Benthic Toxicity Evaluation:

Improving and Streamlining Dredged Material Testing and Evaluation

J. Daniel Farrar

US Army Engineer Research and Development Center

Environmental Laboratory

Vicksburg, MS

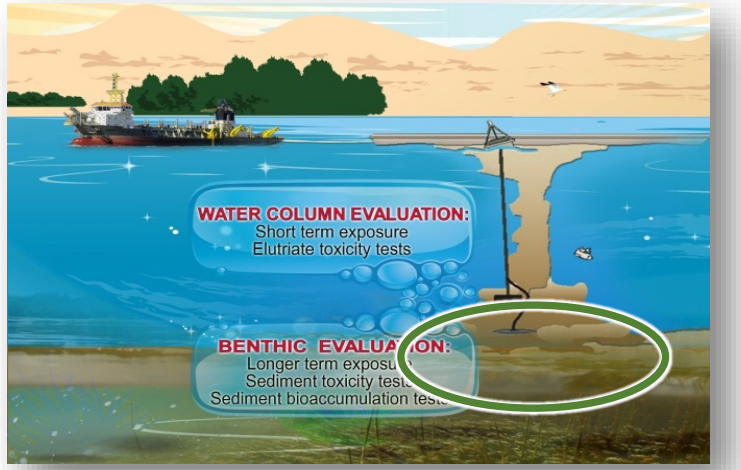
Daniel.Farrar@usace.army.mil

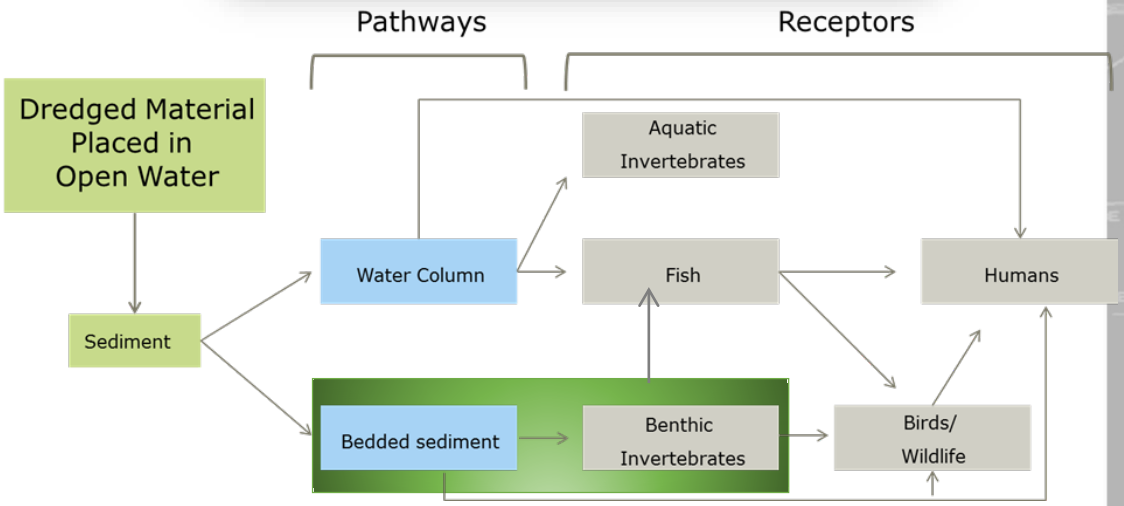
601-634-2118

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

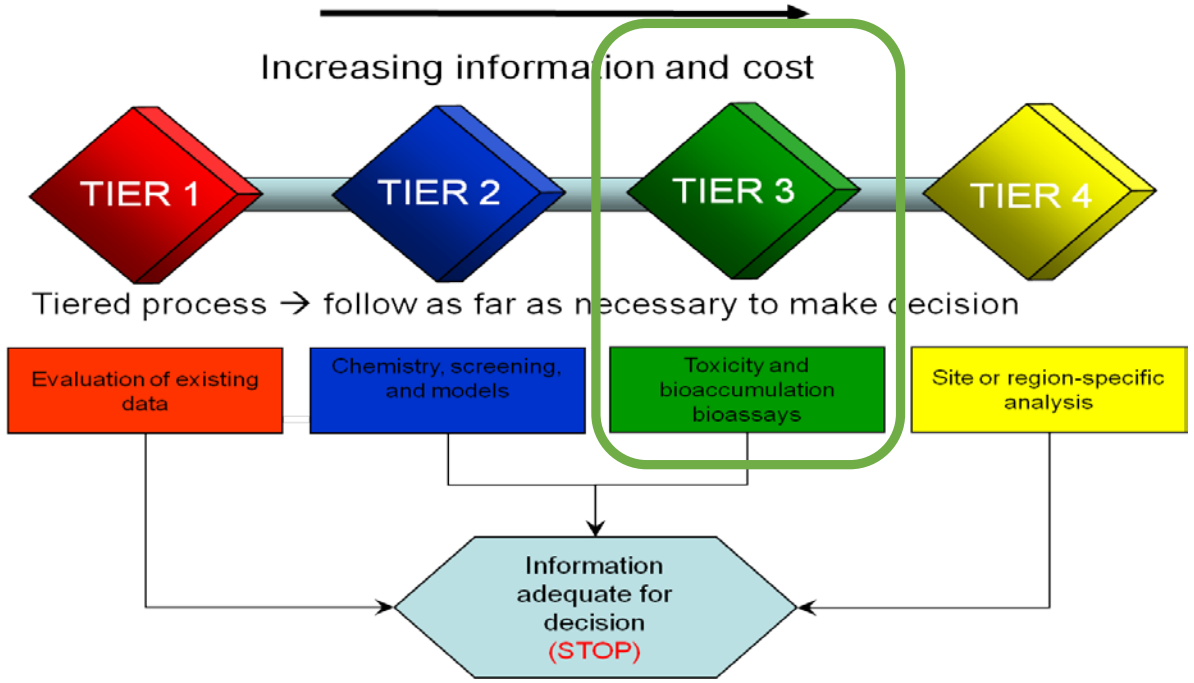




Benthic Toxicity Evaluation

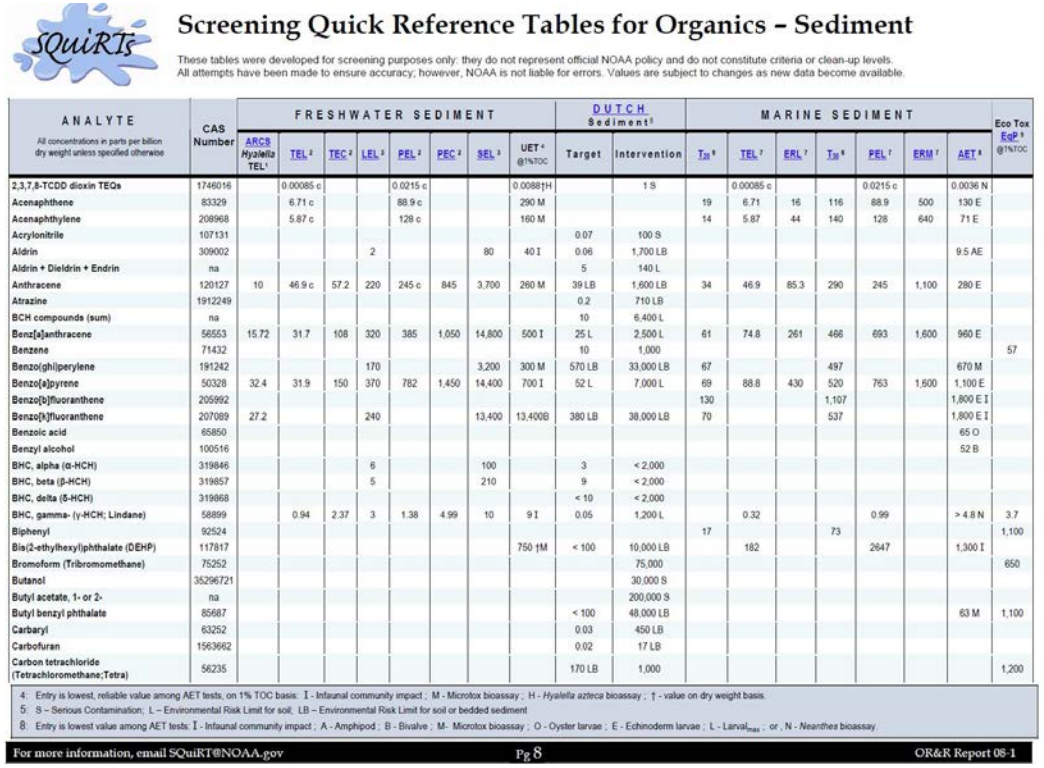
Main Discussion Points

- 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



Screening Quick Reference Tables for Organics – Sediment

These tables were developed for screening purposes only: they do not represent official NOAA policy and do not constitute criteria or clean-up levels. All attempts have been made to ensure accuracy; however, NOAA is not liable for errors. Values are subject to changes as new data become available.

ANALYTE (All concentrations in parts per billion dry weight unless specified otherwise)	CAS Number	FRESHWATER SEDIMENT							DUTCH Sediment[5]		MARINE SEDIMENT						Eco Tox EqP[9] @1%TOC
		ARCS *Hyalella* TEL[1]	TEL[2]	TEC[2]	LEL[3]	PEL[2]	PEC[2]	SEL[3]	UET[4] @1%TOC	Target	Intervention	TM[6]	TEL[7]	ERL[7]	TM[8]	PEL[7]	ERM[7]	AET[8]	
2,3,7,8-TCDD dioxin TEQs	1746016		0.00085 c			0.0215 c			0.0088†H		1 S		0.00085 c			0.0215 c		0.0036 N	
Acenaphthene	83329		6.71 c			88.9 c			290 M			19	6.71	16	116	88.9	500	130 E	
Acenaphthylene	208968		5.87 c			128 c			160 M			14	5.87	44	140	128	640	71 E	
Acrylonitrile	107131									0.07	100 S								
Aldrin	309002				2			80	40 I	0.06	1,700 LB							9.5 AE	
Aldrin + Dieldrin + Endrin	na									5	140 L								
Anthracene	120127	10	46.9 c	57.2	220	245 c	845	3,700	260 M	39 LB	1,600 LB	34	46.9	85.3	290	245	1,100	280 E	
Atrazine	1912249									0.2	710 LB								
BCH compounds (sum)	na									10	6,400 L								
Benz[a]anthracene	56553	15.72	31.7	108	320	385	1,050	14,800	500 I	25 L	2,500 L	61	74.8	261	466	693	1,600	960 E	
Benzene	71432									10	1,000								57
Benzo(ghi)perylene	191242				170			3,200	300 M	570 LB	33,000 LB	67			497			670 M	
Benzo[a]pyrene	50328	32.4	31.9	150	370	782	1,450	14,400	700 I	52 L	7,000 L	69	88.8	430	520	763	1,600	1,100 E	
Benzo[b]fluoranthene	205992											130			1,107			1,800 E I	
Benzo[k]fluoranthene	207089	27.2			240			13,400	13,400B	380 LB	38,000 LB	70			537			1,800 E I	
Benzoic acid	65850																	65 O	
Benzyl alcohol	100516																	52 B	
BHC, alpha (α-HCH)	319846				6			100		3	< 2,000								
BHC, beta (β-HCH)	319857				5			210		9	< 2,000								
BHC, delta (δ-HCH)	319868									< 10	< 2,000								
BHC, gamma- (γ-HCH; Lindane)	58899		0.94	2.37	3	1.38	4.99	10	9 I	0.05	1,200 L		0.32			0.99		> 4.8 N	3.7
Biphenyl	92524											17			73				1,100
Bis(2-ethylhexyl)phthalate (DEHP)	117817								750 †M	< 100	10,000 LB		182			2647		1,300 I	
Bromoform (Tribromomethane)	75252										75,000								650
Butanol	35296721										30,000 S								
Butyl acetate, 1- or 2-	na										200,000 S								
Butyl benzyl phthalate	85687									< 100	48,000 LB							63 M	1,100
Carbaryl	63252									0.03	450 LB								
Carbofuran	1563662									0.02	17 LB								
Carbon tetrachloride (Tetrachloromethane;Tetra)	56235									†70 LB	1,000								1,200

4: Entry is lowest, reliable value among AET tests, on 1% TOC basis: I - Infaunal community impact ; M - Microtox bioassay ; H - *Hyalella azteca* bioassay ; † - value on dry weight basis.
5: S – Serious Contamination; L – Environmental Risk Limit for soil; LB – Environmental Risk Limit for soil or bedded sediment
8: Entry is lowest value among AET tests: I - Infaunal community impact ; A - Amphipod ; B - Bivalve ; M- Microtox bioassay ; O - Oyster larvae ; E - Echinoderm larvae ; L - Larval$_{max}$; or , N - *Neanthes* bioassay.

For more information, email SQuiRT@NOAA.gov Pg 8 OR&R Report 08-1

https://response.restoration.noaa.gov/environmental-restoration/environmental-assessment-tools/squirt-cards.html

Benthic Toxicity Evaluation (Reference Sediment)

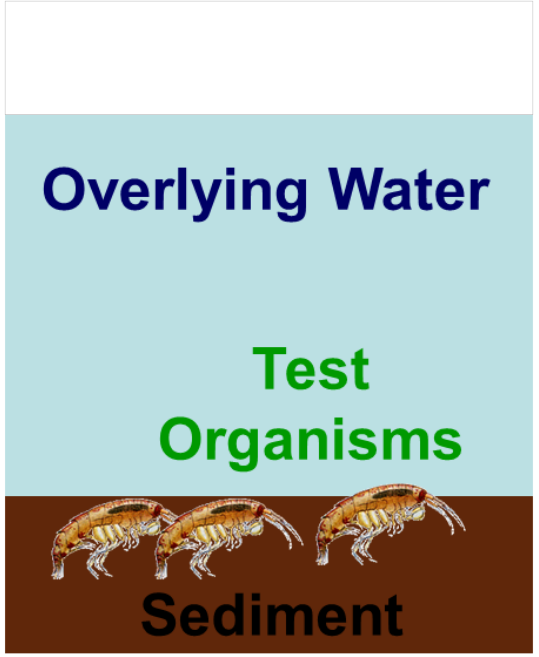
- Reference Sediment provides point of comparison for DM toxicity evaluations
- Reference sediment should reflect conditions at disposal site in absence of disposal activity (as practicable as possible)
- Possess physical characteristics similar to DM (e.g., grain size, organic carbon)
- Not be collected 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.)

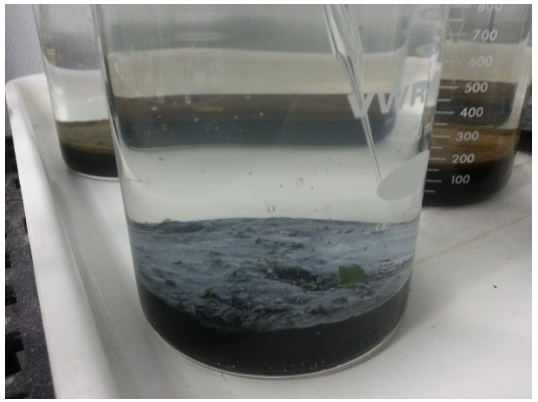
Benthic Toxicity Evaluation (Control Sediment)

- 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

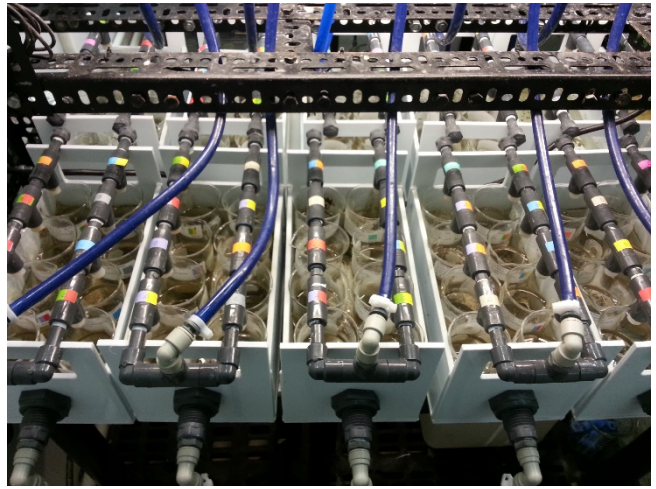
- Conduct whole-sediment toxicity tests
- Compare DM to reference sediment
- Survival of organisms as toxicological endpoint





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)

Leptocheirus 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)

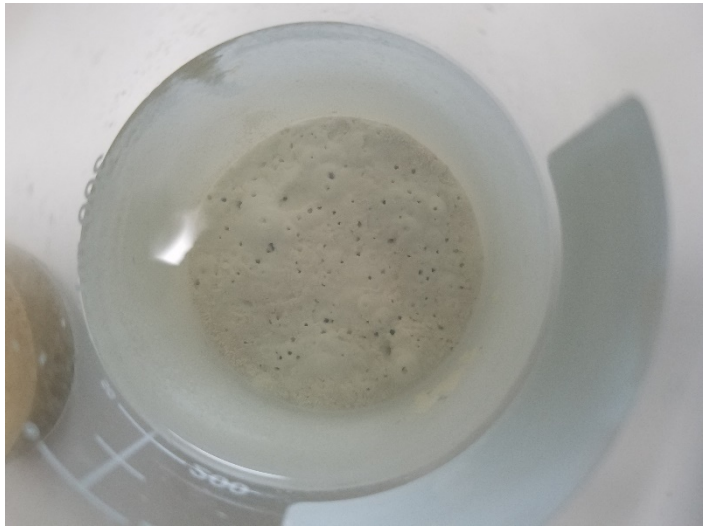
- Example Calculation #2:
  - Marine amphipod survival in sediment B equals 74% and IS statistically different from the reference
  - Reference sediment survival equals 87%
  - Material is not predicted to be toxic (i.e., statistically different but mortality does not exceed the reference by 20%)

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

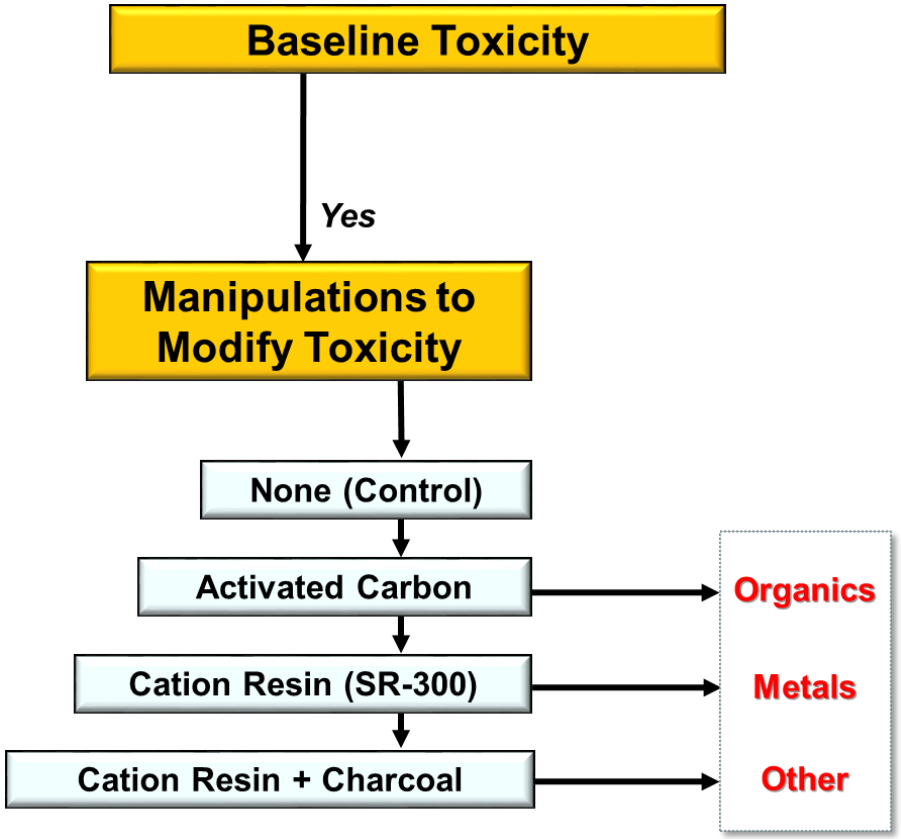
Confounding or Non-contaminant Factors

- 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