



Ecological Risk Assessment of Contaminated Offshore Sediments in Ashland, Wisconsin

A publication of the Hazardous Substance Research Centers' Technical Outreach Services for Communities (TOSC) Program.

Hazardous Substance Research Centers

The five regional Hazardous Substance Research Centers were established in 1989 and funded by the U.S. Environmental Protection Agency (U.S. EPA). The Centers' mission is to support and conduct innovative research and technology development in hazardous substance control, cleanup and management. The Centers have an interdisciplinary group of knowledgeable scientists and engineers who can offer technical advice, review sites, and help increase understanding of hazardous contamination.

For more information visit www.toscprogram.org or call 1-800-490-3890.



The Great Lakes & Mid-Atlantic Center is a consortium of the University of Michigan, Michigan State University and Howard University

BACKGROUND

In April 1998, Short Elliott Hendrickson, Inc. (SEH), under contract from Wisconsin DNR, completed an ecological risk assessment (ERA) for sediments offshore from the Northern States Power (NSP) property in Ashland, Wisconsin. The sediments are contaminated with polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). SEH concluded there is a high probability of adverse effects to aquatic organisms from contaminated sediments at the Ashland site. NSP has questioned the methods used in the SEH study and the study's conclusion that nearly 10 acres of sediments should be dredged from Lake Superior. In October 1999, NSP released an ERA conducted by Dames and Moore (D&M) which concluded there was a low probability of effects on organisms at the Ashland site, and that the area requiring remediation is smaller than that identified by SEH.

At the request of Ashland citizens groups, the TOSC program conducted an independent review of the SEH and D&M ecological risk assessments, with particular focus on findings and methodology. TOSC examined the major areas of disagreement between the SEH and D&M reports on the basis of:

- Adherence to the U.S. EPA guidelines for conducting ERAs
- Likely source of contaminants
- Assumptions regarding exposure of organisms to contaminants

- Choice of biological species and tests used to assess ecological effects
- Appropriate use of toxicological models and statistics
- Probability of long-term effects on organisms
- Validity of conclusions

ERA GUIDELINES

The U.S. EPA has published guidelines for conducting ERAs (see *Ecological Risk Assessment: A TOSC Environmental Brief*). The EPA guidelines provide a framework that promotes scientifically sound decisions, the appropriate choice of endpoints, and adherence to risk management goals. The ERAs conducted by both SEH and D&M followed the basic EPA outline. However, the assessment prepared by SEH more closely adhered to the EPA guidelines. D&M did not address several issues related to data sampling in its assessment because it relied on data gathered for the SEH assessment. Because the SEH assessment addressed issues such as data quality objectives and the sampling plan, it is considered a more comprehensive assessment.

MEASUREMENT ENDPOINTS

During this phase of the ERA, the impacts of contaminants on ecological integrity are quantified using *measurement endpoints*, which can include quantitative measures of exposure to contaminants, effects on organisms,

This document summarizes the TOSC Program report "Review of Short Elliott Hendrickson, Inc. and Dames & Moore Ecological Risk Assessments of Contaminated Offshore Sediments in Ashland, Wisconsin." Dr. Christopher Marwood, a Post-Doctoral Research Fellow at Miami University is the author of both documents.

and ecosystem characteristics.

In the SEH assessment, a number of measurement endpoints were chosen to assess PAH effects on sediment-dwelling (benthic) organisms, aquatic invertebrates (zooplankton), and fish. A survey of the benthic community was conducted, to compare populations of organisms in contaminated sediment versus clean sediment. The toxicity of the contaminated sediment to benthic organisms, zooplankton, and fish was examined in laboratory experiments.

Because D&M chose not to take additional measurements, the endpoints used in its assessment were the same as those used by SEH. However, discrepancies between the two ERAs arose because very different techniques were used to compare the endpoints to the known concentrations of PAHs in the sediment at the Ashland site.

EXPOSURE CHARACTERIZATION

The exposure of organisms to PAHs was estimated by comparing the PAH concentrations in the sediment with benchmark concentrations known to produce adverse effects at other contaminated sites. SEH used benchmarks for toxicity to the aquatic organism *Hyaella azteca* using contaminated sediments from various sites around the Great Lakes. SEH compared the PAH concentrations in Ashland sediments with those benchmarks and determined that for most of the sediment samples taken, PAH concentrations were as great as, or greater than those which have been shown to be lethal to *Hyaella*.

D&M characterized exposure using a mathematical model. The model used known chemical properties, such as solubility in water and

chemical structure to estimate the toxicity of each PAH. D&M then summed the estimated toxicity of each PAH, and compared them to the concentrations in the Ashland sediment. In the D&M assessment, it was stated that few sediment samples from Ashland contained PAHs at concentrations greater than those that cause mortality in 25% of organisms, so there is minimal risk to organisms. However, a careful examination of the D&M calculations revealed several deviations from the model and mathematical errors in calculations. When the calculations were performed correctly, the model estimated substantial toxicity to organisms from PAHs in all but a few sediment samples, a result similar to SEH's findings.

ECOLOGICAL EFFECTS CHARACTERIZATION

SEH characterized potential ecological effects of PAHs on organisms using several types of analyses. A benthic community survey revealed that the abundance and species diversity of sediment-dwelling organisms was lower in contaminated sediment versus clean sediment. Laboratory experiments were performed to measure the toxicity of sediments to various freshwater species under controlled conditions. SEH found exposure to PAH-contaminated sediments caused mortality or reduced growth in all species. Despite the compelling results of the benthic survey and the laboratory toxicity studies, D&M chose not to use those results in its ERA. D&M considered the survey and laboratory experiments flawed due to variability in the results.

SEH found much greater toxicity from sediments when organisms were also exposed to ultraviolet (UV) radiation at levels similar to those present in the lake from

sunlight. D&M stated the exposures to PAHs in the presence of UV radiation were not representative of conditions at the site, and did not include those results in its ERA. However, many other studies with PAH contaminated sediments have demonstrated severe toxicity to aquatic organisms from PAHs in sunlight. Therefore, PAH photoinduced toxicity from solar UV is likely occurring at Ashland.

RISK CHARACTERIZATION

SEH used a triad approach to estimate the risk from PAHs in Ashland sediments: evidence from the comparison of PAH levels to benchmarks, the benthic community survey, and the laboratory experiments were considered in a "weight-of-evidence" manner. SEH concluded that based on those three lines of evidence, the ecological effects of contaminated sediments offshore from Ashland are likely severe.

Because D&M disregarded the benthic survey and laboratory experiments, its risk characterization was based entirely on the flawed results of its analysis, as described under *Exposure Characterization* above. The exclusion of those results seriously compromised the assessment. D&M does not provide justification for its conclusion that only minimal risk exists to aquatic organisms from exposure to PAHs in Ashland sediments.

CONCLUSIONS

The ecological effects of PAHs in contaminated sediments offshore from Ashland are likely severe. The concentrations of PAHs measured in the sediments are similar to other contaminated sites in which severe impacts have been documented. Because PAHs tend to remain bound to sediments, sediment-dwelling or burrowing organisms

are at the greatest risk. The benthic survey conducted by SEH indicated there are likely substantial impacts to the sediment-dwelling community (>20% reduction in abundance) from the contaminated sediments. Aquatic organisms that reside in the water column only

(e.g., fish) are likely to receive less exposure to the sediment-bound PAHs, and are at less risk. However, exposures conducted in the laboratory indicate PAHs liberated from sediments are also toxic to aquatic organisms, due to photoinduced toxicity. Because

PAHs are metabolized by bacteria very slowly, the recovery of ecological integrity in the sediments offshore from Ashland will not likely occur through natural processes.

Methods, findings and conclusions of two ecological risk assessments

Issue	Short Elliott Hendrickson	Dames & Moore
PAH source	Former MGP on NSP site.	Undetermined.
Chemical analysis	1998 sediment PAH concentrations (fewer samples).	1998 data plus 1996 data (more samples but incomplete).
Calculation of exposure	PAH concentration vs. benchmark.	PAH concentration vs. model estimate.
Toxicity to benthic organisms	Survey indicates degraded benthic community.	High variability in data; not enough data points to demonstrate a trend.
Toxicity to aquatic organisms	Laboratory exposures demonstrated toxicity of sediments to fish, amphipods, oligochaetes, cladocerans and midges.	Experiments were flawed, data suggests moderate toxicity at best.
Phototoxicity	UV phototoxicity indicated greater toxicity in sunlight.	Experiments not representative of conditions at site.
Calculation of risk	Triad approach (chemical analysis, benthic survey, laboratory exposures).	Based on chemistry data only.
Area of impact	Large. Most sediment samples taken from bay were toxic.	Smaller area.
Recovery	Recovery unlikely.	Recovery possible.

This report has been prepared by the Technical Outreach Services for Communities (TOSC) Program at Michigan State University. Funded under grant from the U.S. Environmental Protection Agency, TOSC provides independent technical assistance to communities with contaminated sites. No endorsement of the report by U.S. EPA should be inferred.

Inquiries should be directed to:
 Kirk Riley, Program Manager
 B-100A Research-Complex-Engineering
 Michigan State University
 East Lansing, MI 48824
 (517) 355-7493
 rileyki@egr.msu.edu