Benthic Toxicity Evaluation:
Improving and Streamlining Dredged Material Testing and Evaluation

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Conceptual Model

*Benthic Toxicity Evaluation*

• One of the pathways considered in open water placement
  ➢ Still consider elutriate toxicity
  ➢ Still consider bioaccumulation

• Evaluate potential of DM disposal for adverse effects on benthic organisms

• Implications
  ➢ Test failure could require upland placement (e.g., CDF) or other alternative management option
Assess potential for toxicity of DM following open water disposal

Concerned with toxicity from direct contact with DM at placement site

Will DM placement result in an unacceptable risk at the placement site?

All benthic toxicity evaluations occur in Tier 3
Benthic Toxicity Evaluation

- Sediment Quality Guideline values are numerical chemical concentrations intended to be protective of biological resources.
- Include empirical and mechanistically derived values.
- ER-L/ER-M.
- TEL/PEL.
- AET.
- EqP approach for nonionic organics and metals (e.g., AVS-SEM).
- Sediment chemistry is compared to SQG values and the potential for effects is determined.
Benthic Toxicity Evaluation
(Reference Sediment)

• Reference Sediment provides point of comparison for DM toxicity evaluations

• Reference sediment should reflect conditions at disposal site in absence of disposal activity (as practicable as possible)

• Possess physical characteristics similar to DM (e.g., grain size, organic carbon)

• Not be collected in the vicinity of spills, outfalls, or other significant sources of contaminants (i.e., substantially free of contaminants)

• Be subject to the same hydrologic influences, within the limits of what is practicable, as the disposal site

• Selected reference must be compatible with benthic organisms used in testing (e.g., grain size, TOC, etc.)
Benthic Toxicity Evaluation
(Control Sediment)

• Control Sediment used to assess the acceptability of a toxicity test
• Confirms the biological acceptability of test conditions and organism health
• May be sediment in which the organism was collected or cultured
• Carried through testing procedures in an identical manner as test sediments
• Excessive mortality in control sediment suggests a problem with the test and can invalidate results
Benthic Toxicity Testing Summary

- Conduct whole-sediment toxicity tests
- Compare DM to reference sediment
- Survival of organisms as toxicological endpoint
Benthic Toxicity Test Design

- Short-term exposure (typically 10 days)
- Measure survival
- Recommend testing with at least two species
- Feeding is test dependent
- Minimum 5 replicates/ treatment
- Test validity based on survival in control sediment
Test Species Selection

• Species representing three life history strategies (burrowing organism, deposit feeder, and filter feeder)

• If only two different species are used, they should together cover the three life history strategies
Test Species Selection

• Other factors to consider:

  ➢ High responsiveness to contaminants
  ➢ Low responsiveness to non-contaminant effects (e.g., grain size)
  ➢ Standardized protocol
  ➢ Ecologically relevant (e.g., infaunal)
  ➢ Availability (e.g., amenable to culturing)
Marine/Estuarine Species (Amphipods)

- *Leptochirus plumulosus*
- *Ampelisca abdita*
- *Eohaustorius estuarius*
- *Rhepoxynius estuarius*
Marine/Estuarine Species
(Other Invertebrates)

Polychaete

Neanthes arenaceodentata

Mysid Shrimp

Americamysis bahia
Freshwater Species

Amphipod

Hyalella azteca

Midge

Chironomus dilutus
Data Evaluation

• Is mortality in dredged sediment 10% greater than reference (20% for marine/estuarine amphipods), and statistically different from reference?
  ➢ If No, material is not predicted to be toxic
  ➢ If Yes, material is predicted to be toxic
Data Evaluation

• Example Calculation #1:
  ➢ Freshwater amphipod survival in Sediment A equals 75% and IS statistically different from the reference
  ➢ Reference sediment survival equals 86%
  ➢ Material is predicted to be toxic (i.e., mortality greater than 10% different and statistically different from reference)

• Example Calculation #2:
  ➢ Marine amphipod survival in sediment B equals 74% and IS statistically different from the reference
  ➢ Reference sediment survival equals 87%
  ➢ Material is not predicted to be toxic (i.e., statistically different but mortality does not exceed the reference by 20%)
Tier 4 Evaluations

• Case specific studies designed to address uncertainties that must be resolved to reach a decision
  ➢ Implemented when Tier III toxicity tests do not provide adequate information for a risk based decision
  ➢ Includes advanced sediment evaluations (i.e., chronic sublethal toxicity tests, sediment toxicity identification evaluations, etc.)

• Occurrence is rare
Confounding or Non-contaminant Factors

• Toxicity not always due to CoC
  ➢ Sediment grain size (clay, sand, etc.)
  ➢ Salinity
  ➢ Ammonia
  ➢ Nutrition (TOC as an indicator)
  ➢ Low moisture content
  ➢ Should evaluate potential for non-contaminant effects prior to testing when possible (e.g. site historical grain size, TOC, ammonia, etc.)
Identifying Confounding or Non-contaminant Factors

• Evaluate sediment chemistry (e.g., SQGs, etc.) to ensure a contaminant is not cause of toxicity

• Perform factor specific identification procedures:
  - Ammonia: perform ammonia reduction procedures (e.g., water exchanges, TRE with zeolite, alternate organism, etc.).
  - Nutrition: re-test with minimal feeding or re-test concurrently with alternate approved organism
  - Grain size: re-test concurrently with alternate approved organism with tolerance for grain size range observed

• TRE/TIE as component of side by side re-tests with same or alternate approved organism to demonstrate toxicity is likely not due to a contaminant

• MUST consult oversight agency (e.g., USACE and EPA) if pursuing methods to identify or eliminate the influence of confounding factors
Conclusions

• Main Goal: Evaluate potential of DM to cause adverse effects on Benthic organisms

• Process: Evaluate toxicity test data with consideration of confounding factors to determine risk associated with DM disposal

• Procedure: Follow tiered process only as far as necessary to make a risk based decision