B:

- For the raccoon, HMW PAHs, LMW PAHs, and mammal PCDD/F TEQs had HQ results less than 1 using either an AUF of 1 or 0.12.
- For the woodcock, results of the ERA were below 1 for LMW PAHs and avian PCDD/F TEQs. For HMW PAHs, HQs were 3 to 6 using an AUF of 1, and 2 to 4 using an AUF of 0.63.

### 3.3.2.2 Food Web Model Results for Small Home Range Ecological Receptors

The 2-acre SWACs presented in Section 3.2.2 and the site-specific uptake factors presented in Section 2.3 were used to evaluate small home range receptors, robin and shrews, using only an AUF of 1 assuming that these receptors will spend all their time within OU2 in the areas of highest PAH and PCDD/F TEQ concentrations. A detailed summary of food web calculations for the 2-acre area is presented in Appendix I2. The LOAEL HQs are presented in Exhibit 3-3A and Exhibit 3-3B.

**Exhibit 3-3A. Summary of LOAEL HQs for American Robin**

| Receptor | Chemical | LOAEL HQ (unitless) | | | |
|---|---|---|---|---|---|
| | | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
| American Robin (AUF=1) | Σ10 HMW PAHs | 20 | 10 | 9 | 7 |
| | Σ7 LMW PAH | 0.2 | 0.09 | 0.09 | 0.07 |
| | Avian PCDD/F TEQ | 0.1 | 0.07 | 0.09 | 0.07 |

Blue shading = HQs between 2 and 10; Green shading = HQs between 10 and 100
Scenario 1 = 100% belowground invertebrates (High Exposure Diet)
Scenario 2 = 50% belowground invertebrates and 50% plants
Scenario 3 = 50% belowground invertebrates and 50% aboveground invertebrates
Scenario 4 = 30% plants, 35% belowground invertebrates, and 35% aboveground invertebrates (Realistic Exposure Diet)

**Exhibit 3-3B. Summary of LOAEL HQs for Shrew**

| Receptor | Chemical | LOAEL HQ (unitless) | |
|---|---|---|---|
| | | Scenario 1 | Scenario 2 |
| Short-tailed Shrew (AUF = 1) | Σ10 HMW PAHs | 3 | 1 |
| | Σ7 LMW PAH | 0.02 | 0.01 |
| | Mammal PCDD/F TEQ | 0.8 | 0.5 |

Blue shading = HQs between 2 and 10
Scenario 1 = 100% belowground invertebrates (High Exposure Diet)
Scenario 2 = 50% belowground invertebrates and 50% aboveground invertebrates (Realistic Exposure Diet)

As can be seen in Exhibits 3-3A and 3-3B:

- For the robin, HQs were below 1 for LMW PAHs and avian PCDD/F TEQs, but were between 7 and 20 for HMW PAHs. The HQ of 20 is based on ingestion of 100% belowground invertebrates (high exposure scenario). The HQ using a mixed diet that may be typical of robins in the natural environment range from 7 to 10.
- For the shrew, HQs were below 1 for LMW PAHs and mammal PCDD/F TEQs. For HMW PAHs, HQs were 1 and 3. The HQ of 3 is based on ingestion of 100% belowground invertebrates which likely overestimates the true exposure. The HQ using a mixed diet that may be typical of shrews is 1.

### 3.3.3 Soil Invertebrate Evaluation for OU2

As stated in the Risk Strategy White Paper, risk characterization to soil invertebrates due to PAHs was evaluated to address resident ecological function for areas of OU2 that may be redeveloped as a natural trail system. Invertebrates lack the AhR-1 aryl hydrocarbon (AhR) receptor which is responsible for high-affinity binding to PCDD/Fs; therefore, invertebrates generally do not have a dioxin-induced toxic response (Borgmann et al., 1990, Hahn et al. 1994, West et al., 1997). As such, PCDD/F TEQs were not included in the OU2 soil invertebrate evaluation.

Location-specific PAH HQs for each polygon based on invertebrate-specific ecological screening values (ESVs) from USEPA R4 (2018) are presented in Table 3-4A and Table 3-4B for HMW and LMW PAHs, respectively. These ESVs are sourced from the USEPA PAH Ecological Soil Screening Levels (Eco-SSLs) for soil invertebrates exposed to HMW PAHs and LMW PAHs (USEPA, 2007). The USEPA Eco-SSL for soil invertebrates is based on non-specific nonpolar narcosis, using data from studies of the maximum acceptable toxicant concentration in invertebrate tissues and the 10% effect concentration (i.e., PAH concentrations that may result in lower growth and reproduction for 10% of the organisms tested, with 90% of organisms unimpacted). Therefore, an HQ greater than 1 indicates that it is possible that approximately 10% of the soil dwelling organism community may have measurable changes to reproduction and growth.

The ERA for soil invertebrates indicates that the majority of OU2 has HMW and LMW PAH concentrations less than the USEPA PAH EcoSSLs for soil invertebrates (i.e., HQs less than 1):

- For HMW PAHs, 56 of 88[11] polygons had HQs of 1 or below. The HMW PAH concentrations for 29 polygons yielded HQs of 2 to 10. Three polygons with HQs greater than 10 were SS-117 (HQ=20), TB-12 (HQ=20), and TB-16 (HQ=100) (Figure 3-3).
- For LMW PAHs, 85 of 88 polygons had HQs below 1. The three polygons with HQs greater than 1 were TB-12 (HQ=2), TB-16F (HQ=8), and TB-16 (HQ=20).
- The June 2020 soil invertebrate survey involved collection of soil invertebrates from polygons at OU2 with soil concentrations that yielded HMW PAH HQs that ranged from 0.03 to 20 and LMW PAH HQs that ranged from 0.003 to 8.
- Six of the polygons where soil invertebrates were collected had HMW PAH HQs ranging from 2 to 20 and one of the six polygons had an LMW PAH HQ of 8. Soil invertebrates were present in all 6 of these polygons.
- The OU2 soil invertebrate study did not sample at polygon TB-16 where the highest HMW and LMW PAH HQs for soil invertebrates were seen (i.e., HMW PAH HQ of 100, LMW PAH HQ of 20). At this location, there is the greatest potential for adverse impacts to the highly exposed belowground soil invertebrates because the HMW PAH concentration was approximately 100 times higher than the USEPA PAH EcoSSL. As TB-16 was not targeted for sampling during the June 2020 investigation, there is no data on the presence or absence of invertebrates in this polygon. TB-16 represents less than 0.15% of the OU2 area.

[11] OU2 is comprised of 92 polygons. Four of the 92 polygons did not have the full suite of PAHs available. As described in Section 3.1.1., the use of these four polygons would underestimate risk; therefore, 88 polygons were used for this analysis as a conservative measure. A quantitative evaluation of the exclusion of these four polygons is included in Section 3.3.

## 3.4 Uncertainties

Uncertainty can be introduced into an ERA at every step in the process, as information of varying quality is gathered from diverse sources to be integrated into a complex framework. The ERA approach is often designed to address uncertainties related to chemical bioaccumulation and bioavailability though conservative assumptions in order to be protective. A summary of uncertainties associated with the OU2 ERA can be found in Table 3-5. Some of the assumptions lead to the overestimate of risk and some of the assumptions lead to the underestimate of risk. A few of the OU2 uncertainties that have a bearing on the interpretation of potential risks for birds and mammals include the following:

- The dose estimates assume that PAHs and PCDD/Fs in prey items are 100% bioavailable; however, actual bioavailability is most likely less than 100%.

- Invertivorous/omnivorous birds like the robin have a varied diet comprising of plants and various types of soil and leaf-litter dwelling invertebrates depending on the season (USEPA, 1993). As seen in the OU2 ERA results (Table 3-3A), a 100% earthworm diet results in the highest LOAEL HQs of the scenarios considered; however, this risk is driven by a conservative diet assumption and is not representative of what a robin actually eats. Plants can comprise a portion of a robin's diet, but measured site-specific data are not available for PAH concentrations in plants and, as stated in Section 3.2, the ERA modeled soil-to-plant uptake. As described in the OU1 ERA (USEPA R4, 2020), plant material is not expected to contain a significant amount of PAHs; therefore, the modeled concentration is likely an overestimate of what is actually present, and HQs for those diet scenarios containing plant material are likely lower than what is reported here.

- The food web model used OU2 soil data for ∑17 PAHs (i.e., ∑10 HMW PAHs and ∑7 LMW PAHs), which includes the USEPA 16 priority pollutant PAHs and 2-methylnapthalene. The 15 soil samples included in the 2020 OU2 soil invertebrate study were analyzed for 35 PAHs (i.e., 18 more PAHs than were considered in the food web model). The 18 additional PAHs include: two non-alkylated HMW PAHs (benzo(e)pyrene and perylene), 5 HMW alkylated PAHs, one non-alkylated LWM PAH (1-methylnapthalene), and 10 alkylated LWM PAHs. Current research indicates that the alkylated PAHs found in petroleum may be more abundant and more persistent than the non-alkylated PAHs (Barron and Holder, 2003; Andersson and Achten, 2015). The OU2 soil data and tissue data for the ∑35 PAHs from the 2020 OU2 soil invertebrate study were evaluated to estimate the approximate percentage of PAH exposure may be underestimated in the food web model from focus on ∑10 HMW PAHs and ∑7 LMW PAHs. The 2020 soil and soil belowground invertebrate tissue data are summarized Tables 3-6. The data indicate:
    - In the soil matrix benzo(e)pyrene and perylene comprise approximately 6% to 11% of the total PAHs with an average of approximately 9%. Therefore, the food web model may underestimate HMW PAHs via soil exposure by approximately 9% for these two constituents. Excluding the two PAHs (benzo(e)pyrene and perylene) and the ∑5 HMW alkylated PAHs results in an average underestimate of approximately 28% for soil exposures.
    - In the biological tissues, benzo(e)pyrene and perylene comprise approximately 8% to 13% of the tissue concentrations, with an average of approximately 11%. Therefore, the food web model may underestimate HMW PAHs in belowground invertebrate tissue exposure by an average of approximately 11% for these two constituents. Excluding the two non-alkylated HMW PAHs (benzo(e)pyrene and perylene) and the ∑5 HMW alkylated PAHs results in an average underestimate of approximately 27% for biological tissue exposures.

  - The ∑17 HMW PAHs (alkylated and non-alkylated) in soil ranged from 10.3 mg/kg to 624 mg/kg and soil invertebrate tissues ranged from 0.8 mg/kg to 74.4 mg/kg. Excluding the two non-alkylated HMW PAHs (benzo(e)pyrene and perylene) and the additional ∑5 HMW alkylated PAHs potentially resulted in an average underestimate of soil and soil invertebrate exposures of 28% and 27% respectively.
  - A similar comparison was done for LMW PAHs as illustrated in Table 3-6. The 1-methylnapthalene comprises approximately 0.1% to 5% of the LMW PAHs in soil with an average of approximately 1% for soil. The 1-methylnapthalene comprises approximately 0.2% to 4% of the LMW PAHs (Table 3-6), with an average of approximately 1% for belowground invertebrates.
  - The ∑18 LMW PAHs (alkylated and non-alkylated) in soil ranged from 3.55 mg/kg to 136 mg/kg and soil invertebrate tissues ranged from 0.224 mg/kg to 12.5 mg/kg (Table 3-6). Excluding the 1-methylnapthalene and the additional ∑10 LMW alkylated PAHs potentially resulted in an average underestimate of soil and soil invertebrate exposures by 78% and 75%, respectively. The location where biological tissues used in the food web model may have been underestimate by approximately 92% is from location TB-10, which had soil invertebrate tissue concentration of 2.69 mg/kg for the ∑18 LMW PAHs and a soil concentration of 8.83 mg/kg for the ∑18 LMW PAHs.

- Four polygons (RISB05, RISB06, RISB07, and RISB08) were excluded from the ERA for PAHs as summarized in Section 3 because the data available had an insufficient number of PAHs compared to other locations available for the ERA. The polygon sizes ranged from 0.038 to 0.226 acres (Table 3-1A and Appendix J) and comprise 0.2 to 1.6% of OU2. The Σ9 HMW PAH concentrations ranged from 0.0885 to 10.2 mg/kg and Σ4 LMW PAH concentrations ranged from 0.033 to 0.114 mg/kg. The decision to exclude the four polygons from the SWAC calculation was determined after an evaluation of their use indicated that their use would depress the SWAC given that not all the PAHs are available, as shown in Appendix J. Their use in calculating a SWAC would yield a SWAC of 33.5 mg/kg for HMW PAHs and 7.31 mg/kg for LMW PAHs. By comparison, the SWAC used in the ERA is 35.3 mg/kg and 7.73 mg/kg for HMW PAHs and LMW PAHs, respectively.

- There are 7 polygons with multiple grab samples but no composite sample for PAHs: SS-110; SS-114; SS-117; SS-119; TB-08; TB-11; and TB-12. The 95% UCL or maximum value (where a 95% UCL could not be calculated or the 95% UCL was greater than the maximum value) for each polygon was used to represent the polygon. High 95% UCLs can be produced when the data exhibits high variance and the sample size is small as is the case with these seven polygons. For each polygon, there is typically 4 to 5 sample points and the variance is high. For example, SS-110 has 5 samples with the following HMW PAH concentrations: 8.78 mg/kg; 10.9 mg/kg; 17.1 mg/kg; 51.5 mg/kg and 161 mg/kg. ProUCL calculated a 95% UCL of 111 mg/kg, whereas an average is calculated to be 49.8 mg/kg. The use of the 95% UCL or maximum value (in cases where the 95% UCL exceeded the maximum value) to represent these polygons can create a higher bias and may not accurately reflect the exposure at the polygon.

# 4. DISCUSSION AND CONCLUSIONS

This OU2 ERA Technical Memorandum is submitted to the USEPA and NCDEQ on behalf of the Multistate Trust for the Former Kerr-McGee Chemical Company Superfund Site located in Navassa, North Carolina. The ERA Technical Memorandum was developed in accordance with the Risk Strategy White Paper and presents the results of the June 2020 field event, the calculation of site-specific uptake equations using the June 2020 data, and an ERA for OU2.

Measured soil and co-located tissue concentrations for belowground and aboveground invertebrates collected in June 2020 were used to develop the EPCs applied in the site-specific uptake equations. A site-specific linear equation was selected for use in the OU2 ERA for both PAHs and PCDD/F TEQs. As detailed in Appendix G, concentrations estimated using site-specific equations yielded lower tissue concentrations than those calculated using modeled equations used in ERAs when site-specific uptake equations are not available (Eco-SSL for PAHs, and Sample et al. [1998] for PCDD/F TEQs).

**Food Web Modeling Approach, Results and Conclusions for Birds and Mammals**

As agreed upon in the Risk Strategy White Paper (Integral, Ramboll, and EarthCon, 2021), ecological functions of two different types of land use scenarios were evaluated in the OU2 ERA: (1) the land is developed for residential, commercial/industrial, and/or recreational (sports field) use; and (2) the land is largely undisturbed from the current conditions and is used for recreational nature trails. Because the residential, commercial/industrial, and/or recreational (sport field) land uses would limit the quality and amount of wildlife habitat in OU2, the ERA for this land use scenario focused on risks to animals that may be part of offsite populations that forage on the Site some of the time. Songbirds were selected as a representative receptor for this scenario, as they are prevalent in the area and have the potential to be highly exposed through their diet. The existing site habitat would not be significantly disturbed under a recreational nature trail land use for OU2; therefore, the evaluation of risks included a broader range of species, including songbirds, mammals, and soil invertebrates.

Songbirds and mammals were evaluated in this ERA using a food web model approach, considering large home range (American woodcock and raccoon) and small home range (American robin and short-tailed shrew) species. The food web model considered diet scenarios for each receptor that reflect high exposure and more realistic exposure. For each ecological receptor, diets include: (1) a diet consisting solely of belowground invertebrates that would result in a high degree of exposure and (2) a species specific diet that is more representative of the mix of food items the receptor eats. A total of four diet scenarios were considered for the robin—the two scenarios considered for the robin in the OU1 ERA and two additional scenarios that included consumption of plants, as plants are known to represent a component of the robin's diet.

The food web model for birds and mammals reflects uptake from soil to prey items based on site-specific uptake factors, which were derived from the June 2020 soil and soil invertebrate PAH and PCDD/F study. The food web model considers multiple diet scenarios for each species. The ERA considered two exposure areas:

- For large home range receptors (woodcock and raccoon), the ERA assumed that the large home range species spent their entire lives in OU2 (i.e., an exposure area of 15.6 acres and an AUF = 1) with the EPC calculated as a SWAC across the whole of OU2. Because the home range for the woodcock and raccoon is larger than the 15.6-acre area of OU2, the ERA also evaluated risk based on species-specific AUFs.

- For small home range receptors (robin and shrew), a 2-acre exposure area was used. The EPC was calculated based on the SWACs for circles centered on the areas of highest PAH and PCDD/F TEQ concentration.

The food web model was used to calculate intakes for each receptor for PAHs and PCDD/F TEQs for each diet scenario and, in the case of large home range species, for the two AUF scenarios. Intakes were then compared to TRVs to generate HQs. As indicated in the Risk Strategy White Paper, an HQ > 1 indicates potentially unacceptable risks; however, as was determined for OU1 (USEPA, 2020), a higher HQ may be acceptable (e.g., 2 to 4) given: (1) the uncertainty in the risk estimates that, if accounted for, would tend to lower the risk, and (2) under most future land use scenarios, all or a large portion of OU2 will likely be redeveloped.

HQ results for birds and mammals are summarized in Exhibit 4-1, with blue and green highlighted cells showing HQs greater than 1. Exhibit 4-1 summarizes the HQs for birds and mammals for each of the diet scenarios, considering SWACs and AUFs based on the size of the home range of the species.

**Exhibit 4-1. Summary of LOAEL SWAC HQs**

| Receptor | Chemical | LOAEL SWAC HQ (unitless) | | | |
|---|---|---|---|---|---|
| | | **Scenario 1 (Highest Exposure Scenario)** | **Scenario 2** | **Scenario 3** | **Scenario 4 (Most Realistic Exposure Scenario)** |
| **American Robin** | | | | | |
| American Robin (AUF=1) | Σ10 HMW PAHs | **20** | **10** | **9** | **7** |
| | Σ7 LMW PAHs | 0.2 | 0.09 | 0.09 | 0.07 |
| | PCDD/F Avian TEQ | 0.1 | 0.07 | 0.09 | 0.07 |
| **American Woodcock** | | | | | |
| | | **High Exposure Scenario** | | **Realistic Exposure Scenario** | |
| American Woodcock (AUF=1) | Σ10 HMW PAHs | **6** | | **3** | |
| | Σ7 LMW PAHs | 0.03 | | 0.02 | |
| | PCDD/F Avian TEQ | 0.04 | | 0.02 | |
| American Woodcock (AUF=0.63) | Σ10 HMW PAHs | **4** | | **2** | |
| | Σ7 LMW PAHs | 0.02 | | 0.01 | |
| | PCDD/F Avian TEQ | 0.03 | | 0.01 | |
| **Mammal Receptors** | | | | | |
| | | **High Exposure Scenario** | | **Realistic Exposure Scenario** | |
| Short-tailed Shrew (AUF = 1) | Σ10 HMW PAHs | **3** | | 1 | |
| | Σ7 LMW PAHs | 0.02 | | 0.01 | |
| | PCDD/F Avian TEQ | 0.8 | | 0.5 | |
| Raccoon (AUF = 1) | Σ10 HMW PAHs | 0.3 | | 0.2 | |
| | Σ7 LMW PAHs | 0.002 | | 0.0009 | |
| | PCDD/F Avian TEQ | 0.07 | | 0.04 | |

Note: The HQ is the ratio of exposure concentration and toxicity reference value, rounded to one significant figure)

The following HQ results from the food web model were observed for the birds and mammals (Exhibit 4-1):

- **LMW PAHs and PCDD/F TEQ HQs:** The HQs for were less than 1 for each of the birds and mammals considered in the food web modeling, whether based on a highly exposed diet or the more realistic species-specific diets that consist of a mix of food sources. HQs in this range do not indicate an unacceptable risk.

- **HMW PAH HQs**: The HQs varied based on the type of bird or mammal and the type of diet. For these species, the lower HQ end of the range reflects the more realistic species-specific mixed diet and the upper end of the range reflects the highly exposed diet (i.e., a diet comprised solely of belowground invertebrates).
  - Robin: HQs range from 7 to 20
  - Woodcock: HQs range from 3 to 6 when the AUF is based on 100% use of OU2, and HQs range from 2 to 4 when the AUF reflects species-specific home ranges.
  - Raccoon: HQs range from 0.2 to 0.3
  - Shrew: HQs range from 1 to 3.

**ERA Approach, Results, and Conclusions for Soil Invertebrates**

This OU2 ERA considers potential risks for soil invertebrates exposed to PAHs at OU2. Soil invertebrate's exposure to PCDD/Fs was not considered because invertebrates lack the AhR receptor where PCDD/F binding occurs and therefore, are not sensitive to PCDD/F toxicity. The PAH evaluation of ecological risk on soil invertebrates is based on a comparison of OU2 HMW and LMW PAH soil concentrations to the USEPA PAH EcoSSLs for soil invertebrates. HQs are calculated as the ratio of concentration in the polygon to the USEPA PAH EcoSSLs. The ERA for soil invertebrates indicates that the majority of OU2 has HMW and LMW PAH concentrations less than the USEPA PAH EcoSSLs for soil invertebrates (i.e., HQs less than 1):

- For HMW PAHs, 56 of 88[12] polygons had HQs of 1 or below. The HMW PAH concentrations for 29 polygons yielded HQs of 2 to 10. The remaining three polygons (SS-117, TB-12, and TB-16) had HMW PAH HQs of 20, 20, and 100, respectively.
- For LMW PAHs, 85 of 88 polygons had HQs below 1. The three remaining polygons (TB-12, TB16-F, and TB-16) had HQs of 2, 8, and 20, respectively.
- The June 2020 soil invertebrate survey involved collection of soil invertebrates from polygons with soil concentrations that yielded HMW PAH HQs that ranged from 0.03 to 20 and LMW PAH HQs that ranged from 0.003 to 8. Six of the polygons where soil invertebrates were collected had HMW PAH HQs ranging from 2 to 20 and one LMW PAH HQ of 8. Soil invertebrates were present in these polygons.

Collectively, the invertebrate risk characterization indicates there is no unacceptable risk to invertebrates across the majority (approximately 70% for HMW PAHs and approximately 98% for LMW PAHs) (i.e., HQs less than or equal to 1). The analysis suggests potential risks to invertebrates in polygons with PAH HQs >1 based on the EPA EcoSSLs, which reflects a 10% reduction in soil invertebrate growth rates and reproduction; which, in turn, suggests a potential that PAH concentrations may locally impact the availability of invertebrates as a food source in the food web or

[12] OU2 is comprised of 92 polygons. Four of the 92 polygons did not have the full suite of PAHs available. Therefore, 88 polygons were used for this analysis.

reduce other soil functions. This is particularly true of polygon TB-16, which had an HQ = 100. Polygon TB-16 coincides with the area of highest HQs for robins. All other polygons had an HQ ≤ 20. Field observations suggest that invertebrates were present in polygons with HQs as high as 20.

# 5. REFERENCES

Andersson, J.T., and C. Achten. 2015. Time to Say Goodbye to the 16 EPA PAHs? Toward an Up-to-Date Use of PACs for Environmental Purposes. Polycyclic Aromatic Compounds 35(2-4): 330-354. DOI: 10.1080/10406638.2014.991042.

Baron, M.G., and E. Holder. 2003. Are Exposure and Ecological Risks of PAHs Underestimated at Petroleum Contaminated Sites? Human and Ecological Risk Assessment: An International Journal 9(6): 1533-1545.

Borgmann, U., W.P. Norwood, and K.M. Ralph. 1990. Chronic toxicity and bioaccumulation of 2,5,2',5' and 3,4,3',4'-tetrachlorobiphenyl and Aroclor 1242 in the amphipod (*Hyalella azteca*). Archives of Environmental Contamination and Toxicology 19:558-564.

DeGraaf, R.M., and M. Yamasaki. 2000. "Part I Natural Histories of New England's Wildlife Species." In: New England Wildlife: Habitat, Natural History, and Distribution. Hanover, New Hampshire: University Press of New England. 496 pages.

EarthCon. 2019a. Final Remedial Investigation Report, Kerr-McGee Chemical Corp—Navassa Superfund Site, Navassa, North Carolina. EPA ID #NCD980557805. Prepared for Greenfield Environmental Multistate Trust LLC. August.

EarthCon. 2019b. 2019 Soil Sampling Technical Memorandum. Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina, EPA ID #NCD980557805. Prepared for Greenfield Environmental Multistate Trust LLC. August.

EarthCon. 2020. OU1 Soil Sampling Technical Memorandum-Residential Criteria Area Delineation. Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina, EPA ID #NCD980557805. Prepared for Greenfield Environmental Multistate Trust LLC. October.

EarthCon 2020. OU2 Soil and Tissue PAH Data Submittal to USEPA EQuIS Database Plan, Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina USEPA ID #NCD980557805.

EarthCon 2021. OU2 Soil and Tissue PCDD/F Data Submittal to USEPA EQuIS Database Plan, Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina USEPA ID #NCD980557805.

Hahn, M.E., A. Poland, E. Glover, and J.J. Stegeman. 1994. Photoaffinity labeling of the Ah receptor: Phylogenetic survey of diverse vertebrate and invertebrate species. Arch. Biochem. Biophys. 310:218-228.

Integral, Ramboll, and EarthCon. 2021. White Paper on Addressing Human Health and Ecological Risks from Exposures to Impacted Soils in OU2 and OU4. Updated June.

Integral. 2021. OU2 Technical Memorandum. Draft to Beneficiaries.

Pitts, T.D. 1984. Description of American Robin Territories in Northwest Tennessee. The Migrant 55(1): 1-28.

Ramboll and EarthCon LLC (Ramboll and EarthCon). 2020. OU2 Soil Invertebrate Sampling Work Plan, Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina USEPA ID #NCD980557805. May. USEPA approved May 19, 2020.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II, T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Prepared for the U.S. Department of Energy Office of Environmental Management. ES/ER/TM-220.

University of Michigan ADW. 2021. The Animal Diversity Web [online]. Accessed at https://animaldiversity.org (Accessed January 2021).

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. USEPA/600/R-93/187. http://cfpub.epa.gov/ncea/cfm/wefh.cfm.

USEPA. 2007. Ecological Soil Screening Level (Eco-SSL) Guidance and Documents. https://www.epa.gov/chemical-research/guidance-developing-ecological-soil-screeninglevels.

USEPA R4. 2016. "EPA Region 4 Preferred Parameters to be Used in Ecological Risk Assessment in Region 4 – Version 9 – Last Revised November 01, 2016." Received by email from Brett Thomas, USEPA Region 4, on June 26, 2017.

USEPA R4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Supplemental Guidance to ERAGS: Region 4, Ecological Risk Assessment. March 2018 Update.

USEPA R4. 2020. "Revised Semi-Screening Level Ecological Risk Assessment Calculations for OU1 of the Kerr-McGee Chemical Company Site in Navassa, North Carolina." Received by email from Erik Spalvins via EarthCon on October 19, 2020.

Van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environmental Health Perspectives 106(12): 775–792.

West, C., G. Ankley, J Nichols, G. Elonen, and D. Nessa. 1997. Toxicity and bioaccumulation of 2,3,7,8-TCDD in long-term tests with freshwater benthic invertebrates. ET&C, 16:1287-1294.

## TABLES

**Table 2-1. Summary of Sample Collection**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Sample ID (a) | Target HMW PAH | Aboveground Invertebrates | | Belowground Invertebrates (undepurated) | Earthworms (depurated) | Surface Soil (paired with earthworms) | Distance from Stake (for paired soil/ earthworm samples) | QA Samples (Sample ID) |
|---|---|---|---|---|---|---|---|---|
| | | Field Weight and Description of Organisms | Polygon Extended? (b) | Field Weight and Description of Organisms | Sample Collected? | Description of Soil | | |
| **P01(SS-121)** | 1 – 10 | 18.6 g - yellow jackets (x50), spiders (x17), centipedes (x5), snail (x1), slug (x1), beetles (x3), pillbugs (x3), ants (x20)<br>14.1 g - yellow jacket larvae | No | 35.2 g - earthworms, grub (x1) | --- | dark brown/black, silty sand, high organic material, saturated, sheen | Within 4 feet of stake | MS/MSD (undepurated belowground invertebrates) sample |
| **P02(SS-117)** | >100 | 12.35 g - spiders (x9), beetle (x1), snail (x4), ants (x8), centipede (x2); wasps<br>27.10 g -yellow jacket larvae | No | 22.5 g - earthworms | Yes | dark brown/black, silty sand, high organic material, saturated, sheen | Within 5 feet of stake | --- |
| **P03(SS-123)** | <1 | 16.77 g - pill bugs, spiders, beetle (x1), snail (x1), ant (x1), slugs (x9) | No | 14.06 g - earthworms, grubs (x2) | --- | dark brown/black, silty sand, high organic material, saturated | Within 10 feet of stake | --- |
| **P04(RISB-09)** | 50 – 100 | 2.8 g - centipedes (x5), ant (x1), snails (x3), slug (x1), pillbugs (x2), spiders (x8) | No | 25.14 g - earthworms<br>25.74 g - earthworms | Yes | dark brown/black, silty sand, high organic material, saturated | Within 15 feet of stake | FD (earthworms - undepurated) |
| **P05(RISB-10)** | 50- 100 | 17.94 g - snails (x2), slugs (x15), pill bugs (x11), spiders (x5), centipedes (x20), beetle (x1) | Yes - to the north (similar habitat) | 19.72 g - earthworms | --- | dark brown/black, silty sand, high organic material, saturated | Within 20 feet of stake | FD (soil) |

**Table 2-1. Summary of Sample Collection**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Sample ID (a) | Target HMW PAH | Aboveground Invertebrates | | Belowground Invertebrates (undepurated) | Earthworms (depurated) | Surface Soil (paired with earthworms) | Distance from Stake (for paired soil/ earthworm samples) | QA Samples (Sample ID) |
|---|---|---|---|---|---|---|---|---|
| | | Field Weight and Description of Organisms | Polygon Extended? (b) | Field Weight and Description of Organisms | Sample Collected? | Description of Soil | | |
| **P06(TB-24)** | 11 – 50 | 27.45 g - slugs (x25), centipedes (x30), spiders (x5), pillbugs (x20), snails (x2), beetles (x2), ant (x1) | Yes - to the south slightly (similar habitat) | 21.47 g - earthworms | Yes | dark brown/black, silty sand, high organic material, saturated | Within 5-6 feet of stake | --- |
| **P07(TWSB-23)** | 1 – 10 | 10.59 g - spider (x5), centipedes (x2), wasps (x30), pillbugs (x4), ants (x3) | No | 14.59 g - earthworms, meal worm (x1) | --- | dark brown/black, fine sand, some organic material, dry | Within 20 feet of stake | --- |
| **P08(SS-111)** | <1 | 3.3 g - ants, centipedes, beetle (x3), carpenter bees, snails, slug (x1), spiders (x2), grasshoppers (x3) | No | 18.0 g - earthworms | Yes | dark brown/black, silty sand, high organic material, saturated | Within 15 feet of stake | MS/MSD (soil) |
| **P09(TB-16F)** | 11 – 50 | 1.2 g - cricket (x1), katydid (x1), daddy-longleg (x1), spiders (x4) | Yes - to the west (similar habitat) | 20.36 g - earthworms, meal worms (x2) | --- | dark brown/black, silty sand, saturated | Within 10 feet of stake | --- |
| **P10(TB-14)** | 11 – 50 | 14.01 g - slugs (x10), spiders (x2), snail (x1), pillbug (x1), centipede (x3) | No | 16.23 g - earthworms, meal worms (x1) | --- | dark brown/black, silty sand, high organic material, saturated | Within 10 feet of stake | --- |
| **P11(TB-08)** | 50 – 100 | 18.80 g- slugs (x14), larvae (x20), ants (x10), snails (x2), spiders (x4) | No | 30.28 g - earthworms | --- | dark brown/black, silty sand, organic material | Within 6 feet of stake | --- |

**Table 2-1. Summary of Sample Collection**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Sample ID (a) | Target HMW PAH | Aboveground Invertebrates | | Belowground Invertebrates (undepurated) | Earthworms (depurated) | Surface Soil (paired with earthworms) | Distance from Stake (for paired soil/ earthworm samples) | QA Samples (Sample ID) |
|---|---|---|---|---|---|---|---|---|
| | | Field Weight and Description of Organisms | Polygon Extended? (b) | Field Weight and Description of Organisms | Sample Collected? | Description of Soil | | |
| **P12(SS-110)** | >100 | 10.8 g wasps<br>10.5 g - yellow jacket larvae | No | 27.41 g - earthworms | --- | dark brown/black, sandy, some organic material, dry | Within 10 feet of stake | --- |
| **P13(TB-10)** | <1 | 13.23 g - spiders (x8), snail (x1), slugs (x8), centipedes (x3) | No | 12.6 g - earthworms | --- | fine sand, moderate organic material, saturated | Within 10 feet of stake | |
| **P14(SB-129)** | 1 – 10 | 21.96 g - ants (x10), slugs (x15), centipedes (x6), grasshoppers (x3) | No | 22.81 g - earthworms | --- | dark brown/black, silty sand, high organic material, dry | Within 6 feet of stake | |
| **P15(TB-11)** | >100 | 10.87 g - grasshoppers (x7), spiders (x15), pillbugs (x6), slugs (x2) | No | 17.36 g - earthworms<br>18.38 g - earthworms | --- | dark brown/black, coarse sand, organic material | 20 - 30 feet south of stake | FD (belowground invertebrates)<br>FD (soil) |

**Notes:**
FD = Field duplicate
g = Gram(s)
HMW = High molecular weight
ID = Identification
MS = Matrix spike
MSD = Matrix spike duplicate
PAH = Polycyclic aromatic hydrocarbons
QA = Quality assurance

(a) Each polygon sampled was assigned a sequential identification number (e.g., P01, P02). This identification number along with the historical sample soil sample identification used to select the polygon based on HMW PAH concentration was used to identify a sample from the June 2020 investigation.

(b) For some polygons, the field team could not collect the minimum tissue mass needed for analysis despite their best efforts. Therefore, the sampling effort was extended onto an adjacent polygon with similar PAH concentrations, as detailed in the approved OU2 Work Plan.

Ramboll and EarthCon LLC (Ramboll and EarthCon). 2020a. OU2 Soil Invertebrate Sampling Work Plan, Kerr-McGee Chemical Corp – Navassa Superfund Site, Navassa, North Carolina USEPA ID #NCD980557805. May. USEPA approved May 19, 2020.

**Table 2-2A. Tissues Analyzed for PCDD/Fs**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample ID | Aboveground Invertebrates (a) | Belowground Invertebrates (undepurated) | Earthworms (depurated) | Surface Soil (paired with earthworms) | Additional Samples |
|---|---|---|---|---|---|
| | Remaining Tissue? | Remaining Tissue? | Remaining Tissue? | Remaining Soil? | Remaining Sample? |
| **P1(SS-121)** | 2 grams | Yes - ≥ 10 grams | -- | Yes - analyze | Extra tissue from previous tissue MS/MSD sample. Do MS/MSD analysis for PCDD/F on remaining QA sample. |
| **P2(SS-117)** | No | Yes: 5 grams | Yes - 5 grams | Yes - analyze | --- |
| **P3(SS-123)** | Yes - 2 grams | No | -- | Yes - analyze | --- |
| **P4(RISB-09)** | No | Yes - ≥ 10 grams | Yes - 5 grams | Yes - analyze | -- |
| | | Yes - 5 grams | | | |
| **P5(RISB-10)** | Yes - 2 grams | Yes - 2 grams | -- | Yes - analyze | -- |
| | | | | Yes - analyze | |
| **P6(TB-24)** | Yes - 3 grams | Yes - 5 grams | Yes - 5 grams | Yes - analyze | --- |
| **P7(TWSB-23)** | No | No | -- | Yes - but did not analyze (c) | --- |
| **P8(SS-111)** | No | Yes - 2 grams | Yes - 5 grams | Yes - analyze | Extra soil from previous soil MS/MSD sample. Do soil MS/MSD analysis for PCDD/F on remaining soil MS/MSD sample. |
| **P9(TB-16F)** | No | Yes - 5 grams | -- | Yes - analyze | --- |
| **P10(TB-14)** | Yes - 2 grams | Yes - 2 grams but did not analyze (b) | -- | Yes - but did not analyze (c) | --- |
| **P11(TB-08)** | Yes - 4 grams | Yes - ≥ 10 grams | -- | Yes - analyze | --- |
| **P12(SS-110)** | No | Yes- 7 grams | -- | Yes - analyze | --- |
| **P13(TB-10)** | No | Yes - 8 grams | -- | Yes - analyze | -- |
| **P14(SB-129)** | Yes - 4 grams | Yes - 6 grams | -- | Yes - analyze | -- |
| **P15(TB-11)** | No | Yes - 3 grams | -- | Yes - analyze | -- |
| | | Yes - 2 grams | | Yes - analyze | |
| **Total Samples:** | 7 Parent samples | 13 Parent samples<br>2 Field duplicates | 4 Parent samples | 14 Parent samples<br>2 Field duplicates | 2 Additonal sample for MS/MSD |

**Table 2-2A. Tissues Analyzed for PCDD/Fs**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

**Notes:**
Soil and tissue samples reanalyzed for PCDD/Fs.
-- = Not collected
FD = Field duplicate
g = Gram(s)
ID = Identification
MS = Matrix spike
MSD = Matrix spike duplicate
PCDD/Fs = Polychlorinated dibenzo-p-dioxins and dibenzofurans
QA = Quality assurance

(a) Any remaining larval aboveground invertebrate tissue samples were not re-analyzed and are not included in this table.

(b) After sample retrieval, SGS Axys determined that this sample had been consumed and was not available for analysis.

(c) As the belowground invertebrate sample had been consumed and was not available for analysis, the co-located soil sample was not analyzed.

**Table 2-2B. Axys SGS Laboratory PCDD/F Detection Limits for EPA Method 8290**
**Keer-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| **Matrix** | **SOIL** | | | | | | | **TISSUE** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Units/Sample Size** | pg/g based on 10g sample | | | | | | | pg/g based on 10g sample | | | | |
| **Default Extract Volume** | 20uL | | | | | | | 20uL | | | | |
| **Analyte** ***Dioxins*** | **Typical SDL** | **Mammal TEFs** | **SDL TEQ** | **MDL** | **MDL TEQ** | **RL** | **RL TEQ** | **Typical SDL** | **TEF** | **SDL TEQ** | **MDL** | **MDL TEQ** |
| 2,3,7,8-TCDD | 0.05 | 1.00 | 0.05 | 0.35 | 0.35 | 0.05 | 0.05 | 0.05 | 1.00 | 0.05 | 0.15 | 0.15 |
| 1,2,3,7,8-PECDD | 0.05 | 1.00 | 0.05 | 0.53 | 0.53 | 0.05 | 0.05 | 0.05 | 1.00 | 0.05 | 0.22 | 0.22 |
| 1,2,3,4,7,8-HXCDD | 0.05 | 0.05 | 0.00 | 0.69 | 0.03 | 0.05 | 0.00 | 0.05 | 0.05 | 0.00 | 0.20 | 0.01 |
| 1,2,3,6,7,8-HXCDD | 0.05 | 0.01 | 0.00 | 0.49 | 0.00 | 0.05 | 0.00 | 0.05 | 0.01 | 0.00 | 0.17 | 0.00 |
| 1,2,3,7,8,9-HXCDD | 0.05 | 0.10 | 0.01 | 0.60 | 0.06 | 0.05 | 0.01 | 0.05 | 0.10 | 0.01 | 0.24 | 0.02 |
| 1,2,3,4,6,7,8-HPCDD | 0.05 | 0.001 | 0.0001 | 0.86 | 0.0009 | 0.05 | 0.00005 | 0.05 | 0.001 | 0.0001 | 0.21 | 0.0002 |
| OCDD | 0.05 | 0.0001 | 0.000005 | 3.47 | 0.0003 | 0.05 | 0.00001 | 0.05 | 0.0001 | 0.000005 | 0.91 | 0.0001 |
| ***Furans*** | **Typical SDL** | **TEF** | **SDL TEQ** | **MDL** | **MDL TEQ** | **RL[1]** | **RL TEQ** | **Typical SDL** | **TEF** | **SDL TEQ** | **MDL *** | **MDL TEQ** |
| 2,3,7,8-TCDF | 0.05 | 1.00 | 0.05 | 0.22 | 0.2163 | 0.05 | 0.05000 | 0.05 | 1.00 | 0.05 | 0.13 | 0.1319 |
| 1,2,3,7,8-PECDF | 0.05 | 0.10 | 0.01 | 0.56 | 0.0555 | 0.05 | 0.00500 | 0.05 | 0.10 | 0.01 | 0.16 | 0.0159 |
| 2,3,4,7,8-PECDF | 0.05 | 1.00 | 0.05 | 0.55 | 0.5503 | 0.05 | 0.05000 | 0.05 | 1.00 | 0.05 | 0.15 | 0.1486 |
| 1,2,3,4,7,8-HXCDF | 0.05 | 0.10 | 0.01 | 0.49 | 0.0487 | 0.05 | 0.00500 | 0.05 | 0.10 | 0.01 | 0.15 | 0.0145 |
| 1,2,3,6,7,8-HXCDF | 0.05 | 0.10 | 0.01 | 0.53 | 0.0530 | 0.05 | 0.00500 | 0.05 | 0.10 | 0.01 | 0.19 | 0.0190 |
| 1,2,3,7,8,9-HXCDF | 0.05 | 0.10 | 0.01 | 0.52 | 0.0521 | 0.05 | 0.00500 | 0.05 | 0.10 | 0.01 | 0.17 | 0.0167 |
| 2,3,4,6,7,8-HXCDF | 0.05 | 0.10 | 0.01 | 0.53 | 0.0526 | 0.05 | 0.00500 | 0.05 | 0.10 | 0.01 | 0.14 | 0.0142 |
| 1,2,3,4,6,7,8-HPCDF | 0.05 | 0.01 | 0.000500 | 1.06 | 0.0106 | 0.05 | 0.00050 | 0.05 | 0.01 | 0.000500 | 0.15 | 0.0015 |
| 1,2,3,4,7,8,9-HPCDF | 0.05 | 0.01 | 0.000500 | 0.51 | 0.0051 | 0.05 | 0.00050 | 0.05 | 0.01 | 0.000500 | 0.17 | 0.0017 |
| OCDF | 0.05 | 0.00 | 0.000005 | 1.18 | 0.0001 | 0.05 | 0.00001 | 0.05 | 0.00 | 0.000005 | 0.33 | 0.0000 |
| | | TCDD SDL TEQ (pg/g): | 0.23 | TCDD MDL TEQ (pg/g): | 2.03 | TCDD RL TEQ (pg/g): | 0.23 | | TCDD SDL TEQ (pg/g): | 0.23 | TCDD MDL TEQ (pg/g): | 0.77 |

**Notes:**

Reporting Limit (RL) is the lowest concentration routinely reported for the method.
Method Detection Limit (MDL)
Sample Detection Limit (SDL)
Toxicity effects factor (TEF) - Mammal TEFs used
Toxicity equivalency quotient (TEQ)
Parts per trillion (PPT) is nanogram per kilogram and equal to picogram per gram (pg/g)

**Table 2-3A. PAH and PCDD/F TEQ Soil Concentrations by Polygon**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample ID | Polygon ID | Location ID | Soil Concentration (a) (mg/kg dw) | | | | Soil Concentration (ng/kg dw) (b) | | % Moisture | Total Organic Carbon (mg/kg dw) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Σ12 HMW PAHs | Σ8 LMW PAHs | Σ15 ALK PAHs | Σ35 Total PAHs | PCDD/F TEQ (Avian) | PCDD/F TEQ (Mammal) | | |
| P08 (SS-111)-SS-20200617 | P08 | SS-111 | 10.0 | 1.56 | 5.22 | 16.8 | 1.02 | 1.02 | 34.2 | 27,100 |
| P03 (SS-123)-SS-20200616 | P03 | SS-123 | 22.6 | 1.85 | 9.18 | 33.7 | 11.5 | 25.7 | 33.7 | 43,700 |
| P13 (TB-10)-SS-20200619 | P13 | TB-10 | 37.4 | 1.24 | 17.2 | 55.9 | 1.42 | 2.16 | 28.1 | 26,800 |
| P14 (SB-129)-SS-20200619 | P14 | SB-129 | 8.52 | 1.07 | 4.24 | 13.8 | 1.42 | 1.21 | 27.2 | 35,300 |
| P01 (SS-121)-SS-20200615 | P01 | SS-121 | 311 | 18.0 | 158 | 487 | 6.02 | 8.79 | 40.2 | 60,800 |
| P07 (TWSB-23)-SS-20200617 | P07 | TWSB-23 | 407 | 15.6 | 175 | 597 | NA (c) | NA (c) | 26.1 | 70,100 |
| P10 (TB-14)-SS-20200618 | P10 | TB-14 | 35.3 | 3.52 | 17.9 | 56.7 | 1.88 | 2.49 | 33.2 | 27,400 |
| P06 (TB-24)-SS-20200616 | P06 | TB-24 | 93.1 | 6.23 | 37.7 | 137 | 18.3 | 27.9 | 51.3 | 78,300 |
| P09 (TB-16F)-SS-20200618 | P09 | TB-16F | 220 | 12.9 | 85.3 | 318 | 3.30 | 4.42 | 30.6 | 42,500 |
| P05 (RISB-10)-SS-20200616-FD | P05 | RISB-10-FD | 102 | 10.5 | 56.9 | 169 | 14.5 | 18.1 | 35.4 | 56,200 |
| P05 (RISB-10)-SS-20200616 | P05 | RISB-10 | 105 | 8.66 | 54.3 | 168 | 14.2 | 18.0 | 37.9 | 60,300 |
| P11 (TB-08)-SS-20200618 | P11 | TB-08 | 141 | 11.5 | 66.6 | 219 | 4.24 | 6.52 | 23.0 | 27,700 |
| P04 (RISB-09)-SS-20200616 | P04 | RISB-09 | 159 | 9.78 | 83.8 | 252 | 4.37 | 4.19 | 34.7 | 68,000 |
| P15 (TB-11)-SS-20200618 | P15 | TB-11 | 12.6 | 2.95 | 9.62 | 25.1 | 4.84 | 3.90 | 38.3 | 177,000 |
| P15 (TB-11)-SS-20200618-FD | P15 | TB-11-FD | 12.2 | 3.26 | 10.7 | 26.1 | 4.84 | 3.85 | 39.3 | 321,000 |
| P02 (SS-117)-SS-20200615 | P02 | SS-117 | 350 | 32.8 | 191 | 574 | 4.71 | 8.35 | 37.0 | 65,300 |
| P12 (SS-110)-SS-20200618 | P12 | SS-110 | 501 | 5.92 | 211 | 718 | 5.14 | 9.79 | 25.5 | 45,100 |

**Notes:**

% = Percent
∑ = Sum of
< = Less than
> = Greater than
ALK = Alkylated
Conc. = Concentration
FD = Field duplicate
HMW = High molecular weight
ID = Identification
LMW = Low molecular weight
mg/kg dw = Milligram(s) per kilogram of dry weight
NA = Not analyzed
ng/kg dw = Nanogram(s) per kilogram of dry weight
PAH = Polycyclic aromatic hydrocarbons
PCDD/F TEQ = PCDD/Fs toxic equivalency (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)
PCDD/Fs = Polychlorinated dibenzo-p-dioxins and dibenzofurans

The co-located aboveground invertebrate samples were dominated by wasps. Soil samples and their co-located aboveground invertebrate samples were not used for uptake evaluation.

(a) There were no soil concentrations below the laboratory level of detection for individual PAHs.
(b) Any individual congeners below the laboratory method detection limit was treated as equal to the method detection limit for the purpose of calculating the PCDD/F TEQ.

(c) PCDD/Fs were analyzed in soil after PAH analysis, and only if there was also a sufficient amount of remaining tissue at the sample location for a co-located soil and tissue data.

**Table 2-3B. PAH and PCDD/F TEQ Soil Concentration Summary**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample Type | Analyte (a) | Units | Frequency of Detect | Minimum | Average | Maximum | 95% UCL (b) | UCL Basis | USEPA R4 ESV for Soil (c) | Maximum HQ | Frequency of Exceedence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil | % Moisture | % | 17 / 17 | 23.0 | 33.9 | 51.3 | 36.8 | 95% Student's-t UCL | -- | NA | -- |
| Soil | Total Organic Carbon | mg/kg | 17 / 17 | 26,800 | 72,506 | 321,000 | 119,028 | 95% Chebyshev (MVUE) UCL | -- | NA | -- |
| Soil | Alkylated PAHs (∑15 PAHs) | mg/kg | 17 / 17 | 4.24 | 70.1 | 211 | 100 | 95% Student's-t UCL | -- | NA | -- |
| Soil | HMW PAHs (∑12 PAHs) | mg/kg | 17 / 17 | 8.52 | 149 | 501 | 215 | 95% Student's-t UCL | 1.1 | **500** | 17 / 17 |
| Soil | LMW PAHs (∑8 PAHs) | mg/kg | 17 / 17 | 1.07 | 8.67 | 32.8 | 12.1 | 95% Student's-t UCL | 29 | **1** | 1 / 17 |
| Soil | Total PAHs (∑35 PAHs) | mg/kg | 17 / 17 | 13.8 | 227 | 718 | 325 | 95% Student's-t UCL | -- | NA | -- |
| Soil | PCDD/F TEQ (Avian) | ng/kg | 16 / 16 | 1.02 | 6.35 | 18.3 | 9.81 | 95% Adjusted Gamma UCL | 16 | **1** | 1 / 16 |
| Soil | PCDD/F TEQ (Mammal) | ng/kg | 16 / 16 | 1.02 | 9.15 | 27.9 | 15.1 | 95% Adjusted Gamma UCL | 3.15 | **9** | 12 / 16 |

**Notes:**
There were no soil concentrations below the laboratory level of detection for individual PAHs. For the calculation of PCDD/Fs TEQs, any individual congeners below the laboratory detection limit was treated as equal to the laboratory detection limit.

| | |
|---|---|
| **1** | HQ = 1 |
| **9** | 1 < HQ < 10 |
| **500** | HQ > 100 |

% = Percentage
∑ = Sum of
95% UCL = 95 percent upper confidence level of the mean
HMW = High molecular weight
HQ = Hazard quotient
LMW = Low molecular weight
mg/kg = Milligram(s) per kilogram
NA = Not applicable
ng/kg = Nanograms(s) per kilogram
PAH = Polycyclic aromatic hydrocarbons
UCL = Upper confidence limit
USEPA R4 = United States Environmental Protection Agency Region 4
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

(a) The soil concentrations associated with four aboveground invertebrate samples dominated by wasps are included in this table to describe the soil data. However, the soil data associated with the wasp samples were not used in the uptake evaluation.

(b) UCLs are the 95th% upper confidence limits (UCLs), as calculated by USEPA ProUCL software.

(c) ESV Source: USEPA R4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Supplemental Guidance to ERAGS: Region 4, Ecological Risk Assessment. March 2018 Update. For PCDD/F TEQs, mammalian and avian-specifc ESVs were used to screen for the mammalian and avian PCDD/F TEQ soil concentrations, respectively.

**Table 2-4A. PAH and PCDD/F TEQ Tissue Concentrations by Polygon**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample ID (a) | Polygon ID | Sample Location | Invertebrate Tissue Concentrations (%) | | Invertebrate Tissue PAH Concentrations (mg/kg ww) | | | | Invertebrate Tissue PCDD/F TEQ Concentrations (ng/kg ww) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | % Moisture (b) | % Lipid | LMW PAHs (Σ8 PAHs) | HMW PAHs (Σ12 PAHs) | ALK PAHs (Σ15 PAHs) | Total PAHs (Σ35 PAHs) | Avian PCDD/F TEQ | Mammal PCDD/F TEQ |
| ***Aboveground Invertebrates*** | | | | | | | | | | |
| P12 (SS-110)-AGI | P12 | SS-110 | 71.3 | 3.92 | 0.0930 | 9.09 | 2.73 | 11.9 | NA | NA |
| P12 (SS-110)-AG2 | P12 | SS-110 | 77.3 | 6.84 | 0.0397 | 3.74 | 1.36 | 5.14 | NA | NA |
| P07 (TWSB-23)-AG | P07 | TWSB-23 | 65.7 | 2.32 | 0.0398 | 2.39 | 0.62 | 3.05 | NA | NA |
| P02 (SS-117)-AGI | P02 | SS-117 | 64.0 | 2.95 | 9.57 | 46.3 | 25.4 | 81.3 | NA | NA |
| P02 (SS-117)-AG2 | P02 | SS-117 | 71.4 | 3.90 | 0.00619 | 0.25 | 0.0785 | 0.330 | NA | NA |
| P01 (SS-121)-AGI | P01 | SS-121 | 69.4 | 3.16 | 0.139 | 1.44 | 0.751 | 2.33 | 0.871 | 0.831 |
| P01 (SS-121)-AG2 | P01 | SS-121 | 70.4 | 6.77 | 0.00703 | 0.239 | 0.0733 | 0.319 | NA | NA |
| P09 (TB-16F)-AG | P09 | TB-16F | 80.7 | 3.62 | 0.0534 | 0.587 | 0.201 | 0.841 | NA | NA |
| P04 (RISB-09)-AG | P04 | RISB-09 | 65.7 | 2.93 | 0.0402 | 1.10 | 0.444 | 1.59 | NA | NA |
| P11 (TB-08)-AG | P11 | TB-08 | 81.5 | 2.28 | 0.00513 | 0.126 | 0.0728 | 0.204 | 0.492 | 0.410 |
| P05 (RISB-10)-AG | P05 | RISB-10 | 78.5 | 2.79 | 0.00851 | 0.0813 | 0.0533 | 0.143 | 0.532 | 0.370 |
| P06 (TB-24)-AG | P06 | TB-24 | 80.7 | 1.77 | 0.00459 | 0.144 | 0.0739 | 0.222 | 0.371 | 0.363 |
| P10 (TB-14)-AG | P10 | TB-14 | 84.4 | 1.54 | 0.00213 | 0.0420 | 0.0312 | 0.0754 | 0.805 | 0.544 |
| P13 (TB-10)-AG | P13 | TB-10 | 84.9 | 1.95 | 0.00117 | 0.0253 | 0.0187 | 0.0451 | NA | NA |
| P03 (SS-123)-AG | P03 | SS-123 | 83.9 | 1.88 | 0.00321 | 0.0441 | 0.0155 | 0.0627 | 0.892 | 0.738 |
| P15 (TB-11)-AG | P15 | TB-11 | 84.9 | 3.53 | 0.0111 | 0.0892 | 0.191 | 0.291 | NA | NA |
| P08 (SS-111)-AG | P08 | SS-111 | 80.7 | 2.88 | 0.00142 | 0.000407 | 0.0235 | 0.0253 | NA | NA |
| P14 (SB-129)-AG | P14 | SB-129 | 82.8 | 2.06 | 0.00127 | 0.0145 | 0.0174 | 0.0331 | 0.270 | 0.184 |
| ***Undepurated Belowground Invertebrates*** | | | | | | | | | | |
| P12 (SS-110)-EU | P12 | SS-110 | 79.0 | 2.11 | 0.463 | 38.2 | 9.51 | 48.2 | 1.12 | 1.98 |
| P07 (TWSB-23)-EU | P07 | TWSB-23 | 74.6 | 2.38 | 2.38 | 60.8 | 23.7 | 86.9 | NA | NA |
| P02 (SS-117)-EU | P02 | SS-117 | 83.9 | 2.09 | 0.831 | 12.1 | 5.06 | 18.0 | 0.904 | 1.33 |
| P01 (SS-121)-EU | P01 | SS-121 | 81.5 | 1.60 | 0.586 | 11.9 | 4.91 | 17.4 | 1.46 | 1.44 |
| P09 (TB-16F)-EU | P09 | TB-16F | 78.4 | 1.99 | 0.982 | 26.7 | 5.42 | 33.1 | 0.601 | 0.742 |
| P04 (RISB-09)-EU | P04 | RISB-09 | 82.1 | 2.16 | 1.04 | 22.1 | 8.89 | 32.0 | 0.669 | 0.640 |
| P04 (RISB-09)-EU-FD | P04 | RISB-09 | 81.7 | 3.17 | 0.651 | 16.3 | 6.40 | 23.4 | 0.669 | 0.640 |
| P11 (TB-08)-EU | P11 | TB-08 | 80.8 | 1.63 | 1.02 | 16.2 | 4.98 | 22.2 | 2.32 | 3.89 |
| P05 (RISB-10)-EU | P05 | RISB-10 | 79.3 | 3.09 | 0.660 | 10.5 | 4.18 | 15.3 | 1.98 | 2.29 |
| P06 (TB-24)-EU | P06 | TB-24 | 80.3 | 1.61 | 0.665 | 11.4 | 4.32 | 16.4 | 2.87 | 4.38 |
| P10 (TB-14)-EU | P10 | TB-14 | 76.3 | 1.85 | 0.498 | 6.58 | 2.00 | 9.08 | NA | NA |
| P13 (TB-10)-EU | P13 | TB-10 | 75.1 | 1.90 | 0.215 | 14.0 | 5.62 | 19.8 | 0.549 | 0.773 |
| P03 (SS-123)-EU | P03 | SS-123 | 74.6 | 3.14 | 0.098 | 1.56 | 0.652 | 2.31 | NA | NA |
| P15 (TB-11)-EU | P15 | TB-11 | 73.3 | 1.75 | 0.368 | 2.62 | 1.59 | 4.58 | 0.625 | 0.604 |
| P15 (TB-11)-EU-FD | P15 | TB-11 | 72.8 | 2.30 | 0.231 | 1.93 | 1.00 | 3.16 | 0.625 | 0.604 |
| P08 (SS-111)-EU | P08 | SS-111 | 77.0 | 1.81 | 0.212 | 1.74 | 0.959 | 2.91 | 0.403 | 0.345 |
| P14 (SB-129)-EU | P14 | SB-129 | 77.5 | 2.10 | 0.0613 | 0.680 | 0.282 | 1.02 | 0.310 | 0.277 |

**Table 2-4A. PAH and PCDD/F TEQ Tissue Concentrations by Polygon**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample ID (a) | Polygon ID | Sample Location | Invertebrate Tissue Concentrations (%) | | Invertebrate Tissue PAH Concentrations (mg/kg ww) | | | | Invertebrate Tissue PCDD/F TEQ Concentrations (ng/kg ww) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | % Moisture (b) | % Lipid | LMW PAHs (Σ8 PAHs) | HMW PAHs (Σ12 PAHs) | ALK PAHs (Σ15 PAHs) | Total PAHs (Σ35 PAHs) | Avian PCDD/F TEQ | Mammal PCDD/F TEQ |
| ***Depurated Earthworms*** | | | | | | | | | | |
| P02 (SS-117)-ED | P02 | SS-117 | 82.4 | 2.21 | 0.425 | 6.72 | 2.54 | 9.68 | 0.818 | 1.05 |
| P04 (RISB-09)-ED | P04 | RISB-09 | 82.4 | 2.26 | 0.223 | 7.45 | 2.87 | 10.5 | 0.506 | 0.496 |
| P06 (TB-24)-ED | P06 | TB-24 | 82.6 | 1.75 | 0.284 | 5.22 | 2.00 | 7.51 | 1.69 | 2.30 |
| P08 (SS-111)-ED | P08 | SS-111 | 85.3 | 1.86 | 0.121 | 0.886 | 0.407 | 1.41 | 0.999 | 0.509 |

**Notes:**

% = Percentage
Σ = Sum of
< = Less than
> = Greater than
AG/AG1 = Adult aboveground invertebrates
AG2 = Larval aboveground invertebrates
ALK = Alkylated
ED = Depurated earthworms
EU = Undepurated belowground invertebrates
FD = Field duplicate
HMW = High molecular weight
ID = Identification
LMW = Low molecular weight
mg/kg ww = Milligram(s) per kilogram of wet weight
N/A = Not applicable (Insufficient mass for tissue analysis)
ng/kg ww = Nanograms(s) per kilogram of wet weight
PAH = Polycyclic aromatic hydrocarbons
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

Aboveground samples were dominated by wasps. Samples were not used for uptake evaluation.

(a) Non-detected concentrations comprising the PAH sums were treated as one-half the detection limit. Non-detected concentrations comprising the PCDD/F TEQ sums were treated as equal to the detection limit.
(b) Moisture content was not measured in the laboratory for the aboveground invertebrate sample at P09(TB-16F) due to insufficient sample mass. Therefore, the median of the other aboveground invertebrate samples was used as a surrogate.

**Table 2-4B. PAH and PCDD/F TEQ Tissue Concentration Summary**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Sample Type (a) | Analyte | Units | Frequency of Detect | Minimum | Average | Maximum | 95% UCL (b) | UCL Basis |
|---|---|---|---|---|---|---|---|---|
| Aboveground Invertebrates - Adults | % Lipid | % | 15 / 15 | 1.54 | 2.64 | 3.92 | 2.97 | 95% Student's-t UCL |
| Aboveground Invertebrates - Adults | % Moisture | % | 14 / 14 | 64.0 | 77.0 | 84.9 | 80.8 | 95% Student's-t UCL |
| Aboveground Invertebrates - Adults | Alkylated PAHs (∑15 PAHs) | mg/kg ww | 15 / 15 | 0.0155 | 2.05 | 25.4 | 9.37 | 95% Chebyshev (Mean, Sd) UCL (c) |
| Aboveground Invertebrates - Adults | HMW PAHs (∑12 PAHs) | mg/kg ww | 14 / 15 | 0.000407 | 4.10 | 46.3 | 17.5 | 95% KM (Chebyshev) UCL (c) |
| Aboveground Invertebrates - Adults | LMW PAHs (∑8 PAHs) | mg/kg ww | 15 / 15 | 0.00117 | 0.66 | 9.57 | 3.44 | 95% Chebyshev (Mean, Sd) UCL (c) |
| Aboveground Invertebrates - Adults | Total PAHs (∑35 PAHs) | mg/kg ww | 15 / 15 | 0.0253 | 6.81 | 81.3 | 30.2 | 95% Chebyshev (Mean, Sd) UCL (c) |
| Aboveground Invertebrates - Adults | PCDD/F TEQ Avian | ng/kg ww | 7 / 7 | 0.270 | 0.605 | 0.892 | 0.736 | 95% KM(t) UCL |
| Aboveground Invertebrates - Adults | PCDD/F TEQ Mammal | ng/kg ww | 7 / 7 | 0.184 | 0.491 | 0.831 | 0.640 | 95% KM(t) UCL |
| Aboveground Invertebrates - Larvae | % Lipid | % | 3 / 3 | 3.9 | 5.84 | 6.84 | 8.67 | 95% Student's-t UCL |
| Aboveground Invertebrates - Larvae | % Moisture | % | 3 / 3 | 70.4 | 73.0 | 77.3 | 79.3 | 95% Student's-t UCL |
| Aboveground Invertebrates - Larvae | Alkylated PAHs (∑15 PAHs) | mg/kg ww | 3 / 3 | 0.0733 | 0.50 | 1.36 | 1.75 | 95% Student's-t UCL |
| Aboveground Invertebrates - Larvae | HMW PAHs (∑12 PAHs) | mg/kg ww | 3 / 3 | 0.239120 | 1.41 | 3.74 | 4.81 | 95% Student's-t UCL |
| Aboveground Invertebrates - Larvae | LMW PAHs (∑8 PAHs) | mg/kg ww | 3 / 3 | 0.00619 | 0.02 | 0.0397 | 0.05 | 95% Student's-t UCL |
| Aboveground Invertebrates - Larvae | Total PAHs (∑35 PAHs) | mg/kg ww | 3 / 3 | 0.3194 | 1.93 | 5.1 | 6.61 | 95% Student's-t UCL |
| Depurated Earthworms | % Lipid | % | 4 / 4 | 1.8 | 2.02 | 2.26 | 2.32 | 95% Student's-t UCL |
| Depurated Earthworms | % Moisture | % | 4 / 4 | 82.4 | 83.2 | 85.3 | 84.9 | 95% Student's-t UCL |
| Depurated Earthworms | Alkylated PAHs (∑15 PAHs) | mg/kg ww | 4 / 4 | 0.4 | 1.95 | 2.87 | 3.24 | 95% Student's-t UCL |
| Depurated Earthworms | HMW PAHs (∑12 PAHs) | mg/kg ww | 4 / 4 | 0.9 | 5.07 | 7.45 | 8.53 | 95% Student's-t UCL |
| Depurated Earthworms | LMW PAHs (∑8 PAHs) | mg/kg ww | 4 / 4 | 0.121 | 0.263 | 0.425 | 0.413 | 95% Student's-t UCL |
| Depurated Earthworms | Total PAHs (∑35 PAHs) | mg/kg ww | 4 / 4 | 1.4136 | 7.28 | 10.5 | 12.1 | 95% Student's-t UCL |
| Depurated Earthworms | PCDD/F TEQ Avian | ng/kg ww | 4 / 4 | 0.506 | 1.00 | 1.69 | 1.59 | 95% Student's-t UCL |
| Depurated Earthworms | PCDD/F TEQ Mammal | ng/kg ww | 4 / 4 | 0.496 | 1.09 | 2.30 | 2.09 | 95% Student's-t UCL |
| Undepurated Belowground Invertebrates | % Lipid | % | 17 / 17 | 1.6 | 2.16 | 3.17 | 2.38 | 95% Student's-t UCL |
| Undepurated Belowground Invertebrates | % Moisture | % | 17 / 17 | 72.8 | 78.1 | 83.9 | 79.5 | 95% Student's-t UCL |
| Undepurated Belowground Invertebrates | Alkylated PAHs (∑15 PAHs) | mg/kg ww | 17 / 17 | 0.3 | 5.26 | 23.7 | 8.66 | 95% Adjusted Gamma UCL |
| Undepurated Belowground Invertebrates | HMW PAHs (∑12 PAHs) | mg/kg ww | 17 / 17 | 0.7 | 15.0 | 60.8 | 25.9 | 95% Adjusted Gamma UCL |
| Undepurated Belowground Invertebrates | LMW PAHs (∑8 PAHs) | mg/kg ww | 17 / 17 | 0.1 | 0.645 | 2.38 | 0.876 | 95% Student's-t UCL |
| Undepurated Belowground Invertebrates | Total PAHs (∑35 PAHs) | mg/kg ww | 17 / 17 | 1.02 | 20.9 | 86.9 | 35.3 | 95% Adjusted Gamma UCL |
| Undepurated Belowground Invertebrates | PCDD/F TEQ Avian | ng/kg ww | 14 / 14 | 0.310 | 1.07 | 2.87 | 1.59 | 95% Adjusted Gamma UCL |
| Undepurated Belowground Invertebrates | PCDD/F TEQ Mammal | ng/kg ww | 14 / 14 | 0.277 | 1.42 | 4.38 | 2.32 | 95% Adjusted Gamma UCL |

**Notes:**
Non-detected concentrations comprising the PAH sums were treated as one-half the laboratory method of detection limit. Non-detected concentrations comprising the PCDD/Fs TEQ sums were treated as equal to the laboratory method of detection limit.

% = Percent
∑ = Sum of
95% UCL = 95th percent upper confidence level of the mean
HMW = High molecular weight
LMW = Low molecular weight
mg/kg ww = Milligram(s) per kilogram of wet weight
ng/kg ww = Nanograms(s) per kilogram of wet weight
PAH = Polycyclic aromatic hydrocarbons
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)
UCL = Upper confidence limit
Blue highlighting indicates UCLs > Max

(a) Four adult aboveground invertebrate samples were dominated by wasps. Although the 4 wasp-dominated samples were not used in the uptake evaluation, they were included in the statistical summary presented in this table to describe the data collected.

(b) UCLs are the 95th% upper confidence limits (UCLs), as calculated by USEPA ProUCL software. ProUCL output documentation is provided in Appendix F.
(c) The software ProUCL selected a preferred 99th% UCL; however, Ramboll manually selected a 95th% UCL.

**Table 3-1A. OU2 Representative Soil PAH Data Used for Ecological Risk Assessment**

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) (b) | % Area of Total (b) | HMW PAHs (ND=0.5DL) | | LMW PAHs (ND = 0.5DL) | | Notes |
|---|---|---|---|---|---|---|---|
| | | | Σ10 HMW PAHs (mg/kg) | Polygon Contribution of Σ10 HMW PAHs (mg/kg) (b) | Σ7 LMW PAHs (mg/kg) | Polygon Contribution of Σ7 LMW PAHs (mg/kg) (b) | |
| CS-52 | 0.088 | 0.6% | 6.42 | 0.0383 | 0.979 | 0.00585 | |
| CS-53 | 0.243 | 1.7% | 1.59 | 0.0263 | 0.321 | 0.0053 | |
| CS-55 | 0.169 | 1.1% | 11.3 | 0.13 | 4.95 | 0.0568 | |
| CS-56 | 0.248 | 1.7% | 33.4 | 0.566 | 4.77 | 0.0807 | |
| CS-57 | 0.238 | 1.6% | 0.343 | 0.00556 | 0.077 | 0.00125 | |
| CS-58 | 0.201 | 1.4% | 1.95 | 0.0267 | 0.495 | 0.00678 | |
| CS-59 | 0.205 | 1.4% | 1.26 | 0.0177 | 0.217 | 0.00303 | |
| CS-60 | 0.170 | 1.2% | 29.9 | 0.346 | 3.36 | 0.039 | |
| CS-61 | 0.247 | 2% | 1.14 | 0.0191 | 0.597 | 0.01 | |
| CS-62 | 0.211 | 1% | 5.4 | 0.0776 | 0.779 | 0.0112 | |
| CS-63 | 0.222 | 2% | 1.44 | 0.0218 | 0.361 | 0.00547 | |
| CS-64 | 0.191 | 1% | 0.891 | 0.0116 | 0.183 | 0.00238 | |
| CS-65 | 0.225 | 2% | 3.69 | 0.0566 | 0.411 | 0.00631 | |
| CS-66 | 0.219 | 1% | 5.09 | 0.0758 | 0.591 | 0.00881 | |
| CS-67 | 0.194 | 1% | 79.4 | 1.05 | 5.33 | 0.0705 | |
| CS-68 | 0.178 | 1% | 35 | 0.424 | 5.7 | 0.0691 | |
| RISB05 | 0.038 | -- | -- | -- | -- | -- | (c) |
| RISB06 | 0.250 | -- | -- | -- | -- | -- | (c) |
| RISB07 | 0.202 | -- | -- | -- | -- | -- | (c) |
| RISB08 | 0.226 | -- | -- | -- | -- | -- | (c) |
| RISB09 | 0.222 | 2% | 19.8 | 0.3 | 3.35 | 0.0507 | |
| RISB10 | 0.167 | 1% | 13.3 | 0.151 | 1.83 | 0.0208 | |
| SB-127 | 0.068 | 0.5% | 13.8 | 0.064 | 2.24 | 0.0103 | |
| SB-128 | 0.216 | 1% | 1.78 | 0.0261 | 0.509 | 0.00748 | |
| SB-129 | 0.247 | 2% | 5.41 | 0.0909 | 0.984 | 0.0165 | |
| SB-130 | 0.232 | 2% | 6.32 | 0.0998 | 0.758 | 0.012 | |
| SB-131 | 0.212 | 1% | 7.81 | 0.113 | 0.797 | 0.0115 | |
| SB-132 | 0.130 | 1% | 41.1 | 0.365 | 6.64 | 0.059 | |
| SB-133 | 0.202 | 1% | 10.2 | 0.141 | 2.04 | 0.0281 | |
| SB-134 | 0.223 | 2% | 2.93 | 0.0445 | 0.918 | 0.0139 | |
| SB-135 | 0.211 | 1% | 7.69 | 0.11 | 1.62 | 0.0232 | |
| SB-136 | 0.211 | 1% | 6.63 | 0.0954 | 1.4 | 0.0201 | |
| SB-148 | 0.223 | 2% | 1.79 | 0.0272 | 0.541 | 0.00822 | |
| SB-149 | 0.068 | 0.5% | 4.64 | 0.0216 | 0.776 | 0.00362 | |
| SB-150 | 0.225 | 2% | 22 | 0.338 | 3.84 | 0.059 | |
| SB-151 | 0.161 | 1% | 2.89 | 0.0316 | 0.461 | 0.00504 | |

**Table 3-1A. OU2 Representative Soil PAH Data Used for Ecological Risk Assessment**

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) (b) | % Area of Total (b) | HMW PAHs (ND=0.5DL) | | LMW PAHs (ND = 0.5DL) | | Notes |
|---|---|---|---|---|---|---|---|
| | | | Σ10 HMW PAHs (mg/kg) | Polygon Contribution of Σ10 HMW PAHs (mg/kg) (b) | Σ7 LMW PAHs (mg/kg) | Polygon Contribution of Σ7 LMW PAHs (mg/kg) (b) | |
| SB-152 | 0.151 | 1% | 4.37 | 0.045 | 0.382 | 0.00394 | |
| SB-153 | 0.155 | 1% | 9.04 | 0.0956 | 1.42 | 0.0151 | |
| SD021 | 0.045 | 0.3% | 147 | 0.451 | 19.7 | 0.0604 | |
| SD021R | 0.028 | 0.2% | 8.1 | 0.0157 | 1.2 | 0.00233 | |
| SS08 | 0.188 | 1% | 12.9 | 0.165 | 1.32 | 0.017 | |
| SS-108 | 0.206 | 1% | 139 | 1.95 | 14.7 | 0.207 | (d) |
| SS-109 | 0.122 | 1% | 19.5 | 0.162 | 2.27 | 0.0189 | |
| SS-110 | 0.240 | 2% | 111.3 | 1.82 | 5.53 | 0.0904 | (e) |
| SS-111 | 0.224 | 2% | 0.867 | 0.0133 | 0.0963 | 0.00147 | |
| SS-112 | 0.211 | 1% | 6.53 | 0.0939 | 1.13 | 0.0162 | |
| SS-113 | 0.165 | 1% | 55.1 | 0.621 | 6.29 | 0.0709 | |
| SS-114 | 0.247 | 2% | 108 | 1.82 | 21 | 0.353 | (e) |
| SS-115 | 0.150 | 1% | 63.5 | 0.648 | 10 | 0.102 | |
| SS-116 | 0.184 | 1% | 7.05 | 0.0885 | 0.989 | 0.0124 | |
| SS-117 | 0.157 | 1% | 272 | 2.92 | 20.3 | 0.217 | (e) |
| SS-118 | 0.217 | 1% | 8.78 | 0.13 | 1.33 | 0.0197 | |
| SS-119 | 0.248 | 2% | 83.2 | 1.41 | 10.8 | 0.183 | (e) |
| SS-120 | 0.196 | 1% | 3.82 | 0.0509 | 0.631 | 0.00842 | |
| SS-121 | 0.247 | 2% | 27.4 | 0.461 | 5.02 | 0.0843 | |
| SS-122 | 0.141 | 1% | 4.82 | 0.0463 | 0.56 | 0.00537 | |
| SS-123 | 0.248 | 2% | 0.724 | 0.0123 | 0.107 | 0.00181 | |
| SS-124 | 0.171 | 1% | 35.2 | 0.412 | 3.88 | 0.0453 | |
| SS-125 | 0.086 | 1% | 36 | 0.211 | 6.72 | 0.0394 | |
| SS-126 | 0.121 | 1% | 50.1 | 0.413 | 7.35 | 0.0605 | |
| TB-05 | 0.057 | 0.4% | 111 | 0.429 | 11.8 | 0.0458 | |
| TB-07 | 0.071 | 0.5% | 43.1 | 0.21 | 7.17 | 0.0349 | |
| TB-08 | 0.220 | 2% | 95.4 | 1.43 | 10.6 | 0.159 | (e) |
| TB-09 | 0.203 | 1% | 17.1 | 0.237 | 2.71 | 0.0375 | |
| TB-10 | 0.196 | 1% | 0.565 | 0.00756 | 0.0807 | 0.00108 | |
| TB-11 | 0.197 | 1% | 131 | 1.76 | 21.2 | 0.284 | (e) |
| TB-12 | 0.101 | 1% | 273 | 1.89 | 67.9 | 0.47 | (e) |
| TB-13 | 0.164 | 1% | 1.45 | 0.0163 | 0.379 | 0.00425 | |
| TB-14 | 0.221 | 2% | 16 | 0.242 | 2.34 | 0.0354 | |
| TB-15 | 0.066 | 0.4% | 2.8 | 0.0126 | 0.317 | 0.00142 | |
| TB-16 | 0.026 | 0.2% | 2020 | 3.56 | 659 | 1.16 | |
| TB-16A | 0.029 | 0.2% | 45.2 | 0.0902 | 1.88 | 0.00376 | |

**Table 3-1A. OU2 Representative Soil PAH Data Used for Ecological Risk Assessment**

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) (b) | % Area of Total (b) | HMW PAHs (ND=0.5DL) | | LMW PAHs (ND = 0.5DL) | | Notes |
|---|---|---|---|---|---|---|---|
| | | | Σ10 HMW PAHs (mg/kg) | Polygon Contribution of Σ10 HMW PAHs (mg/kg) (b) | Σ7 LMW PAHs (mg/kg) | Polygon Contribution of Σ7 LMW PAHs (mg/kg) (b) | |
| TB-16B | 0.064 | 0.4% | 32.6 | 0.142 | 2.78 | 0.0121 | |
| TB-16C | 0.056 | 0.4% | 133 | 0.505 | 16.2 | 0.0612 | |
| TB-16D | 0.067 | 0.5% | 52.6 | 0.238 | 4.25 | 0.0193 | |
| TB-16E | 0.150 | 1% | 5.15 | 0.0528 | 0.833 | 0.00853 | |
| TB-16F | 0.165 | 1% | 259 | 2.92 | 243 | 2.74 | |
| TB-16G | 0.126 | 1% | 43.2 | 0.37 | 3.33 | 0.0286 | |
| TB-16H | 0.141 | 1% | 8.56 | 0.0825 | 1.19 | 0.0114 | |
| TB-17 | 0.048 | 0.3% | 95.9 | 0.315 | 11.3 | 0.037 | |
| TB-18 | 0.078 | 1% | 101 | 0.533 | 9.29 | 0.0492 | |
| TB-19 | 0.170 | 1% | 7.37 | 0.0854 | 1.23 | 0.0142 | |
| TB-20 | 0.151 | 1% | 5.61 | 0.0577 | 0.737 | 0.00759 | |
| TB-21 | 0.148 | 1% | 13.6 | 0.137 | 0.732 | 0.00738 | |
| TB-22 | 0.174 | 1% | 10.3 | 0.122 | 1.56 | 0.0185 | |
| TB-23 | 0.133 | 1% | 43.1 | 0.392 | 5.55 | 0.0505 | |
| TB-24 | 0.089 | 1% | 19.5 | 0.117 | 4.03 | 0.0243 | |
| TB-25 | 0.192 | 1% | 0.799 | 0.0105 | 0.134 | 0.00176 | |
| TB-26 | 0.244 | 2% | 2.11 | 0.035 | 0.281 | 0.00467 | |
| TWSB23 | 0.226 | 2% | 5.36 | 0.0827 | 0.305 | 0.0047 | |
| TWSB24 | 0.116 | 1% | 5.31 | 0.0421 | 0.429 | 0.0034 | |
| TWSB27 | 0.168 | 1% | 18.8 | 0.215 | 1.94 | 0.0222 | |
| | | **100%** | **Total HMW PAH SWAC (mg/kg):** | **35.3** | **Total LMW PAH SWAC (mg/kg):** | **7.73** | |

**Notes:**

-- = Insufficient number of individual PAHs for calculation
Σ10 HMW PAHs = Sum of 10 high molecular weight polycyclic aromatic hydrocarbons
Σ7 LMW PAHs = Sum of 7 low molecular weight polycyclic aromatic hydrocarbons
DL = Detection limit (method)
mg/kg = Milligram(s) per kilogram
ND = Not detected
OU2 = Operable Unit 2

(a) Data handling is described in the OU2 Technical Memorandum.

**Table 3-1A. OU2 Representative Soil PAH Data Used for Ecological Risk Assessment**

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

(b) OU2 is 15.6 acres; however, six polygons (blue highlighted polygons) have a part of their polygon within OU2 but were addressed with the OU1 ERA. As such, the actual acreage to use to calculate a SWAC is 15.4 acres. In addition, there are 4 polygons (RISB05 to RISB08) with insufficient individual PAHs to calculate a comparable PAH sum. This column EXCLUDES the acreage of the four polygons from the SWAC calculation for a total acreage of 14.7 mg/kg for use in the SWAC. See text for a qualitative discussion of censored data.

(c) There was an insufficient number of individual PAHs ($\Sigma$13) to calculate a comparable PAH sum ($\Sigma$17). Rather than reduce all PAHs to be a $\Sigma$13 and thereby potentially underestimating the PAH concentration at the site, a decision was made to not include the polygon in the SWAC calculation. The polygon size and percent it comprises OU2 is presented only for comparison to the other polygons.

(d) Maximum of two data points used for characterizing the polygon as a UCL could not be calculated from two data points.

(e) UCL or maximum used, as described in the OU2 Technical Memorandum.

**Table 3-1B. OU2 Representative Soil PCDD/F TEQ Data Used for Risk Characterization**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) | % Area of Total (All) | PCDD/F TEQ Type | Result (ng/kg) | Polygon Contribution to SWAC (ng/kg) | Notes |
|---|---|---|---|---|---|---|
| CS-52 | 0.0877 | 0.6% | PCDD/F TEQ Avian (ND=DL) | 8.37 | 0.05 | |
| CS-53 | 0.2426 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 2.37 | 0.04 | |
| CS-55 | 0.1686 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 1.89 | 0.02 | |
| CS-56 | 0.2484 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 109 | 1.76 | |
| CS-57 | 0.2382 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 1.86 | 0.03 | |
| CS-58 | 0.2011 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 2.57 | 0.03 | |
| CS-59 | 0.2053 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 1.12 | 0.01 | |
| CS-60 | 0.1702 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 2.46 | 0.03 | |
| CS-61 | 0.2470 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 1.19 | 0.02 | |
| CS-62 | 0.2108 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 1.86 | 0.03 | |
| CS-63 | 0.2221 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 2.98 | 0.04 | |
| CS-64 | 0.1909 | 1.2% | PCDD/F TEQ Avian (ND=DL) | 1.18 | 0.01 | |
| CS-65 | 0.2252 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 1.65 | 0.02 | |
| CS-66 | 0.2185 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 33.9 | 0.48 | |
| CS-67 | 0.1939 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 10.8 | 0.14 | |
| CS-68 | 0.1778 | 1.2% | PCDD/F TEQ Avian (ND=DL) | 25.8 | 0.30 | |
| RISB05 | 0.0376 | 0.2% | PCDD/F TEQ Avian (ND=DL) | 35.8 | 0.09 | |
| RISB06 | 0.2500 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 2.10 | 0.03 | |
| RISB07 | 0.2020 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 0.842 | 0.01 | |
| RISB08 | 0.2264 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 1.02 | 0.02 | |
| RISB09 | 0.2221 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 3.45 | 0.05 | |
| RISB10 | 0.1669 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 5.50 | 0.06 | |
| SB-127 | 0.0678 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 9.56 | 0.04 | |
| SB-128 | 0.2156 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 1.17 | 0.02 | |
| SB-129 | 0.2467 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 0.852 | 0.01 | |
| SB-130 | 0.2316 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 5.69 | 0.09 | |
| SB-131 | 0.2123 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 1.52 | 0.02 | |
| SB-132 | 0.1303 | 0.8% | PCDD/F TEQ Avian (ND=DL) | 6.98 | 0.06 | |
| SB-133 | 0.2019 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 0.843 | 0.01 | |
| SB-134 | 0.2225 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 3.38 | 0.05 | |
| SB-135 | 0.2106 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 14.5 | 0.20 | |
| SB-136 | 0.2110 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 76.5 | 1.05 | |
| SB-148 | 0.2231 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 21.2 | 0.31 | |
| SB-149 | 0.0684 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 7.93 | 0.04 | |
| SB-150 | 0.2255 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 4.25 | 0.06 | |
| SB-151 | 0.1605 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 3.38 | 0.04 | |
| SB-152 | 0.1513 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 8.28 | 0.08 | |
| SB-153 | 0.1553 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 9.87 | 0.10 | |
| SD021R | 0.0735 | 0.5% | PCDD/F TEQ Avian (ND=DL) | 3.85 | 0.02 | (b) |
| SS-08 | 0.1880 | 1.2% | PCDD/F TEQ Avian (ND=DL) | 4.09 | 0.05 | |
| SS-108-D | 0.2059 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 1.40 | 0.02 | |
| SS-109 | 0.1218 | 0.8% | PCDD/F TEQ Avian (ND=DL) | 2.39 | 0.02 | |
| SS-110 | 0.2399 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 18.05 | 0.28 | (a) |
| SS-111 | 0.2242 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 1.25 | 0.02 | |
| SS-112 | 0.2110 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 2.67 | 0.04 | |

**Table 3-1B. OU2 Representative Soil PCDD/F TEQ Data Used for Risk Characterization**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) | % Area of Total (All) | PCDD/F TEQ Type | Result (ng/kg) | Polygon Contribution to SWAC (ng/kg) | Notes |
|---|---|---|---|---|---|---|
| SS-113 | 0.1653 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 3.68 | 0.04 | |
| SS-114 | 0.2468 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 1.67 | 0.03 | (a) |
| SS-115 | 0.1499 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 206 | 2.01 | |
| SS-116 | 0.1843 | 1.2% | PCDD/F TEQ Avian (ND=DL) | 3.07 | 0.04 | |
| SS-117 | 0.1571 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 7.95 | 0.08 | (a) |
| SS-118 | 0.2166 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 3.76 | 0.05 | |
| SS-119 | 0.2479 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 20.1 | 0.32 | (a) |
| SS-120 | 0.1959 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 3.66 | 0.05 | |
| SS-121 | 0.2466 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 3.25 | 0.05 | |
| SS-122 | 0.1408 | 0.9% | PCDD/F TEQ Avian (ND=DL) | 4.53 | 0.04 | |
| SS-123 | 0.2483 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 8.09 | 0.13 | |
| SS-124 | 0.1714 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 7.99 | 0.09 | |
| SS-125 | 0.0860 | 0.6% | PCDD/F TEQ Avian (ND=DL) | 7.39 | 0.04 | |
| SS-126 | 0.1208 | 0.8% | PCDD/F TEQ Avian (ND=DL) | 9.94 | 0.08 | |
| TB-05 | 0.0568 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 6.09 | 0.02 | |
| TB-07 | 0.0713 | 0.5% | PCDD/F TEQ Avian (ND=DL) | 6.51 | 0.03 | |
| TB-08 | 0.2202 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 11.92 | 0.17 | (a) |
| TB-09 | 0.2028 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 7.07 | 0.09 | |
| TB-10 | 0.1964 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 0.990 | 0.01 | |
| TB-11 | 0.1966 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 8.24 | 0.11 | (a) |
| TB-12 | 0.1015 | 0.7% | PCDD/F TEQ Avian (ND=DL) | 2.79 | 0.02 | (a) |
| TB-13 | 0.1644 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 3.30 | 0.04 | |
| TB-14 | 0.2214 | 1.4% | PCDD/F TEQ Avian (ND=DL) | 6.04 | 0.09 | |
| TB-15 | 0.0658 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 0.927 | 0.00 | |
| TB-16 | 0.0259 | 0.2% | PCDD/F TEQ Avian (ND=DL) | 5.07 | 0.01 | |
| TB-16A | 0.0293 | 0.2% | PCDD/F TEQ Avian (ND=DL) | 1.01 | 0.00 | |
| TB-16B | 0.0638 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 3.29 | 0.01 | |
| TB-16C | 0.0556 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 18.3 | 0.07 | |
| TB-16D | 0.0666 | 0.4% | PCDD/F TEQ Avian (ND=DL) | 2.22 | 0.01 | |
| TB-16E | 0.1503 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 2.33 | 0.02 | |
| TB-16F | 0.1649 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 10.0 | 0.11 | |
| TB-16G | 0.1258 | 0.8% | PCDD/F TEQ Avian (ND=DL) | 9.39 | 0.08 | |
| TB-16H | 0.1413 | 0.9% | PCDD/F TEQ Avian (ND=DL) | 1.68 | 0.02 | |
| TB-17 | 0.0482 | 0.3% | PCDD/F TEQ Avian (ND=DL) | 10.1 | 0.03 | |
| TB-18 | 0.0777 | 0.5% | PCDD/F TEQ Avian (ND=DL) | 2.66 | 0.01 | |
| TB-19 | 0.1699 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 1.34 | 0.01 | |
| TB-20 | 0.1511 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 2.44 | 0.02 | |
| TB-21 | 0.1480 | 1.0% | PCDD/F TEQ Avian (ND=DL) | 1.87 | 0.02 | |
| TB-22 | 0.1743 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 10.3 | 0.12 | |
| TB-23 | 0.1335 | 0.9% | PCDD/F TEQ Avian (ND=DL) | 7.12 | 0.06 | |
| TB-24 | 0.0885 | 0.6% | PCDD/F TEQ Avian (ND=DL) | 12.8 | 0.07 | |
| TB-25 | 0.1924 | 1.3% | PCDD/F TEQ Avian (ND=DL) | 3.68 | 0.05 | |
| TB-26 | 0.2439 | 1.6% | PCDD/F TEQ Avian (ND=DL) | 12.0 | 0.19 | |
| TWSB23 | 0.2264 | 1.5% | PCDD/F TEQ Avian (ND=DL) | 2.35 | 0.03 | |
| TWSB24 | 0.1163 | 0.8% | PCDD/F TEQ Avian (ND=DL) | 4.32 | 0.03 | |

**Table 3-1B. OU2 Representative Soil PCDD/F TEQ Data Used for Risk Characterization**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) | % Area of Total (All) | PCDD/F TEQ Type | Result (ng/kg) | Polygon Contribution to SWAC (ng/kg) | Notes |
|---|---|---|---|---|---|---|
| TWSB27 | 0.1680 | 1.1% | PCDD/F TEQ Avian (ND=DL) | 1.93 | 0.02 | |
| CS-52 | 0.0877 | 0.6% | PCDD/F TEQ Mammal (ND=DL) | 17.4 | 0.10 | |
| CS-53 | 0.2426 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 1.78 | 0.03 | |
| CS-55 | 0.1686 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 1.43 | 0.02 | |
| CS-56 | 0.2484 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 203 | 3.28 | |
| CS-57 | 0.2382 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 1.59 | 0.02 | |
| CS-58 | 0.2011 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 2.09 | 0.03 | |
| CS-59 | 0.2053 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 0.937 | 0.01 | |
| CS-60 | 0.1702 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 4.07 | 0.04 | |
| CS-61 | 0.2470 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 0.924 | 0.01 | |
| CS-62 | 0.2108 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 1.58 | 0.02 | |
| CS-63 | 0.2221 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 2.06 | 0.03 | |
| CS-64 | 0.1909 | 1.2% | PCDD/F TEQ Mammal (ND=DL) | 1.06 | 0.01 | |
| CS-65 | 0.2252 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 1.89 | 0.03 | |
| CS-66 | 0.2185 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 142 | 2.02 | |
| CS-67 | 0.1939 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 24.78 | 0.31 | |
| CS-68 | 0.1778 | 1.2% | PCDD/F TEQ Mammal (ND=DL) | 50.4 | 0.58 | |
| RISB05 | 0.0376 | 0.2% | PCDD/F TEQ Mammal (ND=DL) | 84.2 | 0.21 | |
| RISB06 | 0.2500 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 1.94 | 0.03 | |
| RISB07 | 0.2020 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 1.37 | 0.02 | |
| RISB08 | 0.2264 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 1.70 | 0.02 | |
| RISB09 | 0.2221 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 3.76 | 0.05 | |
| RISB10 | 0.1669 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 5.46 | 0.06 | |
| SB-127 | 0.0678 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 11.1 | 0.05 | |
| SB-128 | 0.2156 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 0.983 | 0.01 | |
| SB-129 | 0.2467 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 0.766 | 0.01 | |
| SB-130 | 0.2316 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 7.76 | 0.12 | |
| SB-131 | 0.2123 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 1.26 | 0.02 | |
| SB-132 | 0.1303 | 0.8% | PCDD/F TEQ Mammal (ND=DL) | 8.62 | 0.07 | |
| SB-133 | 0.2019 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 1.44 | 0.02 | |
| SB-134 | 0.2225 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 2.43 | 0.04 | |
| SB-135 | 0.2106 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 9.46 | 0.13 | |
| SB-136 | 0.2110 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 129.89 | 1.78 | |
| SB-148 | 0.2231 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 70.44 | 1.02 | |
| SB-149 | 0.0684 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 16.59 | 0.07 | |
| SB-150 | 0.2255 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 5.42 | 0.08 | |
| SB-151 | 0.1605 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 6.68 | 0.07 | |
| SB-152 | 0.1513 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 11.74 | 0.12 | |
| SB-153 | 0.1553 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 15.14 | 0.15 | |
| SD021R | 0.0735 | 0.5% | PCDD/F TEQ Mammal (ND=DL) | 5.17 | 0.02 | (b) |
| SS-08 | 0.1880 | 1.2% | PCDD/F TEQ Mammal (ND=DL) | 5.81 | 0.07 | |
| SS-108-D | 0.2059 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 1.00 | 0.01 | |
| SS-109 | 0.1218 | 0.8% | PCDD/F TEQ Mammal (ND=DL) | 3.39 | 0.03 | |
| SS-110 | 0.2399 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 29.54 | 0.46 | (a) |
| SS-111 | 0.2242 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 1.38 | 0.02 | |

**Table 3-1B. OU2 Representative Soil PCDD/F TEQ Data Used for Risk Characterization**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) | % Area of Total (All) | PCDD/F TEQ Type | Result (ng/kg) | Polygon Contribution to SWAC (ng/kg) | Notes |
|---|---|---|---|---|---|---|
| SS-112 | 0.2110 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 3.15 | 0.04 | |
| SS-113 | 0.1653 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 6.30 | 0.07 | |
| SS-114 | 0.2468 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 2.27 | 0.04 | (a) |
| SS-115 | 0.1499 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 275 | 2.68 | |
| SS-116 | 0.1843 | 1.2% | PCDD/F TEQ Mammal (ND=DL) | 3.71 | 0.04 | |
| SS-117 | 0.1571 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 9.97 | 0.10 | (a) |
| SS-118 | 0.2166 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 3.28 | 0.05 | |
| SS-119 | 0.2479 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 27.2 | 0.44 | (a) |
| SS-120 | 0.1959 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 4.88 | 0.06 | |
| SS-121 | 0.2466 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 3.20 | 0.05 | |
| SS-122 | 0.1408 | 0.9% | PCDD/F TEQ Mammal (ND=DL) | 4.57 | 0.04 | |
| SS-123 | 0.2483 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 13.8 | 0.22 | |
| SS-124 | 0.1714 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 13.7 | 0.15 | |
| SS-125 | 0.0860 | 0.6% | PCDD/F TEQ Mammal (ND=DL) | 11.3 | 0.06 | |
| SS-126 | 0.1208 | 0.8% | PCDD/F TEQ Mammal (ND=DL) | 14.2 | 0.11 | |
| TB-05 | 0.0568 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 7.55 | 0.03 | |
| TB-07 | 0.0713 | 0.5% | PCDD/F TEQ Mammal (ND=DL) | 8.38 | 0.04 | |
| TB-08 | 0.2202 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 23.33 | 0.33 | (a) |
| TB-09 | 0.2028 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 12.5 | 0.16 | |
| TB-10 | 0.1964 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 1.01 | 0.01 | |
| TB-11 | 0.1966 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 8.17 | 0.10 | (a) |
| TB-12 | 0.1015 | 0.7% | PCDD/F TEQ Mammal (ND=DL) | 2.59 | 0.02 | (a) |
| TB-13 | 0.1644 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 4.19 | 0.04 | |
| TB-14 | 0.2214 | 1.4% | PCDD/F TEQ Mammal (ND=DL) | 5.17 | 0.07 | |
| TB-15 | 0.0658 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 0.82 | 0.00 | |
| TB-16 | 0.0259 | 0.2% | PCDD/F TEQ Mammal (ND=DL) | 5.94 | 0.01 | |
| TB-16A | 0.0293 | 0.2% | PCDD/F TEQ Mammal (ND=DL) | 1.03 | 0.00 | |
| TB-16B | 0.0638 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 4.20 | 0.02 | |
| TB-16C | 0.0556 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 18.7 | 0.07 | |
| TB-16D | 0.0666 | 0.4% | PCDD/F TEQ Mammal (ND=DL) | 2.08 | 0.01 | |
| TB-16E | 0.1503 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 1.73 | 0.02 | |
| TB-16F | 0.1649 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 10.3 | 0.11 | |
| TB-16G | 0.1258 | 0.8% | PCDD/F TEQ Mammal (ND=DL) | 14.6 | 0.12 | |
| TB-16H | 0.1413 | 0.9% | PCDD/F TEQ Mammal (ND=DL) | 2.20 | 0.02 | |
| TB-17 | 0.0482 | 0.3% | PCDD/F TEQ Mammal (ND=DL) | 9.45 | 0.03 | |
| TB-18 | 0.0777 | 0.5% | PCDD/F TEQ Mammal (ND=DL) | 2.73 | 0.01 | |
| TB-19 | 0.1699 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 1.48 | 0.02 | |
| TB-20 | 0.1511 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 5.18 | 0.05 | |
| TB-21 | 0.1480 | 1.0% | PCDD/F TEQ Mammal (ND=DL) | 3.77 | 0.04 | |
| TB-22 | 0.1743 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 14.4 | 0.16 | |
| TB-23 | 0.1335 | 0.9% | PCDD/F TEQ Mammal (ND=DL) | 9.93 | 0.09 | |
| TB-24 | 0.0885 | 0.6% | PCDD/F TEQ Mammal (ND=DL) | 20.1 | 0.12 | |
| TB-25 | 0.1924 | 1.3% | PCDD/F TEQ Mammal (ND=DL) | 5.73 | 0.07 | |
| TB-26 | 0.2439 | 1.6% | PCDD/F TEQ Mammal (ND=DL) | 20.5 | 0.32 | |
| TWSB23 | 0.2264 | 1.5% | PCDD/F TEQ Mammal (ND=DL) | 3.83 | 0.06 | |

**Table 3-1B. OU2 Representative Soil PCDD/F TEQ Data Used for Risk Characterization**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (Acres) | % Area of Total (All) | PCDD/F TEQ Type | Result (ng/kg) | Polygon Contribution to SWAC (ng/kg) | Notes |
|---|---|---|---|---|---|---|
| TWSB24 | 0.1163 | 0.8% | PCDD/F TEQ Mammal (ND=DL) | 6.47 | 0.05 | |
| TWSB27 | 0.1680 | 1.1% | PCDD/F TEQ Mammal (ND=DL) | 2.78 | 0.03 | |
| **Acreage:** | 15.4 | 100% | **Total Avian TEQ SWAC (ng/kg):** | | 10.5 | |
| **(OU2 Total)** | | | **Total Mammal TEQ SWAC (ng/kg):** | | 17.7 | |

**Notes:**
DL = Detection limit
ND = Non-detects
ng/kg = Nanogram per kilogram
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency quotient (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

(a) Data handling was performed as described in the OU2 Technical Memorandum. Either UCL or maximum value used for polygons with multiple grab samples.
(b) Represents both SD021 and SD021R so acreage is for both parcels; for PAHs, these two parcels are split.

**Table 3-2A. Exposure Parameters for Ecological Receptors**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Guild | Name | Species | Water IR w (L/day) | Food IR f (kg ww/day) | (kg dw/day) | Notes | Surface Soil IR ss % (a) | (kg dw/day) | Diet (b) Plants | Above-ground Inverte-brates | Below-ground Inverte-brates | BW (kg) | Range (c) (ha) | AUF (unitless) Conser-vative | OU2 Species-Specific (≤1) Using 6.3 hectares |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Insectivore | American Robin | Turdus migratorius | 0.0113 | 0.123 | 0.0252 | Earthworms (d) | 5 | 0.001262 | 0-0.5 | 0-0.35 | 0.35-1 | 0.0810 | 0.160 | 1 | 1 |
| | | | | | 0.0197 | Plants (d) | | 0.000985 | | | | | | | |
| | | | | | 0.0236 | Aboveground | | 0.00118 | | | | | | | |
| Insectivore | American Woodcock | Scolopax minor | 0.0175 | 0.203 | 0.0416 | Earthworms (d) | 10.4 | 0.00433 | 0 | 0-0.5 | 0.5-1 | 0.175 | 10.0 | 1 | 0.63 |
| | | | | | 0.0390 | Aboveground Invertebrates (d) | | 0.00405 | | | | | | | |
| Omnivore | Raccoon | Procyon lotor | 0.496 | 1.49 | 0.305 | Earthworms (d) | 9.4 | 0.0287 | 0.2 | 0-0.40 | 0.4-0.8 | 5.98 | 52.0 | 1 | 0.12 |
| | | | | | 0.238 | Plants (d) | | 0.0224 | | | | | | | |
| | | | | | 0.286 | Aboveground Invertebrates (d) | | 0.0269 | | | | | | | |
| Insectivore | Short-tailed Shrew | Blarina brevicauda | 0.00493 | 0.0138 | 0.00282 | Earthworms (d) | 3.7 | 0.000104 | 0 | 0-0.5 | 0.5-1 | 0.0170 | 0.390 | 1 | 1 |
| | | | | | 0.00220 | Plants (d) | | 0.0000815 | | | | | | | |
| | | | | | 0.00264 | Aboveground Invertebrates (d) | | 0.0000978 | | | | | | | |

**OU2 Site (acres):** 15.6
**OU2 Site (hectares):** 6.3

**Notes:**

| | | | |
|---|---|---|---|
| ≤ | Less than or equal to | IR ss | Ingestion rate of surface soil (dry weight) |
| AG | Aboveground invertebrates | IR w | Ingestion rate of water |
| AUF | Area use factor | kg | Kilograms |
| BW | Body weight | kg dw/day | Kilograms dry weight per day |
| EU | Undepurated belowground invertebrates | kg ww/day | Kilograms wet weight per day |
| ha | Hectares | L/day | Liters per day |
| IR f | Ingestion rate of food (wet weight) | NA | Not applicable |

(a) The ingestion rate for this OU2 ERA is 5% for robin and 10.4% for woodcock. Previous work for OU1 and OU2 have included robin ingestion rates of 5% and 10.4% as part of an uncertainty assessment. The USEPA Exposures Factors Handbook and USEPA R4 exposure parameters both show 5% ingestion rate for the robin. The 10.4% ingestion rate for the robin is not included as an uncertainty assessment.

(b) Different diet scenarios are evaluated in the total daily intake calculations for each receptor. Also, invertebrates are evaluated as both aboveground and belowground invertebrates. Woodcocks only eat invertebrates; therefore, their diet evaluation is 100% invertebrates but evaluated by invertebrate type. For mammals, there will be two different diet scenarios evaluated: one conservative and one realistic.

| **Bird Diet Scenarios:** | | **Robin** | **Woodcock** |
|---|---|---|---|
| Scenario 1 | 100% Belowground Invertebrates | X | X |
| Scenario 2 | 50% Plants and 50% Belowground Invertebrates | X | NA |
| Scenario 3 | 50% Belowground and 50% Aboveground Invertebrates | X | X |
| Scenario 4 | 30% Plants, 35% Belowground and 35% Aboveground Invertebrates | X | NA |

| **Mammal Diet Scenarios:** | |
|---|---|
| Shrew (Conservative): | 100% Belowground Invertebrates |
| Shrew (Realistic) | 50% Belowground and 50% Aboveground Invertebrates |
| Raccoon (Conservative): | 20% Plants and 80% Belowground invertebrates |
| Raccoon (Realistic) | 20% Plants, 40% Aboveground, and 40% Belowground invertebrates |

(c) USEPA R4 guidance document (USEPA R4 2016) presents home range of receptors in hectares. For American woodcock, USEPA R4 (2016) guidance suggested a home range of 10.5 hectares; however, the USEPA R4 (2020) screening discussed a home range of 25 acres which converts to 10 hectares. 10 hectares was used for the American woodcock in the food web model.

(d) Assumed a diet moisture content of 84% to convert from wet weight to dry weight for plants (USEPA, 1993; USEPA R4, 2020); however, the 95% UCL of measured moisture data was used to convert from wet weight to dry weight for belowground invertebrates and aboveground invertebrates:

| | | | |
|---|---|---|---|
| Literature-sourced % Plant Moisture: | 84 | % Solids Plants: | 16.0 |
| % Moisture AG (95% UCL): | 80.8 | % Solids AG: | 19.2 |
| % Moisture EU (95% UCL): | 79.5 | % Solids EU: | 20.5 |

**References:**


USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. EPA/600/R-93/187. http://cfpub.epa.gov/ncea/cfm/wefh.cfm

USEPA R4. 2016. "EPA Region 4 Preferred Parameters to be Used in Ecological Risk Assessment in Region 4 – Version 9 – Last Revised November 01, 2016." Received by email from Brett Thomas, USEPA Region 4, on June 26, 2017.

USEPA R4. 2020. Revised Semi-Screening Level Ecological Risk Assessment Calculations for OU1 of the Kerr-McGee Chemical Company Site in Navassa, North Carolina. Received by email from Erik Spalvins via EarthCon on October 19, 2020.

**Table 3-2B. USEPA Region 4 Preferred LOAEL Toxicity Reference Values**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Chemical | USEPA R4 Identified TRVs | | |
|---|---|---|---|
| | Avian TRV | | |
| | LOAEL | | Units |
| ΣHMW PAHs (ND=1/2 DL) | 1 | a | (mg/kg-bw/day) |
| ΣLMW PAHs (ND=1/2 DL) | 30.5 | a | (mg/kg-bw/day) |
| PCDD/F TEQ Avian (ND=DL) | 64 | b | (ng/kg-bw/day) |

| Chemical | USEPA R4 Identified TRVs | | |
|---|---|---|---|
| | Mammal TRV | | |
| | LOAEL | | Units |
| ΣHMW PAHs (ND=1/2 DL) | 3.1 | c | (mg/kg-bw/day) |
| ΣLMW PAHs (ND=1/2 DL) | 110 | c | (mg/kg-bw/day) |
| PCDD/F TEQ Mammal (ND=DL) | 10 | d | (ng/kg-bw/day) |

**Notes:**
Non-detects are treated as one-half the detection limit for the calculation of the PAH sum, and equal to the laboratory detection limit for the calculation of the PCDD/F TEQ sum.

(a) Stickel and Dieter (1979); Wang et al (2003) from USEPA R4 2016
(b) Nosek et al. 1992 from USEPA R4 2016
(c) USEPA (2007) from USEPA R4 2016
(d) Sample et al. (1996) from USEPA R4 2016

| | |
|---|---|
| DL | Detection limit |
| HMW | High molecular weight |
| LMW | Low molecular weight |
| LOAEL | Lowest observed adverse effect level |
| mg/kg-bw/day | Milligram per kilogram of body weight per day |
| ND | Not detected |
| PAHs | Polycyclic aromatic hydrocarbons |
| PCDD/F TEQ | Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency quotient (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin) |
| TRV | Toxicity reference value |

**References:**

Nosek, J., S. Craven, J. Sullivan, S. Hurley and R. Peterson. 1992. Toxicity and Reproductive Effects of 2,3,7,8-TCDD in Ring Necked Pheasant Hens. Journal of Toxicology and Environmental Health 35:187-198

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratory, Oak Ridge, TN.

Stickel, L.F., and M.P. Dieter. 1979. Ecological and Physiological/Toxicological Effects of Petroleum on Aquatic Birds. A Summary of Research Activities FY76 through FY78. United States Fish and Wildlife Service Report FWS/OBS-79/26. July.

USEPA. 2007. Ecological Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs). Washington, D.C.: USEPA. June.
USEPA R4. 2016. EPA Region 4 Preferred Parameters to be used in Ecological Risk Assessments in Region 4, Ver. 9. Last Revised November 01, 2016. Draft. United States Environmental Protection Agency.

Wang, Z. B.P. Hollebone, M. Fingas, B. Fieldhouse, L. Sigouin, M. Landriault, P. Smith, J. Noonan, and G. Thouin. 2003. Characteristics of Spilled Oils, Fuels, and Petroleum Products: 1. Composition and Properties of Selected Oils (EPA/600/R-03/072). July.

**Table 3-3A. Summary of HMW and LMW PAH Soil Concentrations and HMW PAH Soil SWAC Calculations for 2-acres**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| | | | | | | | | % Polygon Contribution to SWAC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Polygon (a)** | **Polygon Size (acres)** | **Polygon Area Within 2 acre circle (acres)** | **% of Polygon Area within 2 -acre Circle** | **Σ10 HMW PAHs (b) (mg/kg)** | **Σ7 LMW PAHs (b) (mg/kg)** | **% Contribution of Polygon to 2 -acre Home Range (with RISB06 and RISB08)** | **% Contribution of Polygon to 2 -acre Home Range (Excludes RISB06 and RISB08)** | **Σ10 HMW PAHs for 2 acres (mg/kg) (c) (Excludes RISB06 and RISB08)** | **Σ7 LMW PAHs for 2 acres (mg/kg) (c) (Excludes RISB06 and RISB08)** | **Σ10 HMW PAHs for 2 acres (mg/kg) (c) (With RISB06 and RISB08)** | **Σ7 LMW PAHs for 2 acres (mg/kg) (c) (With RISB06 and RISB08)** |
| RISB06 | 0.250 | 0.092 | 37 | -- | -- | 0.0459 | NA (d) | -- | -- | 0 | 0 |
| RISB08 | 0.226 | 0.043 | 19 | -- | -- | 0.0213 | NA (d) | -- | -- | 0 | 0 |
| **TB-16** | **0.026** | **0.026** | **100** | **2020** | **659** | **0.0130** | **0.0139** | **28.1** | **9.19** | **26.2** | **8.57** |
| TB-16F | 0.165 | 0.165 | 100 | 259 | 243 | 0.0825 | 0.0885 | 23 | 21.5 | 21.4 | 20.1 |
| SD021 | 0.045 | 0.042 | 93 | 147 | 19.7 | 0.0209 | 0.0224 | 3.3 | 0.441 | 3.08 | 0.412 |
| TB-16C | 0.056 | 0.056 | 100 | 133 | 16.2 | 0.0278 | 0.0298 | 3.98 | 0.482 | 3.71 | 0.449 |
| TB-18 | 0.078 | 0.078 | 100 | 101 | 9.29 | 0.0389 | 0.0417 | 4.2 | 0.387 | 3.91 | 0.361 |
| TB-17 | 0.048 | 0.048 | 100 | 95.9 | 11.3 | 0.0241 | 0.0258 | 2.48 | 0.291 | 2.31 | 0.271 |
| TB-16D | 0.067 | 0.067 | 100 | 52.6 | 4.25 | 0.0333 | 0.0357 | 1.88 | 0.152 | 1.75 | 0.142 |
| SS-126 | 0.121 | 0.046 | 38 | 50.1 | 7.35 | 0.0232 | 0.0249 | 1.25 | 0.183 | 1.16 | 0.17 |
| TB-16A | 0.029 | 0.029 | 100 | 45.2 | 1.88 | 0.0147 | 0.0157 | 0.71 | 0.0296 | 0.663 | 0.0276 |
| TB-16G | 0.126 | 0.126 | 100 | 43.2 | 3.33 | 0.0630 | 0.0676 | 2.92 | 0.225 | 2.72 | 0.21 |
| TB-23 | 0.133 | 0.008 | 6 | 43.1 | 5.55 | 0.0040 | 0.0043 | 0.185 | 0.0238 | 0.172 | 0.0222 |
| SB-132 | 0.130 | 0.100 | 77 | 41.1 | 6.64 | 0.0501 | 0.0537 | 2.21 | 0.356 | 2.06 | 0.332 |
| SS-125 | 0.086 | 0.086 | 100 | 36 | 6.72 | 0.0430 | 0.0461 | 1.66 | 0.31 | 1.55 | 0.289 |
| TB-16B | 0.064 | 0.064 | 100 | 32.6 | 2.78 | 0.0319 | 0.0342 | 1.11 | 0.0952 | 1.04 | 0.0888 |
| SB-150 | 0.225 | 0.028 | 13 | 22 | 3.84 | 0.0141 | 0.0151 | 0.332 | 0.0581 | 0.31 | 0.0542 |
| TB-14 | 0.221 | 0.032 | 14 | 16 | 2.34 | 0.0159 | 0.0170 | 0.273 | 0.0399 | 0.255 | 0.0372 |
| TB-22 | 0.174 | 0.169 | 97 | 10.3 | 1.56 | 0.0844 | 0.0905 | 0.928 | 0.141 | 0.866 | 0.132 |
| TB-16H | 0.141 | 0.141 | 100 | 8.56 | 1.19 | 0.0705 | 0.0756 | 0.648 | 0.0898 | 0.604 | 0.0837 |
| SD021R | 0.028 | 0.013 | 47 | 8.1 | 1.20 | 0.0067 | 0.0072 | 0.058 | 0.00862 | 0.0541 | 0.00804 |
| TB-19 | 0.170 | 0.122 | 72 | 7.37 | 1.23 | 0.0611 | 0.0655 | 0.483 | 0.0806 | 0.451 | 0.0752 |
| SS-112 | 0.211 | 0.00011 | 0.05 | 6.53 | 1.13 | 0.0001 | 0.0001 | 0.0004 | 0.0000689 | 0.000373 | 0.0000643 |
| TB-16E | 0.150 | 0.150 | 100 | 5.15 | 0.833 | 0.0750 | 0.0804 | 0.415 | 0.067 | 0.387 | 0.0625 |
| SB-151 | 0.161 | 0.003 | 2 | 2.89 | 0.461 | 0.0015 | 0.0016 | 0.00473 | 0.000754 | 0.00441 | 0.000703 |
| TB-15 | 0.066 | 0.066 | 100 | 2.8 | 0.317 | 0.0329 | 0.0353 | 0.099 | 0.0112 | 0.0923 | 0.0104 |
| CS-59 | 0.205 | 0.036 | 18 | 1.26 | 0.217 | 0.0182 | 0.0195 | 0.0246 | 0.00421 | 0.0229 | 0.00393 |
| SS-111 | 0.224 | 0.164 | 73 | 0.867 | 0.0963 | 0.0820 | 0.0879 | 0.0762 | 0.00846 | 0.0711 | 0.00789 |
| | | | | | | 1.00 | 1.00 | | | | |

**Bolded location** is the polygon with the highest HMW and LMW concentration.

| | |
|---|---|
| Total acreage of polygons used for SWACs - without censored data (b): | 1.86 |
| Total acreage of polygons used for SWACs - with censored data (b): | 2.00 |

| | | | | |
|---|---|---|---|---|
| **Total SWAC (mg/kg) (Excludes Acreage of RISB06 and RISB08) (c):** | 80.3 | 34.2 | | |
| **Total SWAC (mg/kg) (with RISB06 and RISB08 contributing 0 mg/kg) (c):** | | | 74.9 | 31.9 |

**Table 3-3A. Summary of HMW and LMW PAH Soil Concentrations and HMW PAH Soil SWAC Calculations for 2-acres**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

**Notes:**
-- = Insufficient number of individual PAHs for calculation
Σ = Sum of
% = Percent
HMW = High molecular weight
LMW = Low molecular weight
mg/kg = Milligram(s) per kilogram
NA = Not applicable
PAH = Polycyclic aromatic hydrocarbons
SWAC = Surface weighted average concentration

(a) TB-16 had the highest HMW and LMW PAH concentration. All the polygons within 2 acres from the center of TB-16 were identified. The 2 acre circle is based on the refined home ranges of robin and shrew.

(b) Two polygons that intersected the boundary of the 2-acre circle had insufficient PAHs to calculate HMW and LMW PAH sums. Two acreages are presented in this table: one including the two polygons and the other excluding the two polygons.

(c) In the 2-acre SWAC approach, a 2-acre radius is used to identify the polygons for consideration. Only the portion of the polygon inside the 2-acre radius is used to calculate a SWAC. For those polygons that are not entirely within the 2-acre radius, the concentration of the polygon is assumed to represent only the portion of the polygon within the 2-acre radius (as shown on on Figure 3-2).

As a conservative measure, the SWAC excluding polygons RISB-06 and RISB-08 was used in the 2-acre food web model because the full set of PAHs needed for the sum of HMW and LMW PAHs were not available for the polygons.

**Table 3-3B. Summary of Avian and Mammal PCDD/F TEQ Concentrations and SWAC Calculations for 2-Acres**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon (a) | Polygon Size (acres) | Polygon Area Within 2 acre circle (acres) | % of Polygon Area within 2 -acre Circle | Avian PCDD/F TEQ (ng/kg) | Mammal PCDD/F TEQ (ng/kg) | % Polygon Contribution to 2-acre Home Range | Avian PCDD/F TEQ Polygon Contribution to SWAC (2-acres) (ng/kg) | Mammal PCDD/F TEQ Polygon Contribution to SWAC (2-acres) |
|---|---|---|---|---|---|---|---|---|
| **SS-115** | **0.150** | **0.150** | **100** | **206** | **275** | **0.0750** | **15.5** | **20.6** |
| CS-66 | 0.219 | 0.219 | 100 | 33.9 | 142 | 0.1093 | 3.7 | 15.5 |
| SS-119 | 0.248 | 0.248 | 100 | 20.1 | 27.2 | 0.1240 | 2.49 | 3.37 |
| TB-24 | 0.089 | 0.0885 | 100 | 12.8 | 20.1 | 0.0443 | 0.569 | 0.89 |
| TB-23 | 0.133 | 0.133 | 100 | 7.12 | 9.93 | 0.0668 | 0.475 | 0.663 |
| RISB10 | 0.167 | 0.167 | 100 | 5.50 | 5.46 | 0.0835 | 0.459 | 0.456 |
| SB-133 | 0.202 | 0.0203 | 10 | 0.84 | 1.44 | 0.01015 | 0.00855 | 0.0146 |
| SB-135 | 0.211 | 0.0011 | 0.5 | 14.5 | 9.46 | 0.000535 | 0.00774 | 0.00507 |
| SB-136 | 0.211 | 0.2010 | 95 | 76.5 | 129.9 | 0.1005 | 7.69 | 13.1 |
| SB-151 | 0.161 | 0.0560 | 35 | 3.38 | 6.68 | 0.0280 | 0.0948 | 0.187 |
| SB-152 | 0.151 | 0.0057 | 3.8 | 8.28 | 11.7 | 0.00287 | 0.0237 | 0.0337 |
| TB-26 | 0.244 | 0.0256 | 11 | 12.0 | 20.5 | 0.01283 | 0.154 | 0.262 |
| TB-19 | 0.170 | 0.0080 | 4.7 | 1.34 | 1.48 | 0.00400 | 0.00535 | 0.0059 |
| TB-22 | 0.174 | 0.0815 | 47 | 10.3 | 14.4 | 0.0407 | 0.42 | 0.585 |
| SS-114 | 0.247 | 0.0652 | 26 | 1.67 | 2.27 | 0.0326 | 0.0545 | 0.074 |
| SS-116 | 0.184 | 0.1697 | 92 | 3.07 | 3.71 | 0.0849 | 0.261 | 0.315 |
| SS-118 | 0.217 | 0.0294 | 14 | 3.76 | 3.28 | 0.0147 | 0.0554 | 0.0483 |
| SS-120 | 0.196 | 0.1873 | 96 | 3.66 | 4.88 | 0.0937 | 0.343 | 0.458 |
| CS-68 | 0.178 | 0.0611 | 34 | 25.8 | 50.4 | 0.0306 | 0.788 | 1.54 |
| CS-65 | 0.225 | 0.0819 | 36 | 1.65 | 1.89 | 0.0410 | 0.0678 | 0.0776 |

**Bolded location** is the polygon with the highest avian and mammal PCDD TEQ concentration.

| | | | | |
|---|---|---|---|---|
| Polygons within approximately 2 acres (total acreage): | 2.00 | **Total SWAC (ng/kg)** | 33.1 | 58.2 |

**Notes:**
ng/kg = Nanogram per kilogram
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency quotient (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

SWAC = Surface weighted average concentration

(a) SS-115 had the highest avian and mammal PCDD/F TEQ concentrations. All the polygons within 2 acres from the center of SS-115 were identified. The 2 acre circle is based on the refined home ranges of robin and shrew.

**Table 3-4A. Location-specific Σ10 HMW PAH Soil Invertebrate HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | Σ10 HMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ10 HMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| TB-16 | 2020 | 18.0 | 100 | no |
| TB-12 | 273 | 18.0 | 20 | no |
| SS-117 | 272 | 18.0 | 20 | YES |
| TB-16F | 259 | 18.0 | 10 | YES |
| SD021 | 147 | 18.0 | 8 | no |
| SS-108 | 139 | 18.0 | 8 | no |
| TB-16C | 133 | 18.0 | 7 | no |
| TB-11 | 131 | 18.0 | 7 | YES |
| SS-110 | 111 | 18.0 | 6 | YES |
| TB-05 | 111 | 18.0 | 6 | no |
| SS-114 | 108 | 18.0 | 6 | no |
| TB-18 | 101 | 18.0 | 6 | no |
| TB-17 | 95.9 | 18.0 | 5 | no |
| TB-08 | 95.4 | 18.0 | 5 | YES |
| SS-119 | 83.2 | 18.0 | 5 | no |
| CS-67 | 79.4 | 18.0 | 4 | no |
| SS-115 | 63.5 | 18.0 | 4 | no |
| SS-113 | 55.1 | 18.0 | 3 | no |
| TB-16D | 52.6 | 18.0 | 3 | no |
| SS-126 | 50.1 | 18.0 | 3 | no |
| TB-16A | 45.2 | 18.0 | 3 | no |
| TB-16G | 43.2 | 18.0 | 2 | no |
| TB-07 | 43.1 | 18.0 | 2 | no |
| TB-23 | 43.1 | 18.0 | 2 | no |
| SB-132 | 41.1 | 18.0 | 2 | no |
| SS-125 | 36.0 | 18.0 | 2 | no |
| SS-124 | 35.2 | 18.0 | 2 | no |
| CS-68 | 35.0 | 18.0 | 2 | no |
| CS-56 | 33.4 | 18.0 | 2 | no |
| TB-16B | 32.6 | 18.0 | 2 | no |
| CS-60 | 29.9 | 18.0 | 2 | no |
| SS-121 | 27.4 | 18.0 | 2 | YES |
| SB-150 | 22.0 | 18.0 | 1 | no |
| RISB09 | 19.8 | 18.0 | 1 | YES |
| SS-109 | 19.5 | 18.0 | 1 | no |
| TB-24 | 19.5 | 18.0 | 1 | YES |
| TWSB27 | 18.8 | 18.0 | 1 | no |
| TB-09 | 17.1 | 18.0 | 1 | no |
| TB-14 | 16.0 | 18.0 | 0.9 | YES |
| SB-127 | 13.8 | 18.0 | 0.8 | no |
| TB-21 | 13.6 | 18.0 | 0.8 | no |
| RISB10 | 13.3 | 18.0 | 0.7 | YES |

**Table 3-4A. Location-specific Σ10 HMW PAH Soil Invertebrate HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | Σ10 HMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ10 HMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| SS08 | 12.9 | 18.0 | 0.7 | no |
| CS-55 | 11.3 | 18.0 | 0.6 | no |
| TB-22 | 10.3 | 18.0 | 0.6 | no |
| SB-133 | 10.2 | 18.0 | 0.6 | no |
| SB-153 | 9.04 | 18.0 | 0.5 | no |
| SS-118 | 8.78 | 18.0 | 0.5 | no |
| TB-16H | 8.56 | 18.0 | 0.5 | no |
| SD021R | 8.10 | 18.0 | 0.5 | no |
| SB-131 | 7.81 | 18.0 | 0.4 | no |
| SB-135 | 7.69 | 18.0 | 0.4 | no |
| TB-19 | 7.37 | 18.0 | 0.4 | no |
| SS-116 | 7.05 | 18.0 | 0.4 | no |
| SB-136 | 6.63 | 18.0 | 0.4 | no |
| SS-112 | 6.53 | 18.0 | 0.4 | no |
| CS-52 | 6.42 | 18.0 | 0.4 | no |
| SB-130 | 6.32 | 18.0 | 0.4 | no |
| TB-20 | 5.61 | 18.0 | 0.3 | no |
| SB-129 | 5.41 | 18.0 | 0.3 | YES |
| CS-62 | 5.40 | 18.0 | 0.3 | no |
| TWSB23 | 5.36 | 18.0 | 0.3 | YES |
| TWSB24 | 5.31 | 18.0 | 0.3 | no |
| TB-16E | 5.15 | 18.0 | 0.3 | no |
| CS-66 | 5.09 | 18.0 | 0.3 | no |
| SS-122 | 4.82 | 18.0 | 0.3 | no |
| SB-149 | 4.64 | 18.0 | 0.3 | no |
| SB-152 | 4.37 | 18.0 | 0.2 | no |
| SS-120 | 3.82 | 18.0 | 0.2 | no |
| CS-65 | 3.69 | 18.0 | 0.2 | no |
| SB-134 | 2.93 | 18.0 | 0.2 | no |
| SB-151 | 2.89 | 18.0 | 0.2 | no |
| TB-15 | 2.80 | 18.0 | 0.2 | no |
| TB-26 | 2.11 | 18.0 | 0.1 | no |
| CS-58 | 1.95 | 18.0 | 0.1 | no |
| SB-148 | 1.79 | 18.0 | 0.1 | no |
| SB-128 | 1.78 | 18.0 | 0.1 | no |
| CS-53 | 1.59 | 18.0 | 0.09 | no |
| TB-13 | 1.45 | 18.0 | 0.08 | no |
| CS-63 | 1.44 | 18.0 | 0.08 | no |
| CS-59 | 1.26 | 18.0 | 0.07 | no |
| CS-61 | 1.14 | 18.0 | 0.06 | no |
| CS-64 | 0.891 | 18.0 | 0.05 | no |
| SS-111 | 0.867 | 18.0 | 0.05 | YES |

**Table 3-4A. Location-specific Σ10 HMW PAH Soil Invertebrate HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | ΣH10 HMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ10 HMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| TB-25 | 0.799 | 18.0 | 0.04 | no |
| SS-123 | 0.724 | 18.0 | 0.04 | YES |
| TB-10 | 0.565 | 18.0 | 0.03 | YES |
| CS-57 | 0.343 | 18.0 | 0.02 | no |

**Notes:**

| | |
|---|---|
| 1 | HQ≤1 |
| 10 | 1 < HQ≤ 10 |
| 50 | 10< HQ <100 |
| 500 | HQ > 100 |

| | |
|---|---|
| Σ10 HMW PAHs | Sum of 10 individual HMW PAHs |
| DL | Detection limit |
| HMW PAHs | High molecular weight polycyclic aromatic hydrocarbons |
| HQ | Hazard quotient |
| mg/kg | Milligram per kilogram |
| ND | Not detected |
| USEPA R4 | United States Environmental Protection Agency Region 4 |

(a) To be consistent across the data sets, the sum of the HMW PAHs included only 10 individual HMW PAHs.

USEPA R4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Updated March 2018. Atlanta, Georgia: Scientific Support Section, Superfund Division, EPA Region 4.

**Table 3-4B. Location-Specific Σ7 LMW PAH Soil Invertebrates HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | Σ7 LMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ7 LMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| TB-16 | 659 | 29.0 | 20 | no |
| TB-16F | 243 | 29.0 | 8 | YES |
| TB-12 | 67.9 | 29.0 | 2 | no |
| TB-11 | 21.2 | 29.0 | 0.7 | YES |
| SS-114 | 21 | 29.0 | 0.7 | no |
| SS-117 | 20.3 | 29.0 | 0.7 | YES |
| SD021 | 19.7 | 29.0 | 0.7 | no |
| TB-16C | 16.2 | 29.0 | 0.6 | no |
| SS-108 | 14.7 | 29.0 | 0.5 | no |
| TB-05 | 11.8 | 29.0 | 0.4 | no |
| TB-17 | 11.3 | 29.0 | 0.4 | no |
| SS-119 | 10.8 | 29.0 | 0.4 | no |
| TB-08 | 10.6 | 29.0 | 0.4 | YES |
| SS-115 | 10 | 29.0 | 0.3 | no |
| TB-18 | 9.29 | 29.0 | 0.3 | no |
| SS-126 | 7.35 | 29.0 | 0.3 | no |
| TB-07 | 7.17 | 29.0 | 0.2 | no |
| SS-125 | 6.72 | 29.0 | 0.2 | no |
| SB-132 | 6.64 | 29.0 | 0.2 | no |
| SS-113 | 6.29 | 29.0 | 0.2 | no |
| CS-68 | 5.7 | 29.0 | 0.2 | no |
| TB-23 | 5.55 | 29.0 | 0.2 | no |
| SS-110 | 5.53 | 29.0 | 0.2 | YES |
| CS-67 | 5.3 | 29.0 | 0.2 | no |
| SS-121 | 5.02 | 29.0 | 0.2 | YES |
| CS-55 | 4.95 | 29.0 | 0.2 | no |
| CS-56 | 4.77 | 29.0 | 0.2 | no |
| TB-16D | 4.25 | 29.0 | 0.1 | no |
| TB-24 | 4.03 | 29.0 | 0.1 | YES |
| SS-124 | 3.88 | 29.0 | 0.1 | no |
| SB-150 | 3.84 | 29.0 | 0.1 | no |
| CS-60 | 3.36 | 29.0 | 0.1 | no |
| RISB09 | 3.4 | 29.0 | 0.1 | YES |
| TB-16G | 3.33 | 29.0 | 0.1 | no |
| TB-16B | 2.78 | 29.0 | 0.1 | no |
| TB-09 | 2.71 | 29.0 | 0.09 | no |
| TB-14 | 2.34 | 29.0 | 0.08 | YES |
| SS-109 | 2.27 | 29.0 | 0.08 | no |
| SB-127 | 2.2 | 29.0 | 0.08 | no |

**Table 3-4B. Location-Specific Σ7 LMW PAH Soil Invertebrates HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | Σ7 LMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ7 LMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| SB-133 | 2.04 | 29.0 | 0.07 | no |
| TWSB27 | 1.94 | 29.0 | 0.07 | no |
| TB-16A | 1.88 | 29.0 | 0.06 | no |
| RISB10 | 1.83 | 29.0 | 0.06 | YES |
| SB-135 | 1.62 | 29.0 | 0.06 | no |
| TB-22 | 1.56 | 29.0 | 0.05 | no |
| SB-153 | 1.42 | 29.0 | 0.05 | no |
| SB-136 | 1.4 | 29.0 | 0.05 | no |
| SS-118 | 1.33 | 29.0 | 0.05 | no |
| SS08 | 1.32 | 29.0 | 0.05 | no |
| TB-19 | 1.23 | 29.0 | 0.04 | no |
| SD021R | 1.2 | 29.0 | 0.04 | no |
| TB-16H | 1.19 | 29.0 | 0.04 | no |
| SS-112 | 1.13 | 29.0 | 0.04 | no |
| SS-116 | 0.989 | 29.0 | 0.03 | no |
| SB-129 | 0.984 | 29.0 | 0.03 | YES |
| CS-52 | 0.979 | 29.0 | 0.03 | no |
| SB-134 | 0.918 | 29.0 | 0.03 | no |
| TB-16E | 0.833 | 29.0 | 0.03 | no |
| SB-131 | 0.797 | 29.0 | 0.03 | no |
| CS-62 | 0.779 | 29.0 | 0.03 | no |
| SB-149 | 0.776 | 29.0 | 0.03 | no |
| SB-130 | 0.758 | 29.0 | 0.03 | no |
| TB-20 | 0.737 | 29.0 | 0.03 | no |
| TB-21 | 0.732 | 29.0 | 0.03 | no |
| SS-120 | 0.631 | 29.0 | 0.02 | no |
| CS-61 | 0.597 | 29.0 | 0.02 | no |
| CS-66 | 0.591 | 29.0 | 0.02 | no |
| SS-122 | 0.56 | 29.0 | 0.02 | no |
| SB-148 | 0.541 | 29.0 | 0.02 | no |
| SB-128 | 0.5 | 29.0 | 0.02 | no |
| CS-58 | 0.495 | 29.0 | 0.02 | no |
| SB-151 | 0.461 | 29.0 | 0.02 | no |
| TWSB24 | 0.429 | 29.0 | 0.01 | no |
| CS-65 | 0.411 | 29.0 | 0.01 | no |
| SB-152 | 0.382 | 29.0 | 0.01 | no |
| TB-13 | 0.379 | 29.0 | 0.01 | no |
| CS-63 | 0.4 | 29.0 | 0.01 | no |
| CS-53 | 0.321 | 29.0 | 0.01 | no |

**Table 3-4B. Location-Specific Σ7 LMW PAH Soil Invertebrates HQs**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Polygon | Σ7 LMW PAHs (ND=0.5DL) (a) | USEPA R4 Invertebrate ESV (USEPA R4 2018) | Σ7 LMW PAH Hazard Quotient | Was Polygon Targeted for Invertebrate Sampling in June 2020? |
|---|---|---|---|---|
| | (mg/kg) | (mg/kg) | (unitless) | |
| TB-15 | 0.317 | 29.0 | 0.01 | no |
| TWSB23 | 0.305 | 29.0 | 0.01 | YES |
| TB-26 | 0.281 | 29.0 | 0.01 | no |
| CS-59 | 0.217 | 29.0 | 0.007 | no |
| CS-64 | 0.183 | 29.0 | 0.006 | no |
| TB-25 | 0.134 | 29.0 | 0.005 | no |
| SS-123 | 0.107 | 29.0 | 0.004 | YES |
| SS-111 | 0.0963 | 29.0 | 0.003 | YES |
| TB-10 | 0.0807 | 29.0 | 0.003 | YES |
| CS-57 | 0.077 | 29.0 | 0.003 | no |

**Notes:**

| | |
|---|---|
| 1 | HQ≤1 |
| 10 | 1 < HQ≤ 10 |
| 50 | 10< HQ <100 |
| Σ7 LMW PAHs | Sum of 7individual LMW PAHs |
| DL | Detection limit (method) |
| HQ | Hazard quotient |
| LMW PAHs | Low molecular weight polycyclic aromatic hydrocarbons |
| mg/kg | Milligram per kilogram |
| ND | Not detected |
| USEPA R4 | United States Environmental Protection Agency Region 4 |

(a) To be consistent across the data sets, the sum of the LMW PAHs included only 7 individual LMW PAHs.

USEPA R4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Updated March 2018. Atlanta, Georgia: Scientific Support Section, Superfund Division, EPA Region 4.

**Table 3-5. Sources of Uncertainty**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Source of Uncertainty | ERA Management Approach |
|---|---|
| **Data** | |
| 2-Acre OU2 Data Set | The 2-acre circle is the upper estimate of exposure because it is unlikely that wildlife spend their entire lives only at areas with the highest concentrations. 2-Acre SWACs, while also biased high, reflect the most likely exposures. |
| Use of UCL to characterize polygons with multiple grab samples | There are 7 polygons with multiple grab samples but no composite sample for PAHs: SS-110; SS-114; SS-117; SS-119; TB-08; TB-11; and TB-12. The Beneficiaries requested that the 95th UCL or maximum value (where a UCL could not be calculated or the UCL was greater than the maximum value) for each polygon be used to represent the polygon. High UCLs are can be produced when the data exhibits high variance and the sample size is small as is the case with these seven polygons. For each polygon, there is typically 4 to 5 sample points and the variance is high. For example, SS-110 has 5 samples with the following HMW PAH concentrations: 8.78 mg/kg; 10.9 mg/kg; 17.1 mg/kg; 51.5 mg/kg and 161 mg/kg. ProUCL calculated a 95th UCL of 111 mg/kg, whereas an average is calculated to be 49.8 mg/kg. The use of the UCL or maximum value to represent these polygons with high variability and small sample size can create a higher bias and may not accurately reflect the exposure at the polygon. |
| Exclusion of polygons from SWAC calculation | The size of OU2 is 15.6 acres; however, there are six polygons (approximately 0.2 acres in size) located along the northern boundary that were evaluated in the OU1 ERA. These polygons are not included in the OU2 SWAC calculation reducing the total acreage used for the SWAC calculation to 15.4 acres. In addition, there are four polygons where there is insufficient number of individual comparable PAHs to fully calculate the HMW and LMW PAH sums . If the partial PAH sum for these polygons were used, the SWAC would be artificially low. Therefore, data from these polygons were excluded from the SWAC calculations. In doing so, the SWAC acreage used to derive the SWAC for large home range birds and mammals was reduced to 14.7 acres and the count of polygons used in the soil invertebrate evaluation is 88 polygons rather than the 92 polygons initially mentioned for PAHs (or 98 polygons if you include the six polygons evaulated in the OU1 ERA). Table 3-5B evaluates what the SWAC would be if all polygons were used. The exclusion of these polygons from the SWAC calculation overestimates the soil concentrations used in the ERA as the excluded polygons have lower concentrations when compared to the other polygons. |
| **Exposure Assessment** | |
| Use of measured soil data to estimate tissue concentrations | Measured soil concentrations were used along with site-specific factors to estimate tissue residues. Use of abiotic media concentrations for tissue modeling may overestimate risk by not accurately accounting for the bioavailable fraction (for the ERA, it is assumed that the contaminants are 100% bioavailable); however, the magnitude of this effect is reduced by the fact that modeling was done using site-specific factors. |
| Use of literature-derived exposure assumptions in the models | There are numerous assumptions made in the food web modeling, including species-specific factors, such as body weight, home range, ingestion rates, and dietary composition that are literature-based and, in many cases, not specific to North Carolina. |

**Table 3-5. Sources of Uncertainty**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

| Source of Uncertainty | ERA Management Approach |
|---|---|
| Area use factors (AUFs) | The AUF accounts for the fraction of the diet that an organism actually obtains from the site. The AUF takes into consideration the dietary fraction derived from a site based on the organism's foraging/feeding range (i.e., the mobility factor, which is the ratio between the site surface area and the foraging/feeding range). High mobility animals have extensive foraging ranges and are known to obtain their diet from multiple locations, while low-mobility organisms, such as invertebrates, have a higher degree of exposure because most or all of their diet is derived from a smaller area. OU2 is approximately 15.6 acres. Organisms whose home range is less than the site size is assumed to spend all their time at the site while organisms whose home range is greater than the site size is assumed to spend only a portion of their time at the site. Ramboll considered both a conservative approach to AUFs (AUF=1) as well as a more realistic approach; however, OU2 is to be redeveloped which may reduce food sources for birds and affect how the area is utilized by ecological receptors. |
| Exposure Duration (ED) | The ED accounts for the fraction of time an organisms spends at the site. An ED of 1 assumes that an organisms spends all their time at the site. An ED of less than 1 assumes that an organisms spends only a portion of their time at the site due to factors such as migratory behevior. Ramboll only considered a conservative approach to EDs (ED=1) and assumed that the ecological receptors represented in the food web model would spend all their time at the site which may overestimate risk as some song birds migrate and would not be present at the site a portion of the season. |
| Absorption Factor | A conservative default absorption factor of 1.0, reflecting the assumption that 100% of the chemical ingested is absorbed in the system. Actual bioavailability under natural conditions is considerably lower. |
| Adaptation and tolerance | Consideration of bioavailability (and, thereby, diminished toxicity) tolerance and adaptation are intentionally not considered directly in this ERA. Further, there is little consistency and no quantitative methodology for the consideration of the bioavailability (and, thereby, diminished toxicity) even though this process is well documented. Similarly, tolerance and adaptation is well documented. |
| **Risk Characterization** | |
| HQs based on maximum AUFs and EDs | Compounding conservative assumptions in the risk assessment likely yields conservative (overestimated) risk estimates. HQs above 1 for ecological receptors are based on the presumption that these receptors live their entire lives at OU2, consume food only from the study area, and food items live entirely at the study area. |
| Interpretation of HQs | An HQ less than or equal to a value of 1 indicates that adverse impacts to wildlife are considered unlikely (USEPA, 2001). However, there is no clear guidance for interpreting the HQs that exceed a value of 1, except that this point of departure may indicate that adverse effects of some kind may have occurred or may occur in the future. |
| Toxicity Reference Values (TRVs) | HQs for risk characterization are calculated using TRVs from the USEPA R4 (2016) guidance document. There is limited information regarding PAH toxicity in birds. The bird TRVs used in the OU2 ERA are based on a Stickel and Dieter (1979) study using mallards and is the concentration at which subtle, unspecified biochemical behavioral changes were observed. There is some uncertainty in the use of this TRV and its use to characterize risk "may be somewhat conservative", as stated in the USEPA 2020 OU1 ERA. |

**Table 3-5. Sources of Uncertainty**
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

**Notes:**
% = Percent
< = Less than
95% UCL = 95 Percent upper confidence level of the mean
AUF = Area use factor
ERA = Ecological risk assessment
HQ = Hazard quotient
OU2 = Operable Unit 2
PAH = Polycyclic aromatic hydrocarbons
TRVs = Toxicity reference values
USEPA R4 = United States Environmental Protection Agency Region 4

**References:**

Stickel, L.F., and M.P. Dieter. 1979. Ecological and Physiological/Toxicological Effects of Petroleum on Aquatic Birds. A Summary of Research Activities FY76 through FY78. United States Fish and Wildlife Service Report FWS/OBS-79/26. July.

USEPA. 2001: ECO-Update: Role of Screening-level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (EPA 540/F-01/014; Publication 9345.0-14). Washington, D.C.: USEPA, Office of Solid Waste and Emergency Response. June.

USEPA R4. 2016. "EPA Region 4 Preferred Parameters to be Used in Ecological Risk Assessment in Region 4 – Version 9 – Last Revised November 01, 2016." Received by email from Brett Thomas, USEPA Region 4, on June 26, 2017.

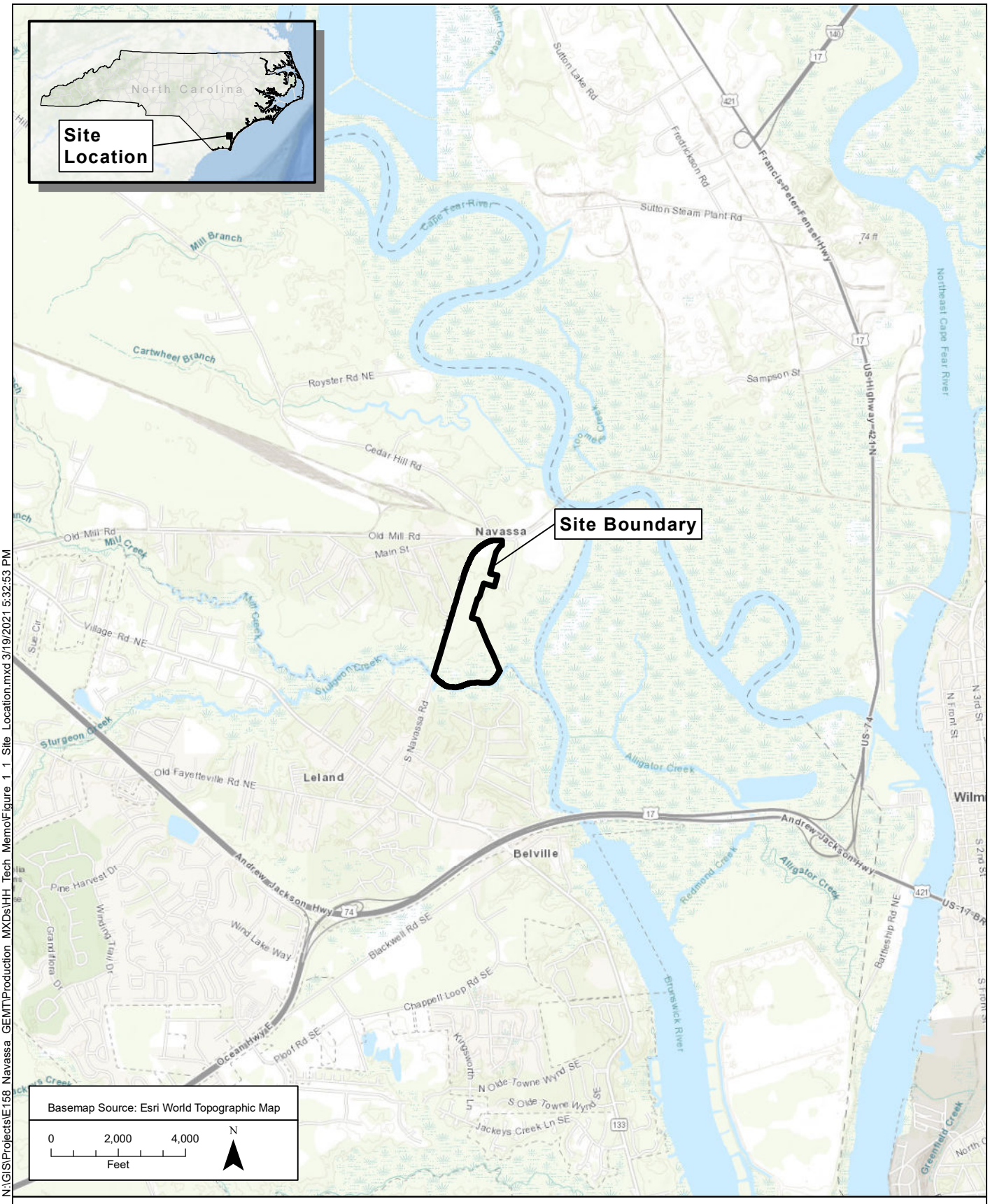
USEPA R4. 2020. "Revised Semi-Screening Level Ecological Risk Assessment Calculations for OU1 of the Kerr-McGee Chemical Company Site in Navassa, North Carolina." Received by email from Erik Spalvins via EarthCon on October 19, 2020.

**Table 3-6. Uncertainty Evaluation of the Exclusion of PAHs in Soil and Biological Tissue**
**Kerr-McGee Chemical Corporation Superfund Site**
**Navassa, North Carolina**

| Location | Matrix | HMW PAH Concentrations | | | | HMW PAH Evaluation | | | | LMW PAH Concentrations | | | | LMW PAH Evaluation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Use of Σ10 HMW PAH in ERA | | Exc. Benzo(e)pyrene + Perylene from ERA | Exc. Σ5 Alkylated HMW PAH from ERA | | | | | Use of Σ7 LMW PAH in ERA | | Exc. 1-MeNa from ERA | Exc. Σ10 Alkylated LMW PAH from ERA |
| | | Σ10 HMW PAH Used in ERA (mg/kg) | Benzo(e)pyrene + Perylene (mg/kg) | Σ5 Alkylated HMW PAHs (mg/kg) | Total Σ17 HMW PAHs (mg/kg) | % Σ10 HMW PAH (Used in ERA) of Total Σ17 HMW PAHs | % ↓ Risk by Using Σ10 HMW PAH in ERA | % Benzo(e)pyrene + Perylene of Total Σ17 HMW PAH % ↓ Risk by Not Including | % Σ5 Alkylated HMW PAH of Total Σ17 HMW PAH % ↓ Risk by Not Including | Σ7 LMW PAH Used in ERA (mg/kg) | 1-Methylnaphthalene (mg/kg) | Σ10 Alkylated LMW PAHs (mg/kg) | Total Σ18 LMW PAHs (mg/kg) | % Σ7 LMW PAH (Used in ERA) of Total Σ18 LMW PAHs | % ↓ Risk by Using Σ7 LMW PAH in ERA | % 1-MeNa (Not in ERA) of Total LMW PAH | % Σ10 Alkylated LMW PAH of Total LMW PAH |
| RISB-09 | EU | 19.4 | 2.690 | 4.770 | 26.9 | 72.2 | 28 | 10 | 18 | 1.02 | 0.0178 | 4.120 | 5.15 | 20 | 80 | 0.3 | 80 |
| RISB-10 | EU | 9.03 | 1.420 | 2.080 | 12.5 | 72.1 | 28 | 11 | 17 | 0.631 | 0.0282 | 2.100 | 2.76 | 23 | 77 | 1 | 76 |
| SB-129 | EU | 0.582 | 0.098 | 0.120 | 0.8 | 72.8 | 27 | 12 | 15 | 0.0573 | 0.00404 | 0.163 | 0.224 | 26 | 74 | 2 | 73 |
| SS-110 | EU | 34.5 | 3.680 | 7.580 | 45.8 | 75.4 | 25 | 8 | 17 | 0.456 | 0.00761 | 1.930 | 2.4 | 19 | 81 | 0.3 | 81 |
| SS-111 | EU | 1.54 | 0.198 | 0.370 | 2.11 | 73.1 | 27 | 9 | 18 | 0.201 | 0.0109 | 0.589 | 0.8 | 25 | 75 | 1 | 74 |
| SS-117 | EU | 10.7 | 1.440 | 2.600 | 14.7 | 72.6 | 27 | 10 | 18 | 0.818 | 0.0131 | 2.460 | 3.29 | 25 | 75 | 0.4 | 75 |
| SS-121 | EU | 10.5 | 1.420 | 2.700 | 14.6 | 71.9 | 28 | 10 | 18 | 0.572 | 0.0145 | 2.210 | 2.79 | 20 | 80 | 1 | 79 |
| SS-123 | EU | 1.34 | 0.225 | 0.317 | 1.88 | 71.2 | 29 | 12 | 17 | 0.0946 | 0.00296 | 0.335 | 0.432 | 22 | 78 | 1 | 77 |
| TB-08 | EU | 14 | 2.190 | 3.430 | 19.7 | 71.4 | 29 | 11 | 17 | 1 | 0.0172 | 1.550 | 2.57 | 39 | 61 | 1 | 60 |
| TB-10 | EU | 12.3 | 1.650 | 3.140 | 17.1 | 72 | 28 | 10 | 18 | 0.209 | 0.00589 | 2.480 | 2.69 | 8 | 92 | 0.2 | 92 |
| TB-11 | EU | 2.32 | 0.305 | 0.549 | 3.17 | 73.1 | 27 | 10 | 17 | 0.311 | 0.0577 | 1.040 | 1.4 | 22 | 78 | 4 | 74 |
| TB-14 | EU | 5.56 | 1.010 | 1.160 | 7.74 | 71.9 | 28 | 13 | 15 | 0.452 | 0.046 | 0.841 | 1.34 | 34 | 66 | 3 | 63 |
| TB-16F | EU | 23.1 | 3.570 | 4.230 | 30.9 | 74.8 | 25 | 12 | 14 | 0.941 | 0.0415 | 1.190 | 2.17 | 43 | 57 | 2 | 55 |
| TB-24 | EU | 9.71 | 1.690 | 2.260 | 13.7 | 71.1 | 29 | 12 | 17 | 0.641 | 0.0245 | 2.050 | 2.72 | 24 | 76 | 1 | 76 |
| TWSB-23 | EU | 54.5 | 6.340 | 13.500 | 74.4 | 73.3 | 27 | 9 | 18 | 2.36 | 0.0198 | 10.100 | 12.5 | 19 | 81 | 0.2 | 81 |
| | | | | | | **Minimum** | **25** | **8** | **14** | | | | | **Minimum** | **57** | **0.2** | **55** |
| | | | | | | **Average** | **27** | **11** | **17** | | | | | **Average** | **75** | **1** | **74** |
| | | | | | | **Maximum** | **29** | **13** | **18** | | | | | **Maximum** | **92** | **4** | **92** |
| RISB-09 | SS | 140 | 18.5 | 43 | 202 | 70 | 31 | 9 | 21 | 9.6 | 0.178 | 40.8 | 50.6 | 19 | 81 | 0.4 | 81 |
| RISB-10 | SS | 92.9 | 12 | 25.7 | 131 | 71 | 29 | 9 | 20 | 8.19 | 0.468 | 28.6 | 37.3 | 22 | 78 | 1 | 77 |
| SB-129 | SS | 7.57 | 0.946 | 1.76 | 10.3 | 74 | 26 | 9 | 17 | 0.983 | 0.0856 | 2.49 | 3.55 | 28 | 72 | 2 | 70 |
| SS-110 | SS | 463 | 37.8 | 123 | 624 | 74 | 26 | 6 | 20 | 5.86 | 0.0587 | 87.9 | 93.8 | 6 | 94 | 0.1 | 94 |
| SS-111 | SS | 8.92 | 1.08 | 2.05 | 12.1 | 74 | 26 | 9 | 17 | 1.49 | 0.065 | 3.16 | 4.72 | 32 | 68 | 1 | 67 |
| SS-117 | SS | 322 | 28.5 | 87.9 | 438 | 73 | 27 | 7 | 20 | 32.1 | 0.708 | 103 | 136 | 24 | 76 | 1 | 76 |
| SS-121 | SS | 278 | 32.7 | 78.1 | 389 | 72 | 29 | 8 | 20 | 17.4 | 0.609 | 79.4 | 97.4 | 18 | 82 | 1 | 82 |
| SS-123 | SS | 19.5 | 3.12 | 4.76 | 27.4 | 71 | 29 | 11 | 17 | 1.78 | 0.0771 | 4.42 | 6.27 | 28 | 72 | 1 | 70 |
| TB-08 | SS | 126 | 15.2 | 31.2 | 172 | 73 | 27 | 9 | 18 | 11.3 | 0.189 | 35.4 | 46.9 | 24 | 76 | 0.4 | 75 |
| TB-10 | SS | 33.6 | 3.88 | 9.64 | 47.1 | 71 | 29 | 8 | 20 | 1.21 | 0.0292 | 7.59 | 8.83 | 14 | 86 | 0.3 | 86 |
| TB-11 | SS | 11.3 | 1.25 | 2.74 | 15.3 | 74 | 26 | 8 | 18 | 2.5 | 0.446 | 6.87 | 9.82 | 25 | 75 | 5 | 70 |
| TB-14 | SS | 31.4 | 3.97 | 6.93 | 42.2 | 74 | 26 | 9 | 16 | 3.2 | 0.322 | 11 | 14.5 | 22 | 78 | 2 | 76 |
| TB-16F | SS | 190 | 29.5 | 47 | 267 | 71 | 29 | 11 | 18 | 12.2 | 0.718 | 38.3 | 51.2 | 24 | 76 | 1 | 75 |
| TB-24 | SS | 81.2 | 11.9 | 19.6 | 113 | 72 | 28 | 11 | 17 | 6.03 | 0.209 | 18.1 | 24.3 | 25 | 75 | 1 | 74 |
| TWSB-23 | SS | 362 | 45 | 93.2 | 500 | 72 | 28 | 9 | 19 | 15.3 | 0.324 | 81.9 | 97.5 | 16 | 84 | 0.3 | 84 |
| | | | | | | **Minimum** | **26** | **6** | **16** | | | | | **Minimum** | **68** | **0.1** | **67** |
| | | | | | | **Average** | **28** | **9** | **19** | | | | | **Average** | **78** | **1** | **77** |
| | | | | | | **Maximum** | **31** | **11** | **21** | | | | | **Maximum** | **94** | **5** | **94** |

**Notes:**
↓ = Understimated
% = Percent
1-MeNa = 1-Methylnaphthalene
AG = Aboveground invertebrates (adult)
ALK = Alkylated
ERA = Ecological risk assessment
EU = Undepurated belowground invertebrates
Exc. = Excluding
HMW = High molecular weight
LMW = Low molecular weight
PAHs = Polycyclic aromatic hydrocarbons
Parent = Nonalkylated
SS = Surface soil (upper six inches)
Total Σ17 HMW PAHs = Sum of Σ10 nonalkylated HMW PAHs used in ERA, 2 nonalkylated HMW PAHs not used in ERA (benzo(e)pyrene and perylene), and Σ5 alkylated HMW PAHs not used in ERA
Total Σ18 LMW PAHs = Sum of Σ7 nonalkylated LMW PAHs used in ERA, 1 nonalkylated LMW PAH not used in ERA (1-MeNA), and Σ10 alkylated LMW PAHs not used in ERA

## FIGURES

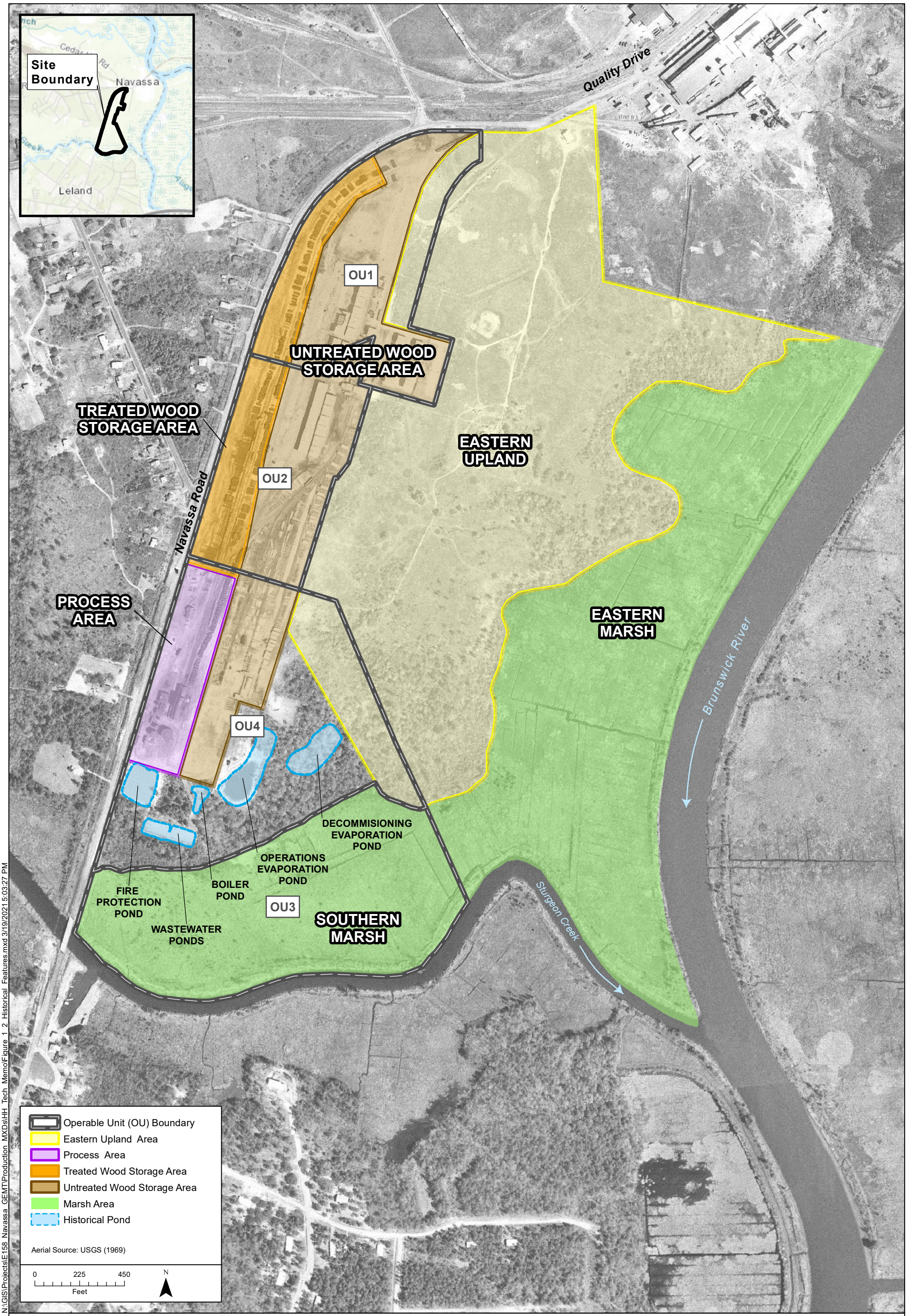



N:\GIS\Projects\E158 Navassa GEMT\Production MXDs\HH Tech Memo\Figure 1 1 Site Location.mxd 3/19/2021 5:32:53 PM

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering pc, EARTHCON, RAMBOLL

**Figure 1-1**
Site Location
Kerr-McGee Chemical Corp. - Navassa Superfund Site
Navassa, North Carolina
June 2021

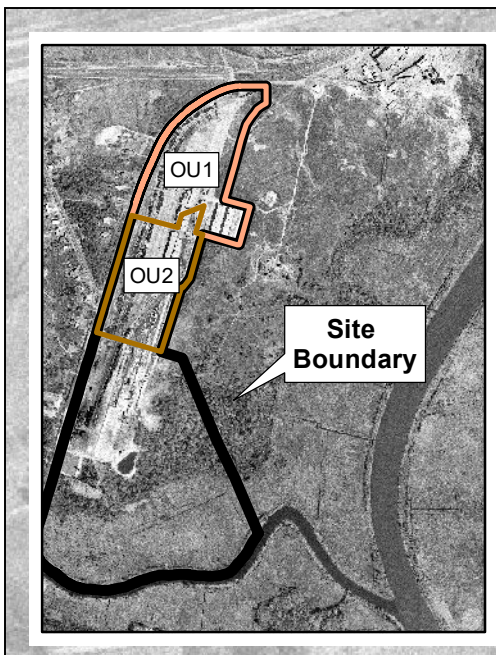



N:\GIS\Projects\E158 Navassa GEMT\Production MXDs\HH Tech Memo\Figure 1-2 Historical Features.mxd 3/19/2021 5:03:27 PM

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering pc. EARTHCON RAMBOLL

**Figure 1-2A**
Historical Site Features
Kerr-McGee Chemical Corp. - Navassa Superfund Site
Navassa, North Carolina
June 2021




OU1
(20.2 acres)

Former
OU1 Area

Former OU1/OU2
Boundary

Navassa Rd

OU2
(15.6 Acres)

**Operable Unit (OU):**
OU1
OU2
Former OU1/OU2 Boundary

Notes:
Aerial Source: USGS (1969)

0 50 100
Feet

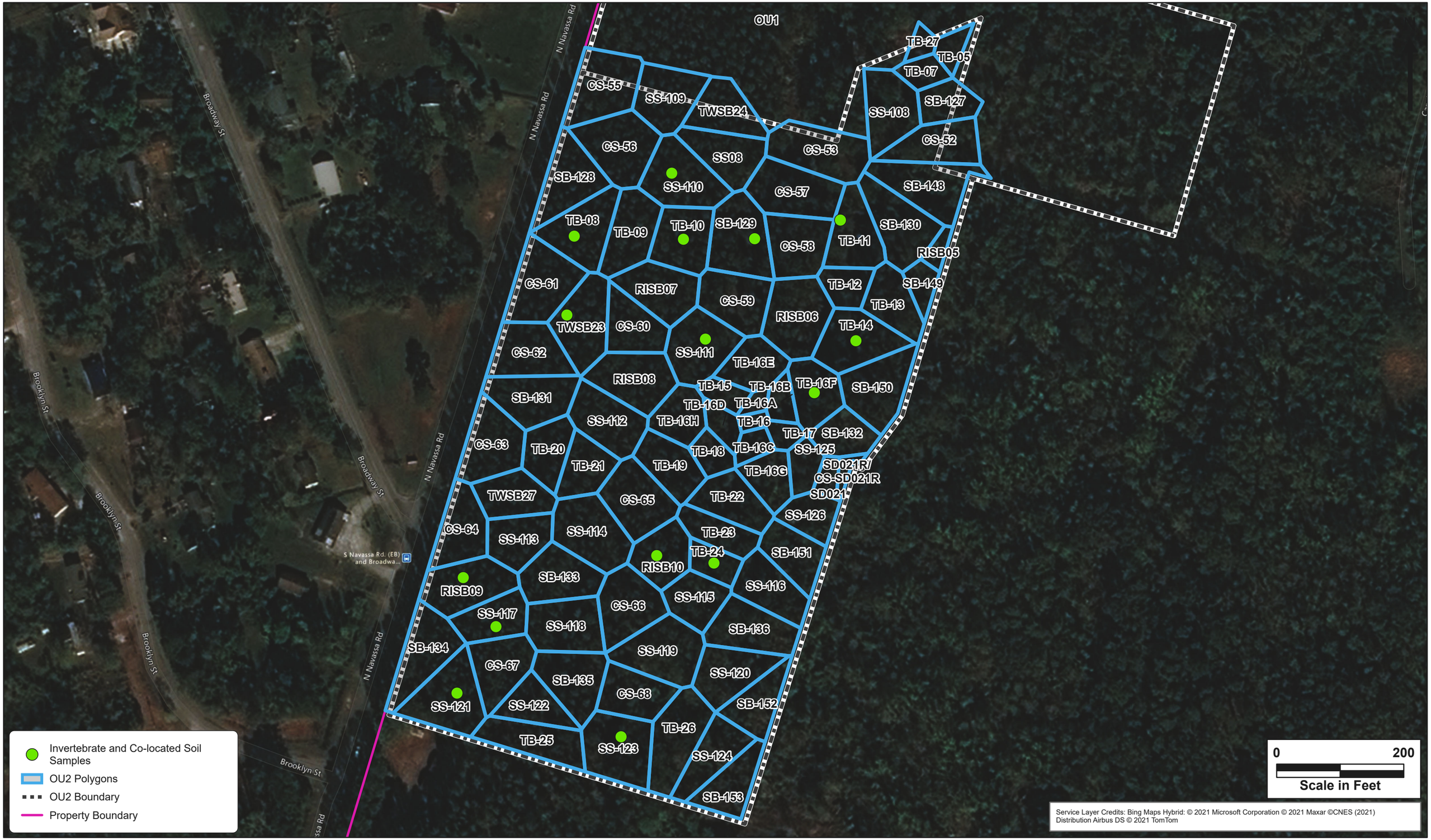
N

N:\GIS\Projects\E158 Navassa GEMT\Production MXDs\HH Tech Memo\Figure 1-3 OU1 OU2 Area.mxd 3/19/2021 5:23:51 PM

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering pc · EARTHCON · RAMBOLL

**Figure 1-2B**
Operable Unit Layout
Kerr-McGee Chemical Corp. - Navassa Superfund Site
Navassa, North Carolina
June 2021




Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

integral engineering p.c.

RAMBOLL

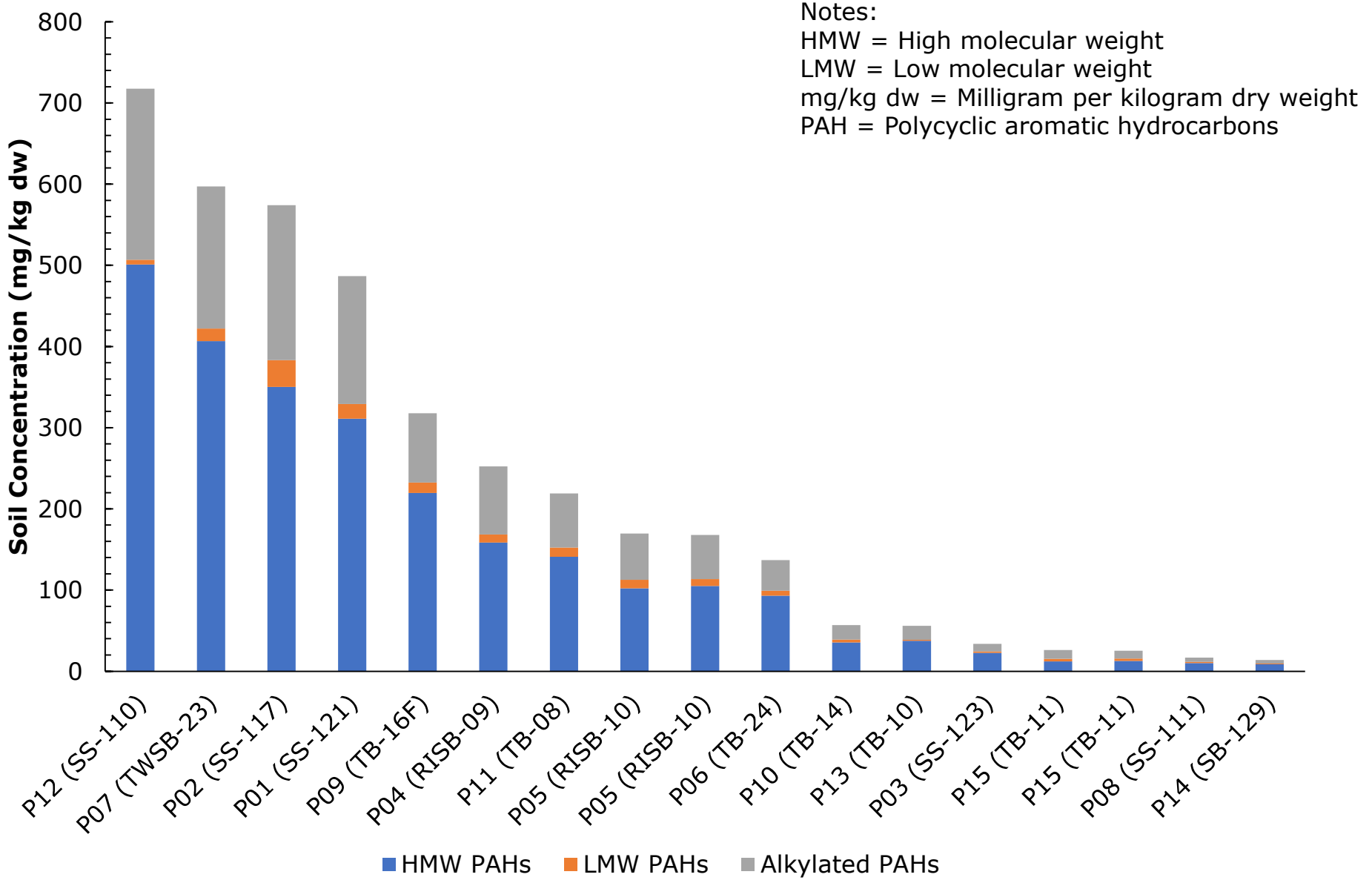
Map Design: SAO, Date: 2/25/2021

# Location of OU2 Surface Soil and Invertebrate Samples

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-1

Project: 1690019547




RAMBOLL

integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

PAH SOIL CONCENTRATIONS BY POLYGON

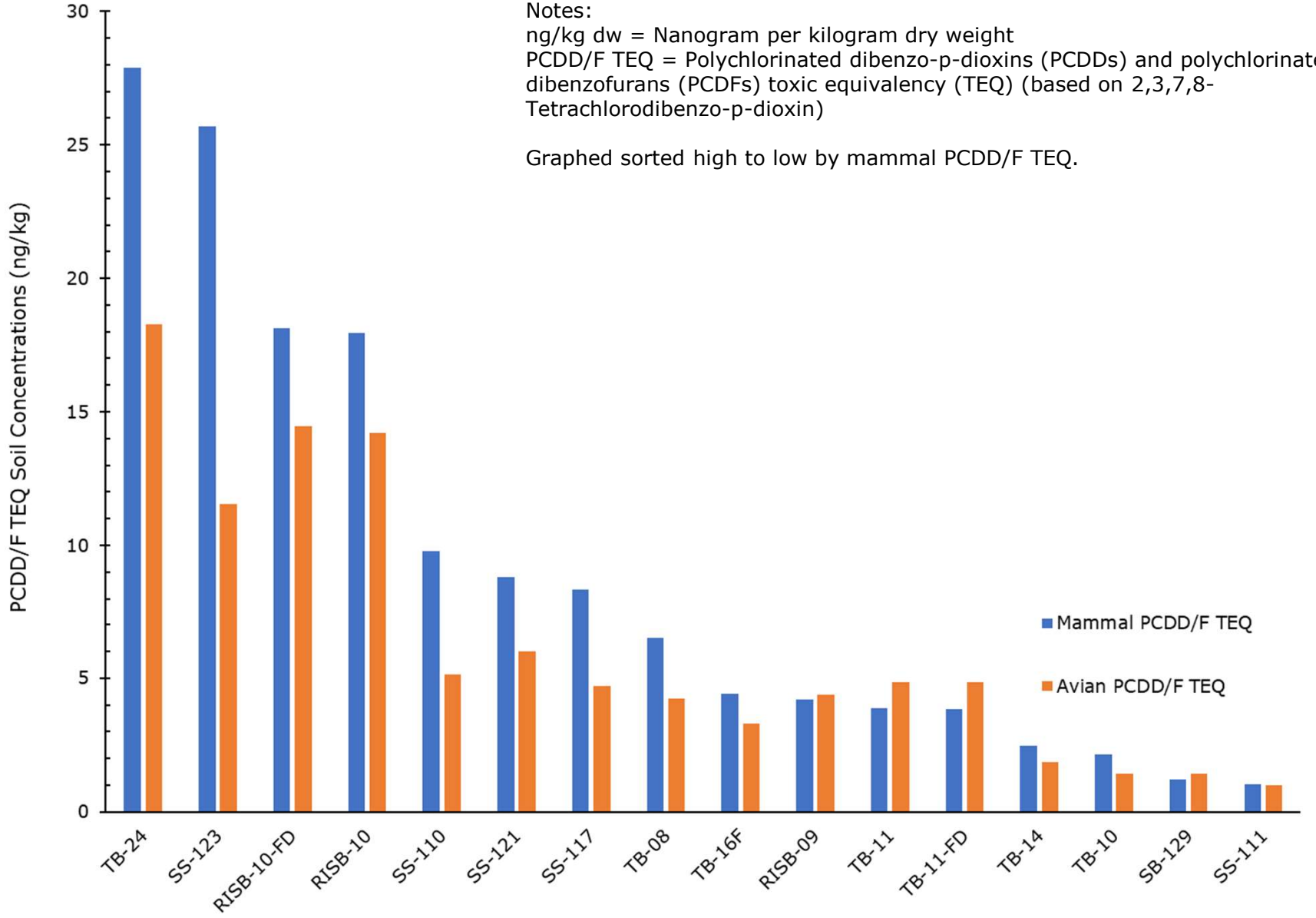
Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-2

Project 1690019547

Notes:
ng/kg dw = Nanogram per kilogram dry weight
PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency (TEQ) (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

Graphed sorted high to low by mammal PCDD/F TEQ.




RAMBOLL
integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

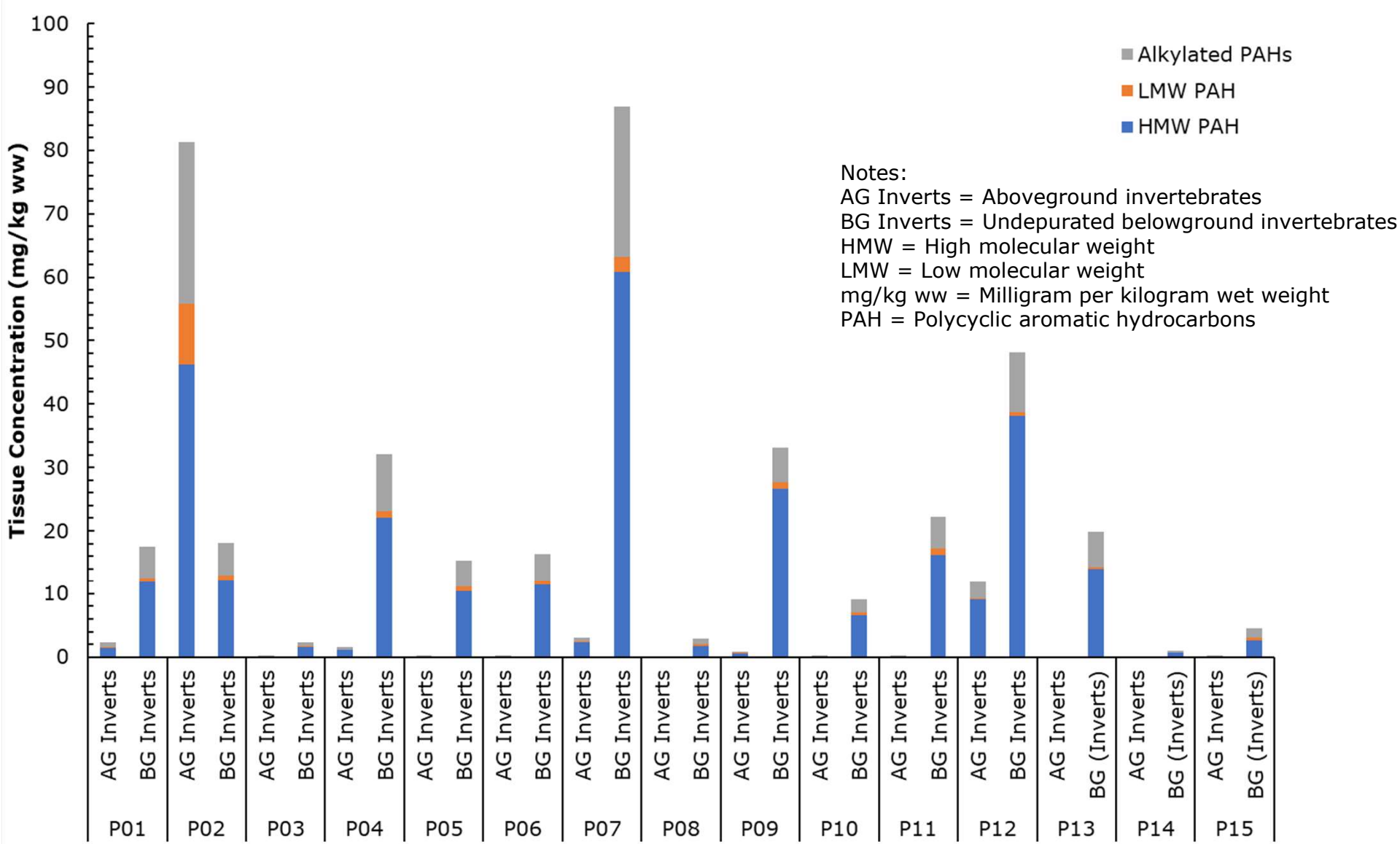
EARTHCON

PCDD/F TEQ SOIL CONCENTRATIONS BY POLYGON

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-3

Project 1690019547




RAMBOLL integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

MEASURED INVERTEBRATE PAH TISSUE CONCENTRATION BY POLYGON

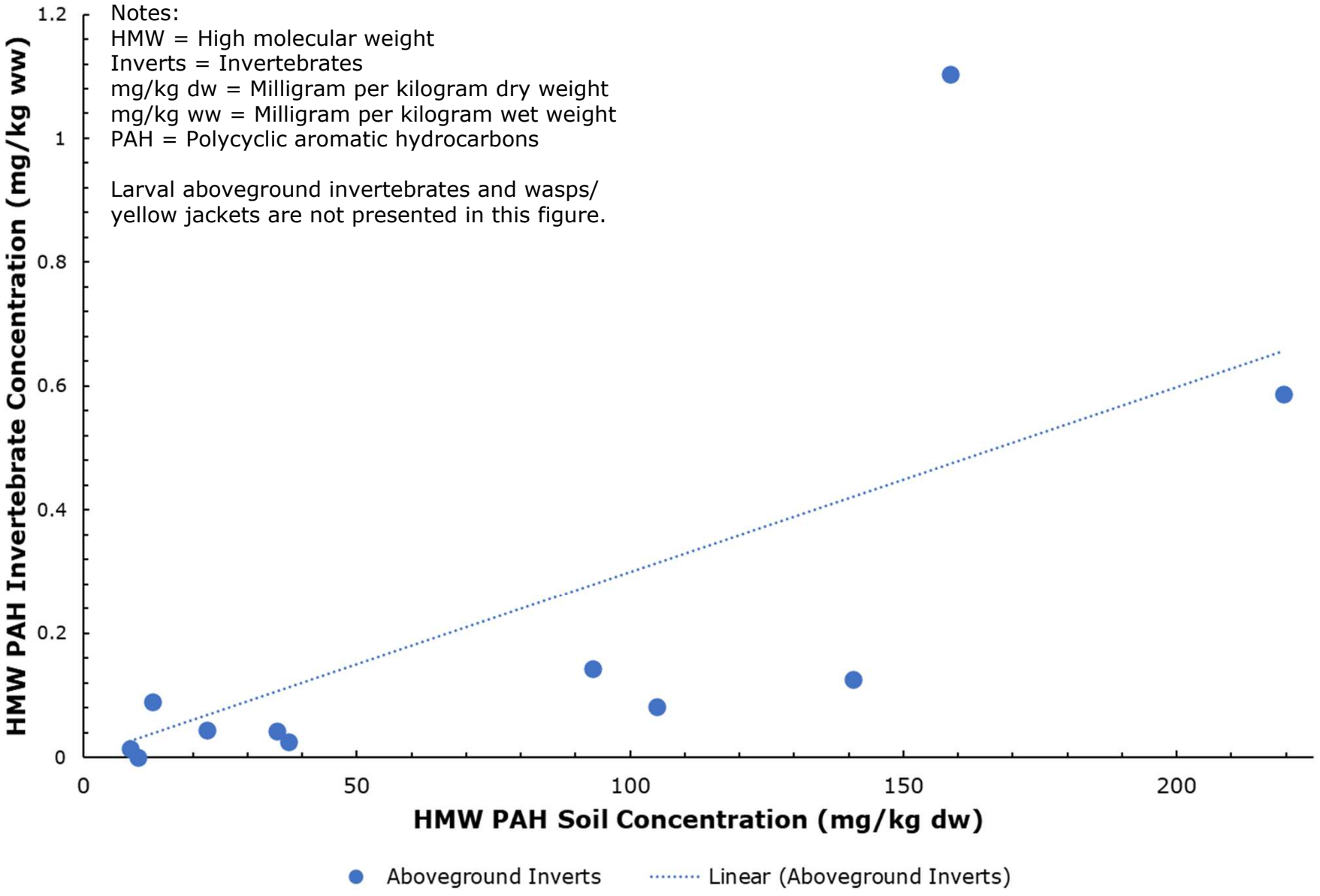
Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE 2-4A

Project 1690019547

Notes:
HMW = High molecular weight
Inverts = Invertebrates
mg/kg dw = Milligram per kilogram dry weight
mg/kg ww = Milligram per kilogram wet weight
PAH = Polycyclic aromatic hydrocarbons

Larval aboveground invertebrates and wasps/ yellow jackets are not presented in this figure.




RAMBOLL integral engineering pc

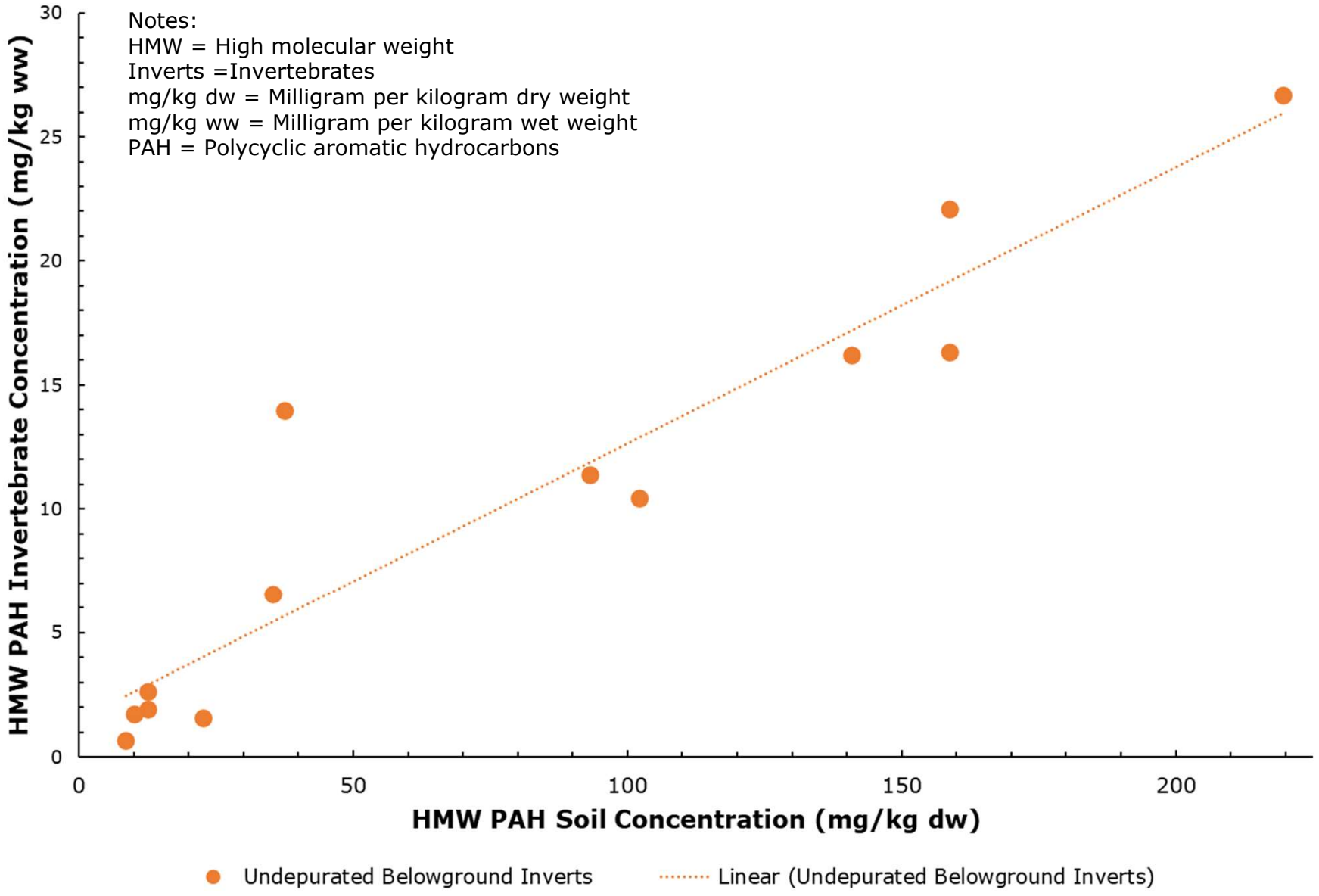
Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

MEASURED HMW PAH ABOVEGROUND INVERTEBRATE TISSUE CONCENTRATION
Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-4B

Project 1690019547




RAMBOLL

integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

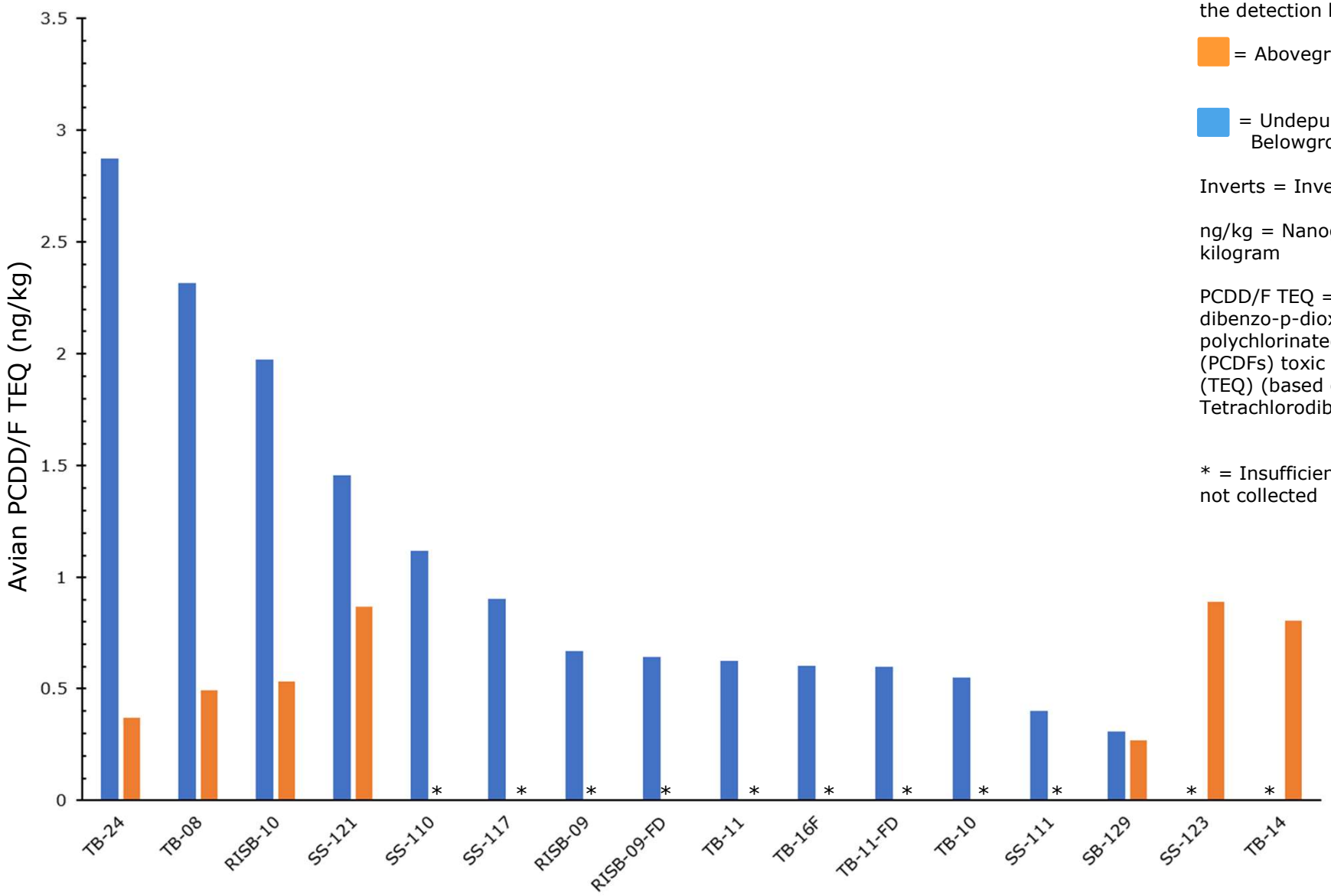
EARTHCON

MEASURED HMW PAH BELOWGROUND INVERTEBRATE TISSUE CONCENTRATION

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-4C

Project 1690019547




RAMBOLL

integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

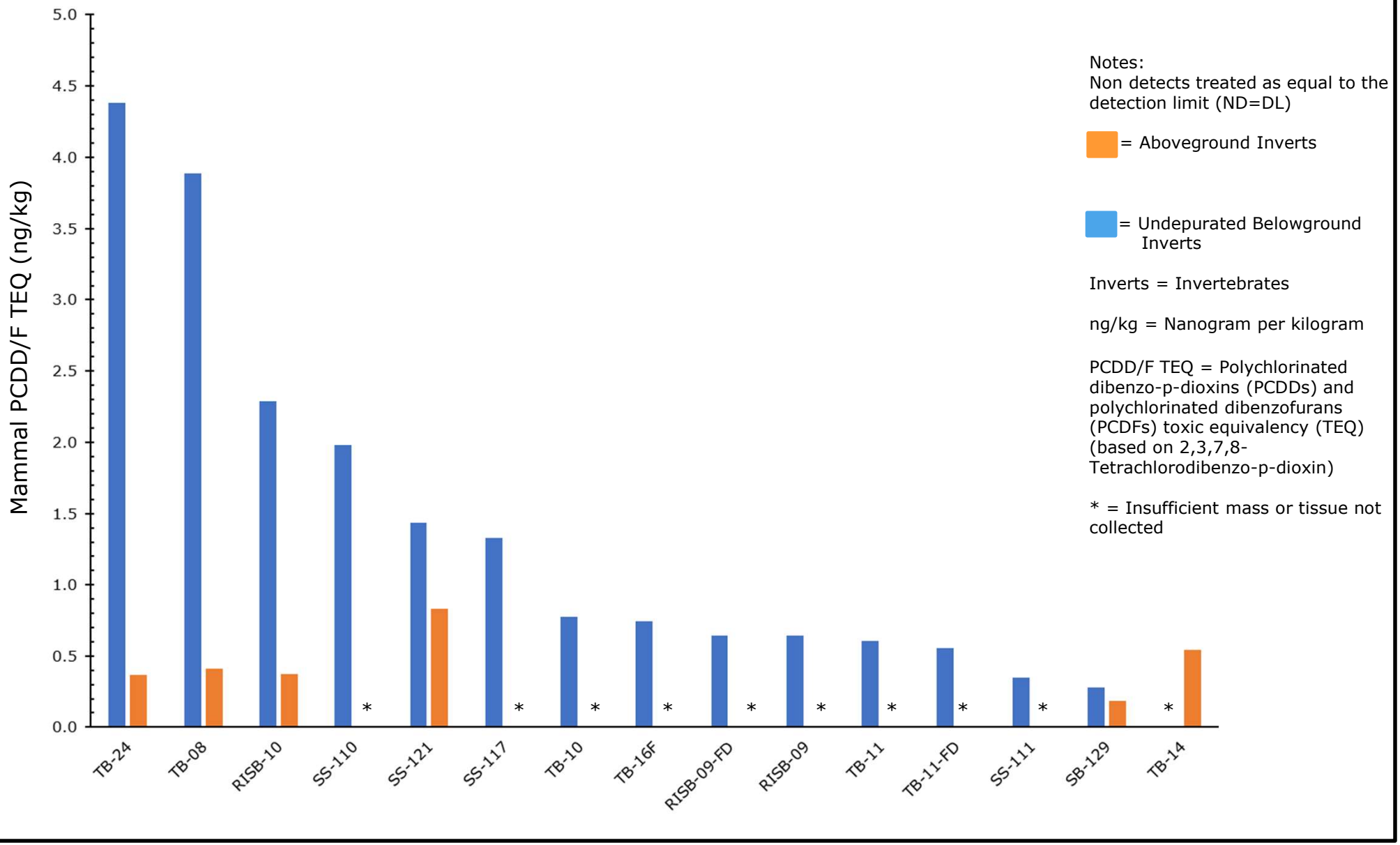
EARTHCON

MEASURED INVERTEBRATE AVIAN PCDD/F TEQ TISSUE CONCENTRATION BY POLYGON

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-5A

Project 1690019547




RAMBOLL

integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

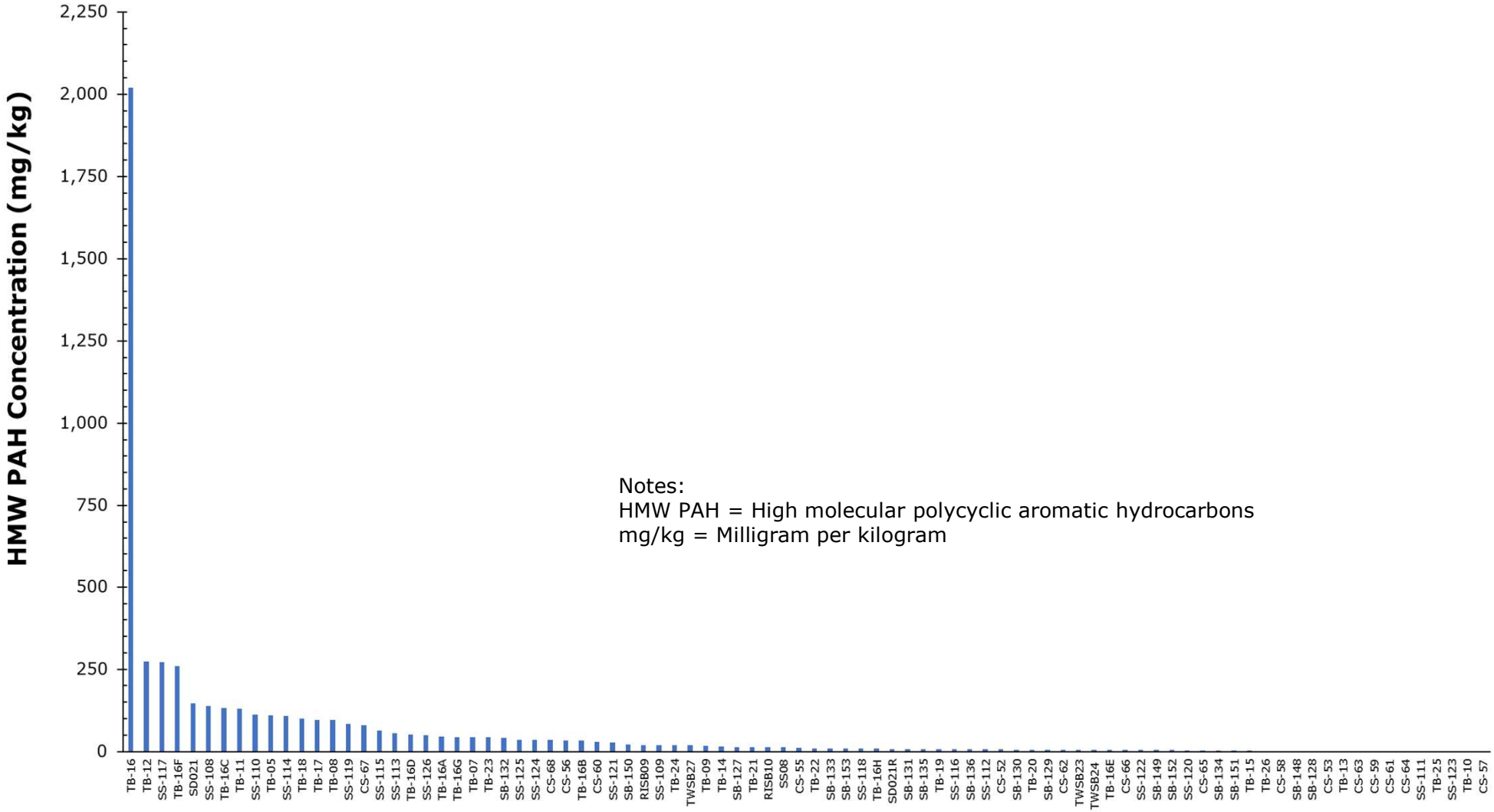
EARTHCON

MEASURED INVERTEBRATE MAMMAL PCDD TEQ TISSUE CONCENTRATION BY POLYGON

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
2-5B

Project 1690019547




Notes:
HMW PAH = High molecular polycyclic aromatic hydrocarbons
mg/kg = Milligram per kilogram

RAMBOLL
integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

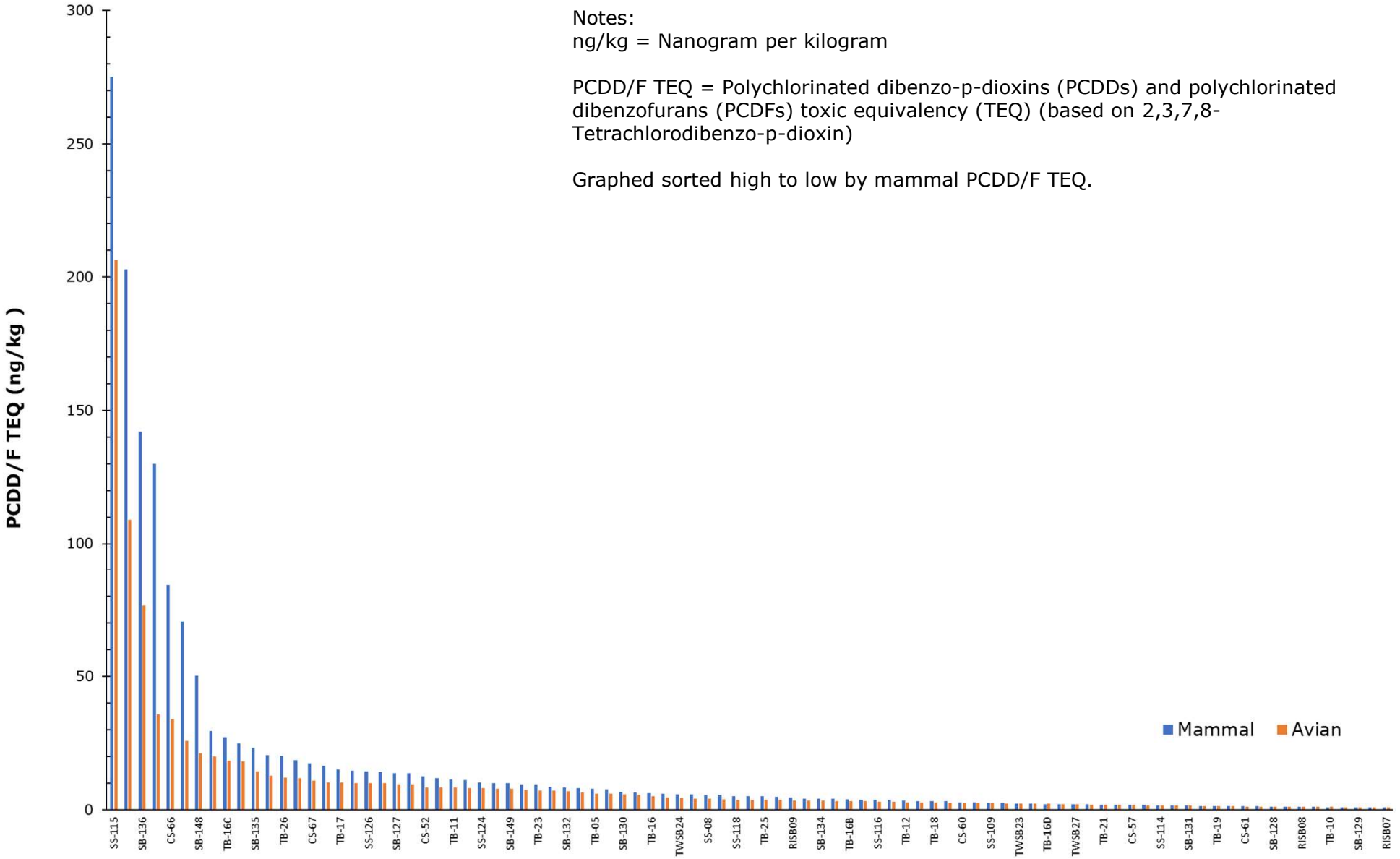
EARTHCON

OU2 SOIL HMW PAH DISTRIBUTION FROM HIGH TO LOW CONCENTRATIONS

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
3-1A

Project 1690019547




Notes:
ng/kg = Nanogram per kilogram

PCDD/F TEQ = Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) toxic equivalency (TEQ) (based on 2,3,7,8-Tetrachlorodibenzo-p-dioxin)

Graphed sorted high to low by mammal PCDD/F TEQ.

RAMBOLL

integral engineering pc

**Greenfield Environmental Multistate Trust, LLC Trustee of the Multistate Environmental Response Trust**

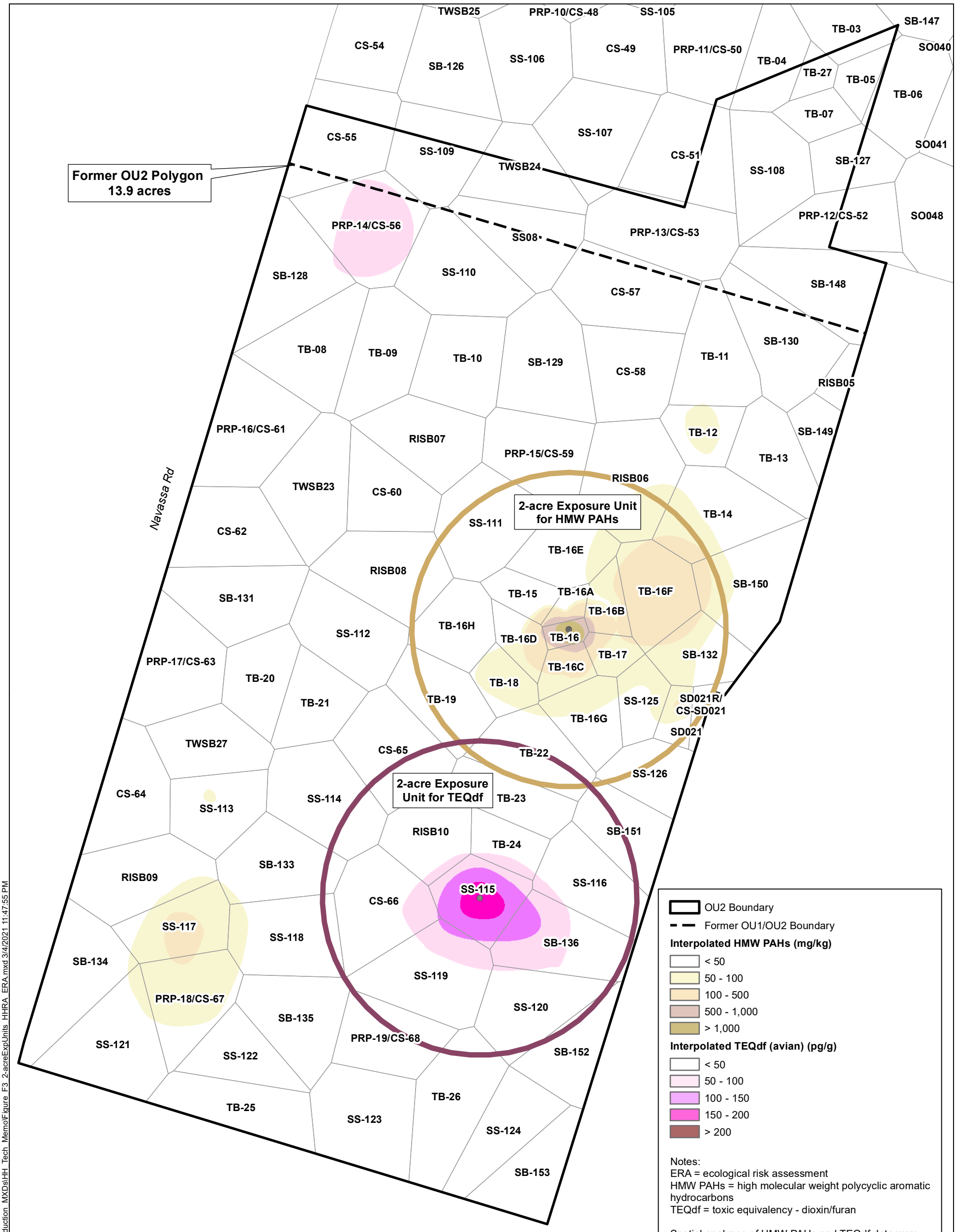
EARTHCON

# OU2 SOIL PCDD/F TEQ DISTRIBUTION FROM HIGH TO LOW CONCENTRATIONS

Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
3-1B

Project 1690019547

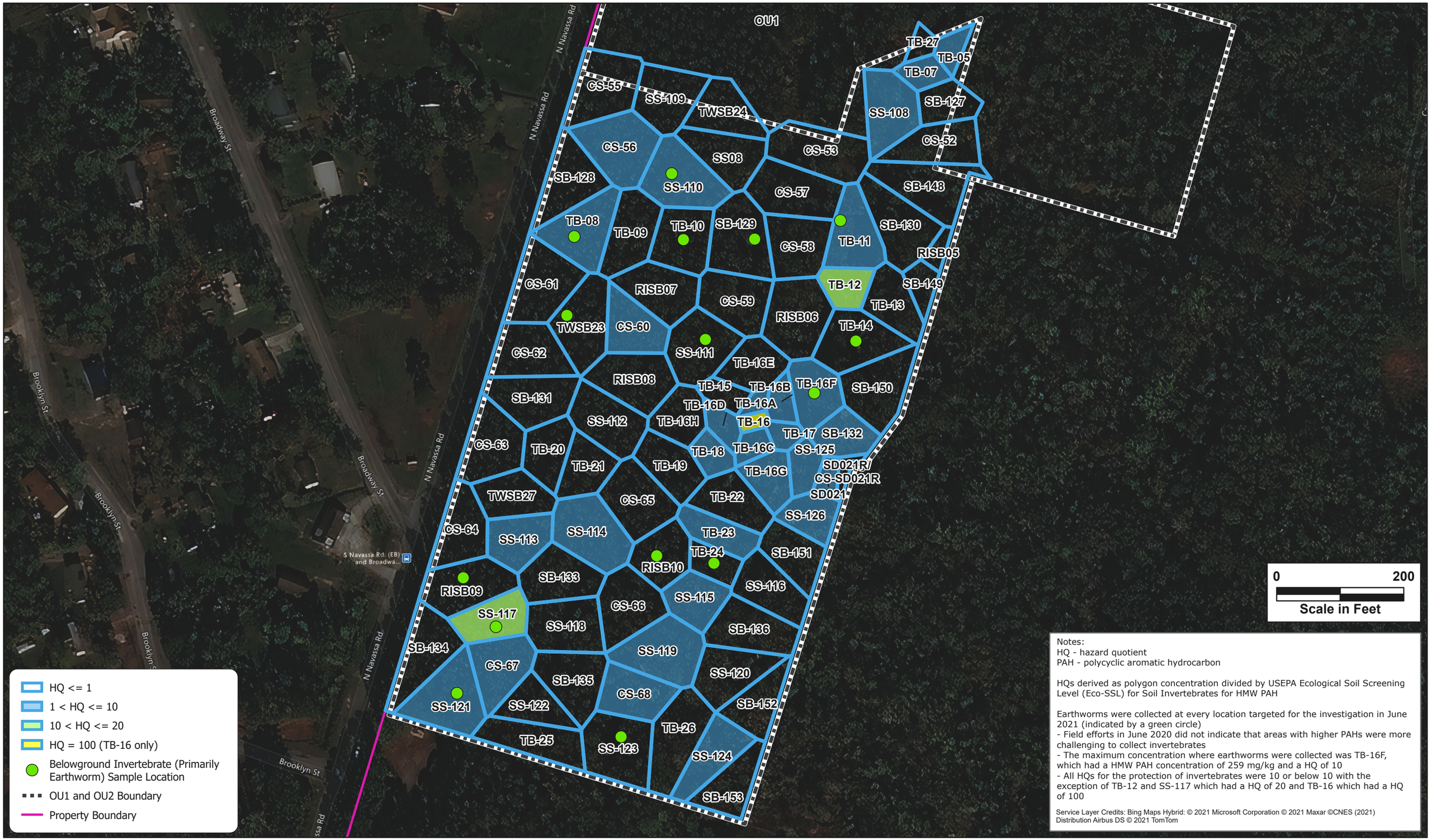



N:\GIS\Projects\E158 Navassa GEMT\Production MXDs\HH Tech Memo\Figure F3 2-acreExpUnits HHRA ERA.mxd 3/4/2021 11:47:55 PM

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: RAMBOLL integral engineering pc.

**Figure 3-2**
OU2 2-Acre Ecological Risk Assessment Exposure Units
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina




Notes:
HQ - hazard quotient
PAH - polycyclic aromatic hydrocarbon

HQs derived as polygon concentration divided by USEPA Ecological Soil Screening Level (Eco-SSL) for Soil Invertebrates for HMW PAH

Earthworms were collected at every location targeted for the investigation in June 2021 (indicated by a green circle)
- Field efforts in June 2020 did not indicate that areas with higher PAHs were more challenging to collect invertebrates
- The maximum concentration where earthworms were collected was TB-16F, which had a HMW PAH concentration of 259 mg/kg and a HQ of 10
- All HQs for the protection of invertebrates were 10 or below 10 with the exception of TB-12 and SS-117 which had a HQ of 20 and TB-16 which had a HQ of 100



Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

integral engineering p.c.

RAMBOLL

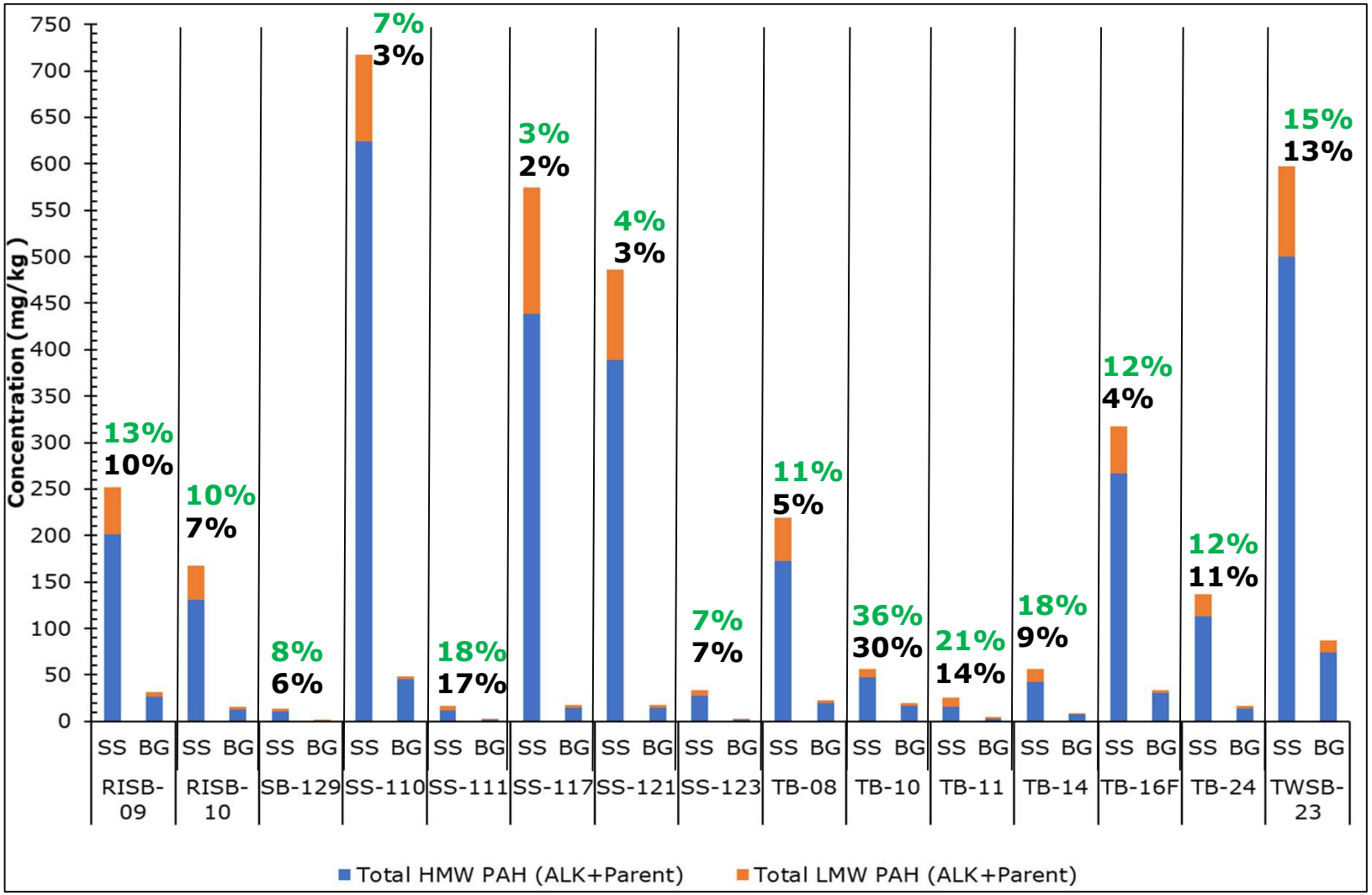
Map Design: SAO, Date: 6/1/2021

# HMW PAH HQs Greater than 1 Using Ecological Soil Screening Level for Invertebrates

Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
3-3

Project: 1690019547




- % = Percent
- ALK = Alkylated
- BG = Belowground Invertebrate
- LMW = Low molecular weight
- HMW = High molecular weight
- mg/kg = Milligram per kilogram
- PAH = Polycyclic aromatic hydrocarbons
- SS = Surface Soil
- **Green font**: % Uptake of Total 17 HMW PAHs from SS to BG
- **Bold Black Font** = : % Uptake of Total 18 LMW PAHs from SS to BG

- Note: The total PAHs takes into account the missing PAHs not available for use in the OU2 food web model.

An evaluation of uptake from soil to the tissues of belowground invertebrates indicate the following:

- Only 2 to 30% of total 18 LMW PAHs soil concentrations accumulated into the tissues of earthworms
- Only 3 to 36% of total 17 HMW PAHs soil concentrations accumulated into the tissues of earthworms.

RAMBOLL integral engineering pc

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

UPTAKE COMPARISON OF SUM 35 PAHS FROM SOIL INTO BELOWGROUND INVERTEBRATES
Navassa OU2 Soil Invertebrate Technical Memorandum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
3-4

Project 1690019547

# APPENDICES