11.10 Former MGP Site, Michigan

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Note: State regulators and consultants used the draft ITRC Bioavailability in Contaminated Soil guidance to understand how to use arsenic bioavailability data in refining a risk assessment that meets Michigan regulatory requirements for risk evaluation.

11.10.1 Former Manufactured Gas Plant (MGP) Site History and Background

MGP operations began at this site in 1925 using a carbureted water gas manufacturing process that was considered cutting edge technology at the time. From 1951 through 2015, the site was used as a natural gas distribution operation center. During MGP operations, coal and coal ash were stored in piles on part of the northern portion of the site. Aerial photographs and soil boring information indicate that filling likely occurred at the northern portion of the site. A portion of the site is shown in Figure 11-11.

Figure 11-11. Former MGP site.
(Source: Courtesy TRC Corporation)

11.10.2 Total Arsenic Soil Investigations and Findings

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Elevated arsenic in shallow soil at the site is attributed to leaching from coal ash and fill material associated with historical site operations. The soil arsenic concentrations exceeded the Michigan generic soil direct contact criteria (DCC) of 37 mg/kg for nonresidential (NR) land use for a portion of the site (primarily within the northern portion of the site). The DCC is the Michigan cleanup criteria for combined incidental ingestion and dermal contact exposures to contaminated soil. Exceedances at the site were found primarily in the northern portion of the site in shallow soil samples collected from the sandy fill material that overlies the native clay-rich soil. The concentrations of total arsenic ranged from 2 to 270 mg/kg, with the highest site-wide concentrations of total arsenic in soil observed within the sandy fill material.

11.10.3 Site and Northern Portion of the Site Stratigraphy

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Data show that the soil encountered at much of the site is predominantly fill within the upper seven feet (consisting of crushed brick/concrete, cinders, metal, wood, and gravel in a sand matrix and, in some cases, fine to medium grained sandy fill). Beneath the fill, a fine to medium grained sand is present to a maximum depth of 13 ft bgs. In the northern portion of the site, the fill is predominantly sandy material present to depths ranging from 4 to 9 ft bgs. The shallow fill and sand-rich soil across the site is underlain by an extensive medium stiff to hard gray clay-rich soil that has been confirmed to a maximum depth of 24 ft bgs onsite and, based on deeper geotechnical borings in the area, likely extends to at least 75 ft bgs.

11.10.4 Total Arsenic Shallow Soil Site Conceptual Model

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The CSM developed for the site includes the following:

- *Background soil concentrations.* Site-specific background total arsenic soil concentrations were not established.
- *Shallow soil concentrations.* Soil total arsenic concentrations ranged from 0.3 to 270 mg/kg across the site. The 95% upper confidence limit on the mean (95% UCL) total arsenic concentration for the soil samples in the northern portion of the site was 67 mg/kg.
- *Soil type.* Anthropogenic soil is predominately sandy fill material. Based on soil boring logs, the clay content of the anthropogenic-affected soil was generally low.
- *Source of arsenic*. Based on site history, especially in the northern portion of the site, it is likely that the arsenic-affected material is related to coal storage, coal ash, or other fill generated during the former MGP operations. The sandy fill area and other isolated arsenic-affected areas were apparently impacted by arsenic leached from coal or coal ash, or other fill from MGP site operations.
- *Present and future land use.* Most of the site is now idle. The northwest portion of the site has remained as open field and woods. The site is currently zoned light industrial (nonresidential) and is expected to continue to be nonresidential.

11.10.5 Methodology Used for Establishing Site-Specific Relative Bioavailability (RBA)

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The generic DCC assume that total arsenic has a 100% bioavailability when ingested. However, studies performed at other sites have demonstrated that arsenic bioavailability in soil typically ranges between 5 and 50% (Roberts, et al. 2007 and USEPA, 2010). Based on its evaluation of available literature and field data, USEPA recommends a default RBA for total arsenic in soil of 60% (USEPA 2012d).

The site-specific RBA study focused primarily on the northern portion of the site to evaluate potential direct-contact risk derived from the measured bioavailability of arsenic within the shallow soils. Soil samples (18 total) were collected from the areas where historical sampling had shown elevated concentrations of total arsenic. Blind duplicate soil samples were collected from two locations for quality assurance/quality control. The soil samples were analyzed for total arsenic using USEPA method 6010B and bioaccessible arsenic using in vitro testing following the Solubility/Bioavailability Research Consortium (SBRC) Appendix C Revision #8 gastric method to provide the IVBA percent arsenic data.

The IVBA results were then used to calculate the final arsenic RBA for each soil sample using the following in vivo – in vitro correlation model (Bradham et al. 2011):

$$\text{RBA (\%)} = 0.72 \times \text{IVBA (\%)} + 5.64$$

Three of the soil samples that had total arsenic concentrations below the generic residential DCC (7.6 mg/kg) were not included in the bioavailability evaluation. The remaining 15 soil samples had total arsenic soil RBAs ranging from 7.32 to 28.33% with a mean of 15.76%. The 95% UCL of 20% was calculated using the ProUCL Version 5.0 statistical software (USEPA 2016d). The site-specific RBA (maximum or 95% UCL) is well below the USEPA default of 60%.

RBA was used in two ways to establish NR DCC. A Tier 2 approach considered exposure over the entire site (including the less contaminated areas). Because this dataset was heavily weighted to arsenic-affected shallow soil samples collected from the northern portion of the site, the USEPA default RBA was used to conservatively calculate a Tier 2 site-wide soil NR DCC. For the northern portion of the site, the site-specific RBA was used to establish a Tier 3 NR DCC.

11.10.6 Tier 2 and 3 Arsenic NR DCC Calculation

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In Michigan, modifying the generic nonresidential DCC to include an RBA parameter in the ingestion part of the DCC equations renders the criterion a site-specific criterion. For calculating the site-wide Tier 2 and North Area Tier 3 NR DCC, the best available information for toxicity values and exposure assumptions (for example, oral cancer slope factor, ingestion absorption efficiency, dermal absorption efficiency, soil ingestion rate and other exposure assumptions) were considered in accordance with state statutory requirements.

The USEPA default RBA (60%) was used with the oral toxicity values (oral cancer slope factor and oral reference dose) to calculate a Tier 2 NR DCC. Using the 20% RBA established for the northern portion of the site, a Tier 3 NR DCC was calculated. (The equations and assumptions used are available upon request.) Table 11-7 includes the results of the calculations.

Table 11-7. Calculated NR DCC using various RBA values

RBA Value	NR DCC	DCC Value (mg/kg)
100%	Generic	37
Site wide, 60%	Tier 2	74
North Area, 20%	Tier 3	130

11.10.7 Analysis and Conclusions

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Using the USEPA default RBA of 60% resulted in a sufficiently conservative Tier 2 NR DCC for the whole site. The Tier 3 NR DCC for the northern portion of the site was calculated using a 95% UCL on the mean RBA from 15 soil samples collected from an area of elevated arsenic concentrations. The RBA samples were biased high and the number of soil samples is considered a robust data set that supports the calculated Tier 3 NR DCC.

The site arsenic concentrations outside the northern portion of the site did not exceed the Tier 2 NR DCC. The 95% UCL on the mean arsenic concentration for soil samples in the northern portion of the site (67 mg/kg) was below the Tier 3 NR DCC. The use of site-specific RBA in developing the soil criterion reflected a more refined risk assessment of arsenic using best available science and resulted in a level of risk that is acceptable and in compliance with Michigan statutes and regulations.

11.10.8 Uncertainty Analysis

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The uncertainties relating to the RBA estimate and the site-specific DCC were reduced by the following actions:

- The IVBA method used is a validated method recommended by USEPA. The Bradham model was selected for its high correlation compared to other models.
- The number of soil samples (15) was considered robust. The use of 95% UCL on the mean RBA is consistent with the Reasonable Maximum Exposure scenario required for human health risk assessments by explicitly considering uncertainty in the estimated mean (and biasing the estimate high).
- Tiered evaluation allowed the identification of the northern portion of the site as the hot spot. Using USEPA default RBA (60%) to calculate a Tier 2 criterion for the site-wide evaluation led to a sufficiently conservative assessment. Using RBA based on soil samples from the northern portion of the site refined the RBA estimate and maintained its conservatism since the soil samples are biased to soils with elevated arsenic levels.
- Bioavailability is reported to be higher in sandy type soils due to their low binding capacity. The northern portion of the site is a predominately sandy fill material. Therefore, the site-specific RBA was based on the most conservative soil type for bioavailability assessment, meaning that changes to the existing soils (such as mixing in clay) would likely reduce the RBA to values even lower than those measured in the site-specific testing.