

Dredged Material Evaluation for HSC

**An Evaluation of the Suitability of Sediment
from Houston Ship Channel for Open Water
Placement**

**US Army Corps of Engineers
Galveston District and
Engineer Research and Development Center**

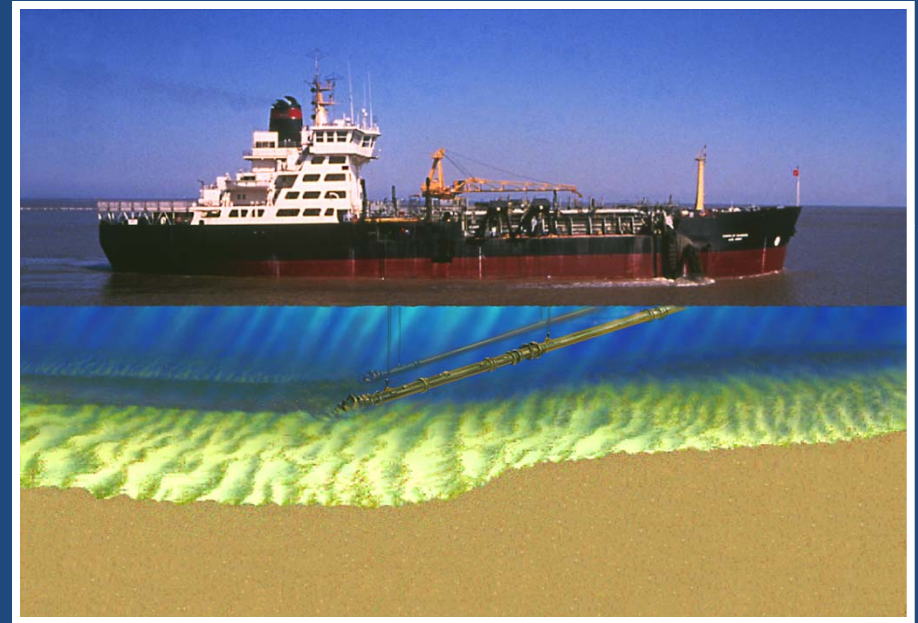
April 4, 2012

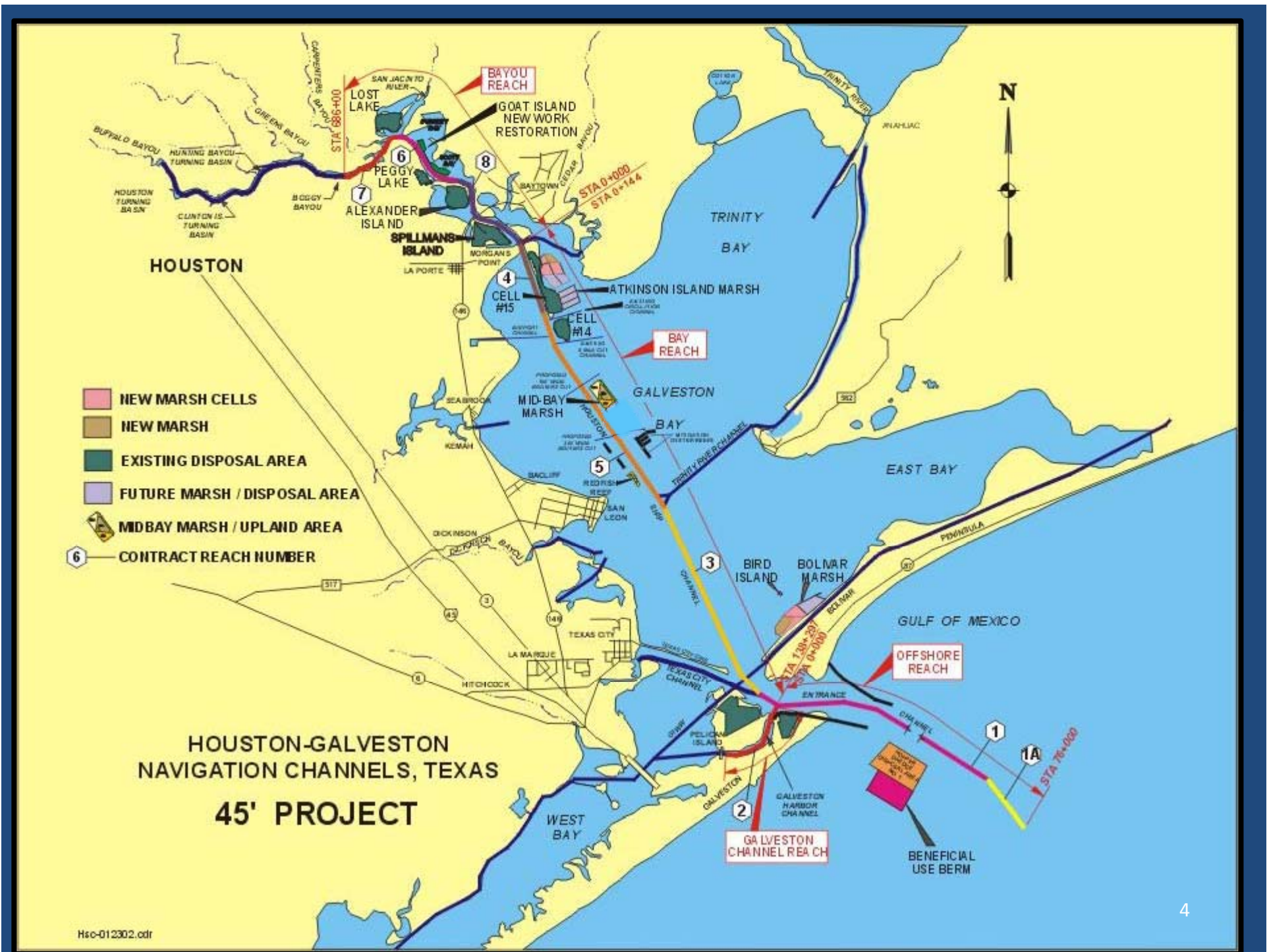
Introduction

1. Project information
2. Dredged material evaluation
(National and Regional Guidance)
3. Sampling and Evaluation
4. Results
5. Conclusions

Dredging Project Overview

- Maintenance Dredging of Galveston Harbor and Channel and Houston Ship Channel
- 2- 5M cubic yards dredged annually from the channels
- Placed upland, used beneficially, or placed at ocean site
- Placement regulated under Clean Water Act (CWA) and Marine Protection, Research, and Sanctuaries Act (MPRSA)

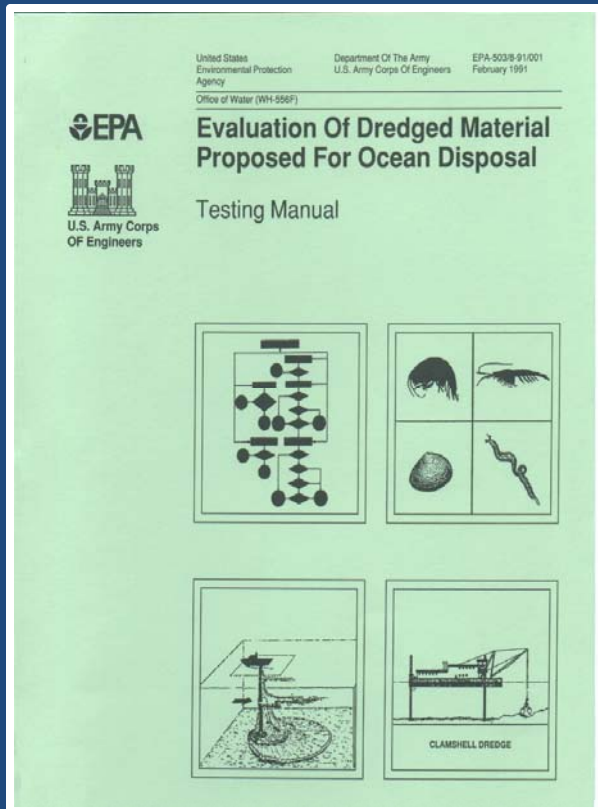




HOUSTON-GALVESTON
NAVIGATION CHANNELS, TEXAS
45' PROJECT

- NEW MARSH CELLS
- NEW MARSH
- EXISTING DISPOSAL AREA
- FUTURE MARSH / DISPOSAL AREA
- MIDBAY MARSH / UPLAND AREA
- 6 CONTRACT REACH NUMBER

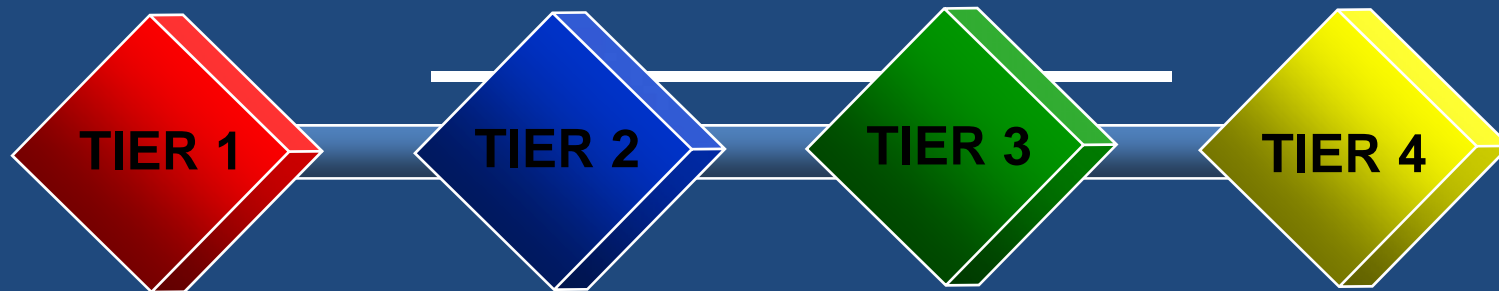
Ocean Testing Manual



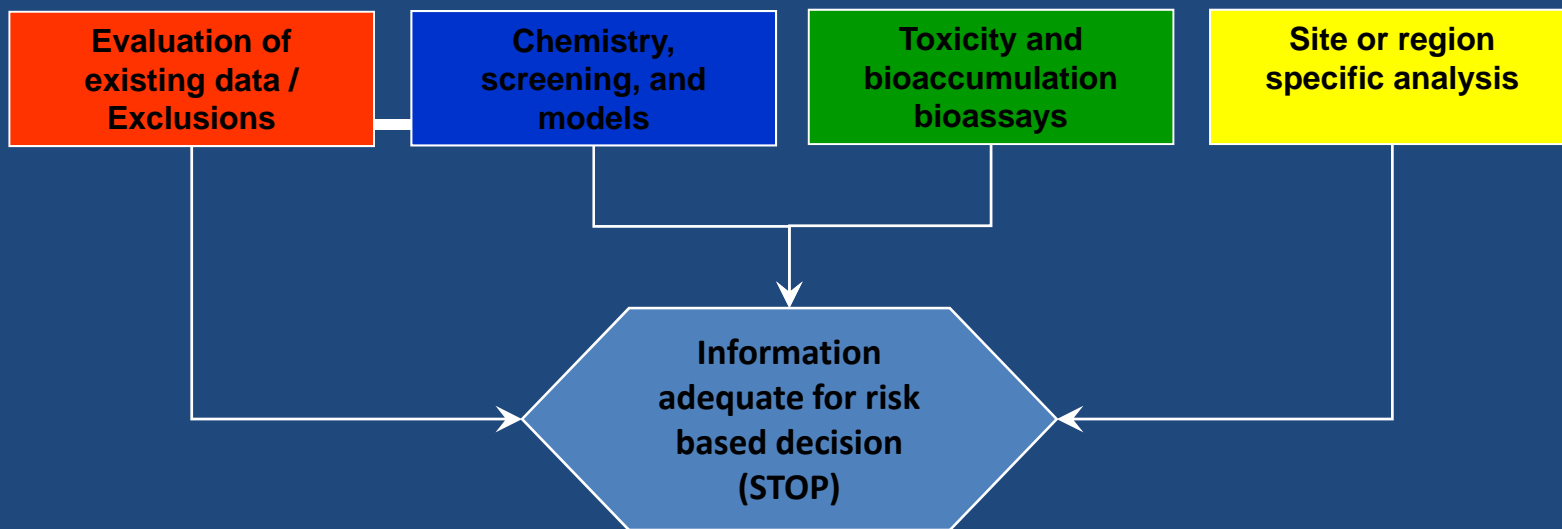
- Addresses MPRSA
 - Jointly regulated by USEPA and USACE
- Originally developed in 1977, updated in 1991
- Tiered Approach:
 - Effects-based testing
 - Bioaccumulation
 - Comparison to reference

DM placement in ocean will not
*“unreasonably degrade or endanger:
human health, welfare, or amenities,
marine environment, ecological systems,
or economic potentialities”*

A National Approach: 4 Tiered Procedure



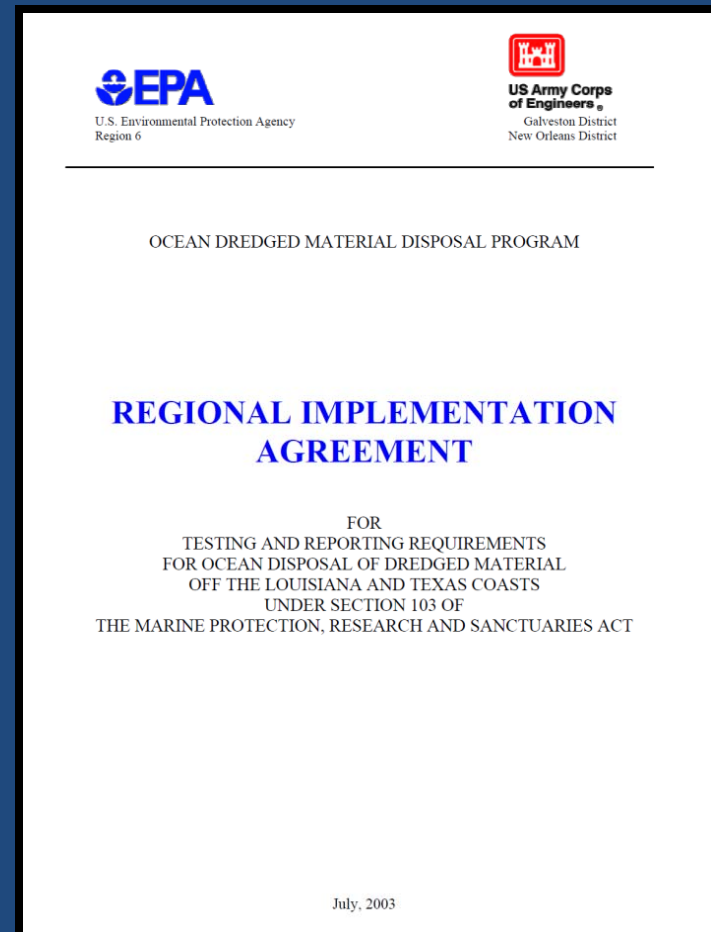
Tiered process → follow as far as necessary to make decision



Increasing complexity, information and cost

Regional Implementation Agreement

- Completed in 2003
- Region specific guidance
 - Joint agreement between EPA and USACE on approach and process
 - Exclusions
 - Sampling
 - Contaminants of concern
 - Bioassays
 - Interpretation of results– effects based and comparison to reference
 - Ocean disposal sites



Sampling

- Water and sediment collected
 - 49 channel sites, 6 placement area sites, and 3 Reference Area sample sites (58 total)
 - 15-16 September 2011
- Composited for analysis
 - Chemical analysis of sediment and water; 10 channel, 2 placement area sites and one reference site (13 total)
 - Elutriate and benthic toxicity and bioaccumulation bioassays; 9 channel sediment samples, reference, control (11 total)

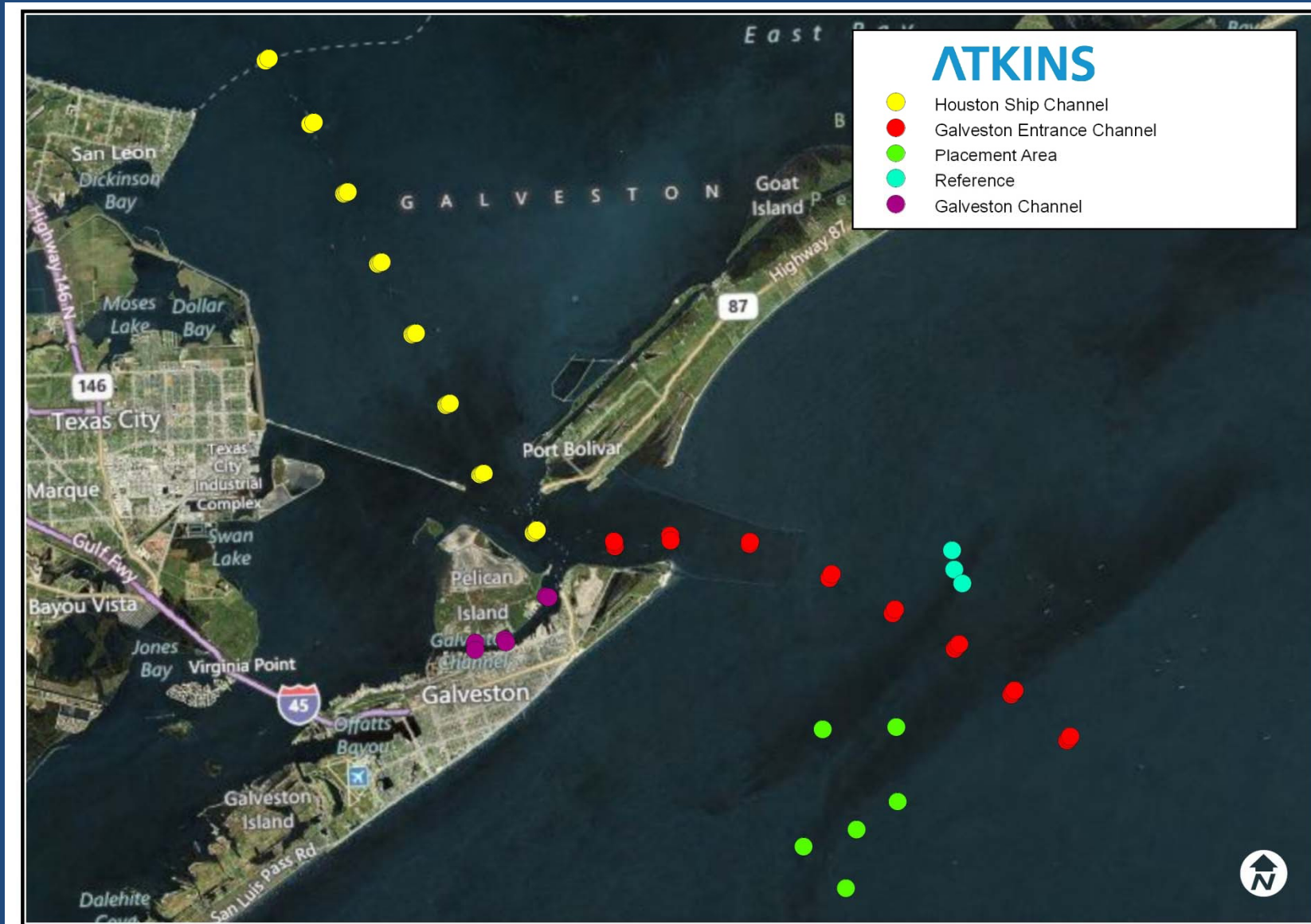
Analysis and Evaluation Approach

1. Chemical Analysis of sediment, water, elutriate
 - Metals, pesticides, PAHs, dioxin/furan congeners using TEQ; Previous EPA data (2009) suggested elevated TEQ
 - Use elutriate data to compare to water quality standards and sediment chemistry to support bioassay results
2. Toxicity Bioassay
 - Suspended particulate phase and solid phase
 - Compare to reference site
3. Bioaccumulation
 - Accumulation of chemicals and tissue analyzed; Same chemical analysis as sediments, include lipids
 - Compare to reference site



Sample Locations

Sample Groupings



Results - Sediment Analyses (total TEQ)

Sample Location Grouping	Min Conc. (pg/g)	Max Conc. (pg/g)
Houston Ship Channel	0.46	3.5
Galveston Entrance Channel	2.4	4.7
Galveston Channel	3.7	5.4
Reference Area	----	4.1
Placement Site	2.2	4.7
Background in NA Sediment	0.012	16.3

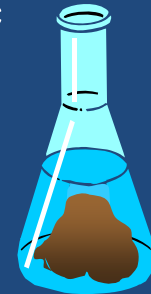
Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD) and Related Compounds (2004) Vol 2, Chap 3. Average concentration in sediments was 5.31 ± 5.83 pg/g.

Suspended Particulate Phase Bioassay

Test Design

- At least 3 concentrations
- control survival > 90%
- 5 replicates/10 organisms
- 48- to 96-hour duration

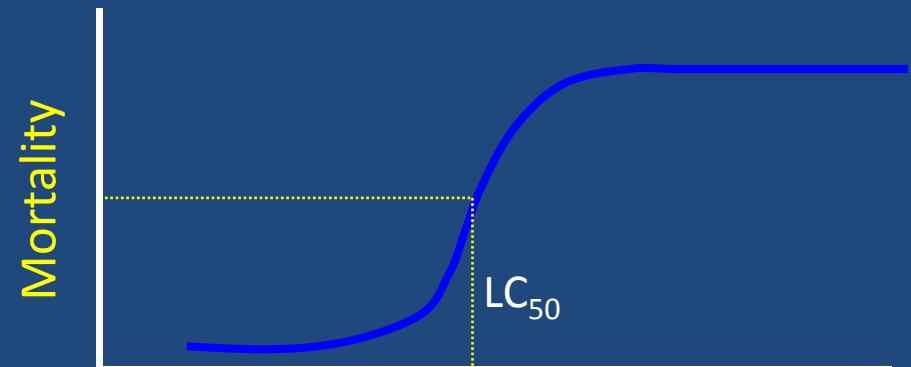
4 parts water *
1 part DM
(volume)



Americamysis bahia



Menidia beryllina



0



10



50



100

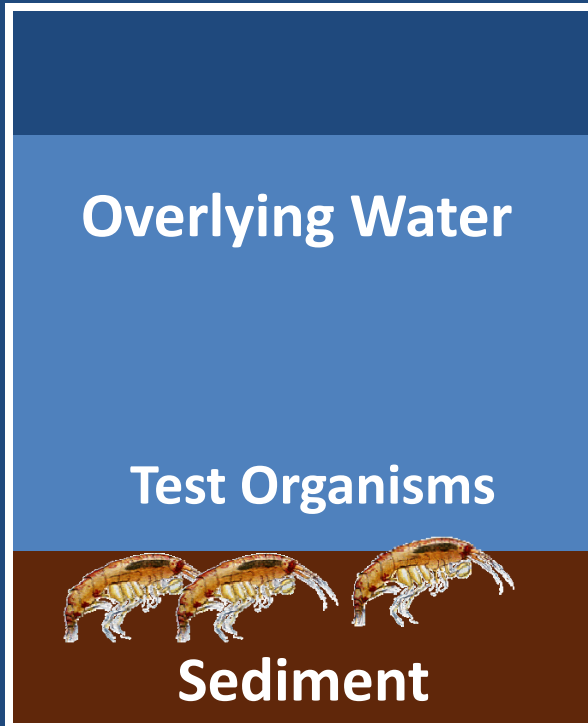
Percent Elutriate

Results - Suspended Particulate Phase Bioassay Survival (100% Test Solution)

Location	Test Species	Survival	
		Lab Control	DM Range
Houston Ship Channel	<i>A. bahia (juveniles)</i>	96 – 100	94
	<i>A. bahia (adults)</i>	92 - 96	94 - 98
	<i>M. beryllina</i>	96	92 - 98
Galveston Entrance Channel	<i>A. bahia (juveniles)</i>	92 - 98	90
	<i>A. bahia (adults)</i>	96 - 100	100
	<i>M. beryllina</i>	96 - 98	88 - 92
Galveston Channel	<i>A. bahia (juveniles)</i>	94 - 100	58 - 72
	<i>A. bahia (adults)</i>	96 - 100	22 - 90
	<i>M. beryllina</i>	96 - 100	6 - 92

After allowance for mixing at placement site, no significant effect from suspended particulate phase

Benthic Toxicity Bioassay



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



Leptocheirus plumulosus



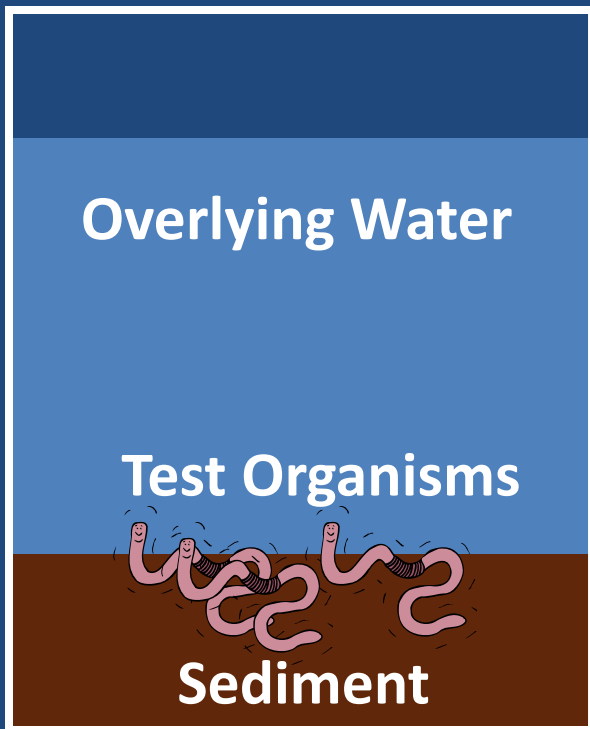
Americamysis bahia

Results – Benthic Toxicity Bioassay Survival (10-day)

Test Location	Test Organism	Sample Type		
		Control	Ref.	DM Range
Houston Ship Channel	<i>L. plumulosus</i>	97	100	95 - 97
	<i>A. bahia</i>	96	100	98 - 100
Galveston Entrance Channel	<i>L. plumulosus</i>	98	89	88 - 94
	<i>A. bahia</i>	100	91	88 - 96
Galveston Channel	<i>L. plumulosus</i>	97	93	90 - 98
	<i>A. bahia</i>	95	86	90 - 99

No Significant Reductions in Survival

Benthic Bioaccumulation Test



- Conduct whole-sediment bioaccumulation tests
- Compare DM to reference and control sediments
- Accumulation of chemicals of interest in organisms as endpoint



Macoma nasuta

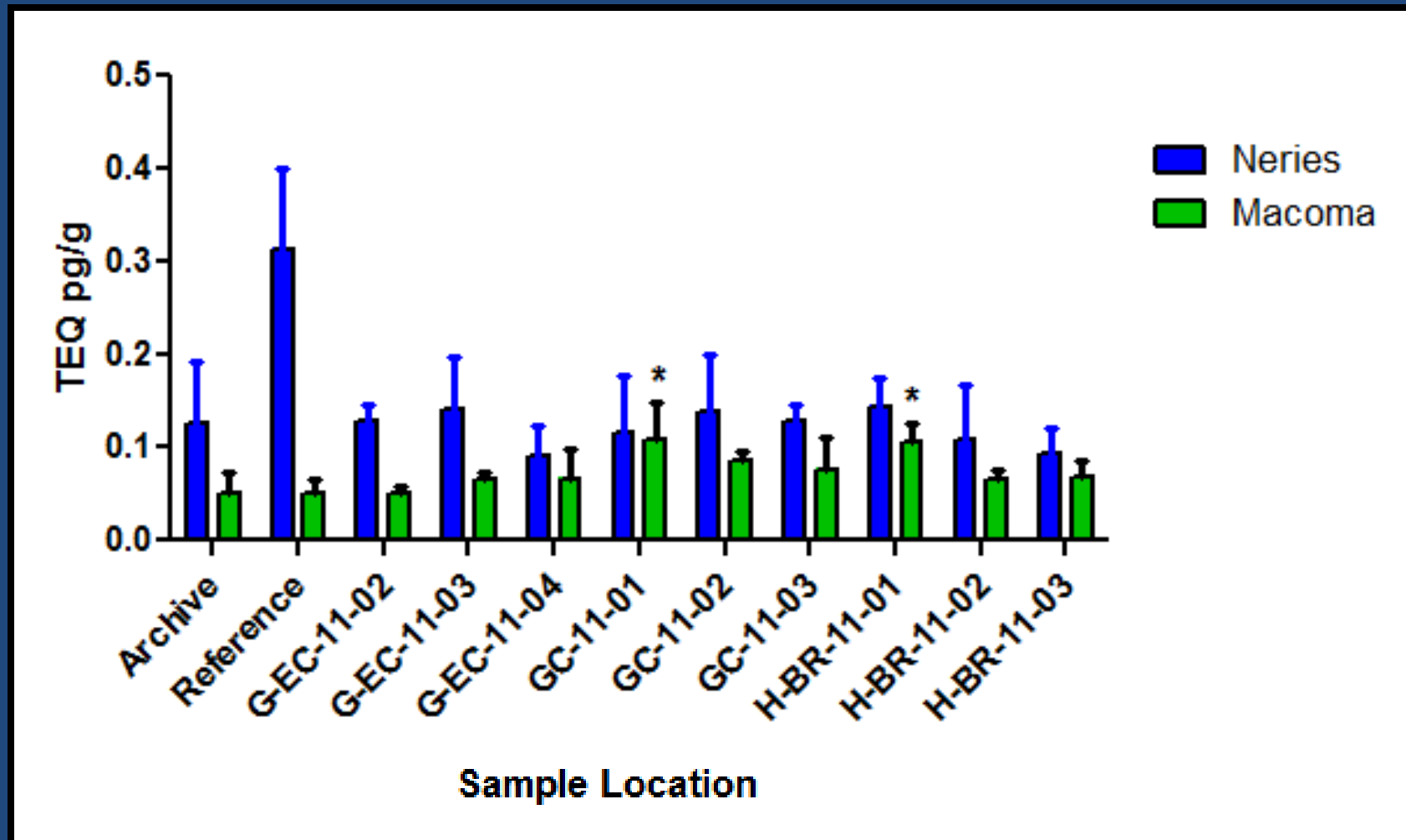


Nereis virens

Results - Bioaccumulation (28-day) Dioxin/Furans TEQs (pg/g)

Test Organism	Location	Sample Type		
		Archive	Ref	Sample
<i>N. virens</i>	Houston Ship Channel	0.124	0.314	0.092 - 0.144
	Galveston Entrance Channel	0.124	0.314	0.089 - 0.128
	Galveston Channel	0.124	0.314	0.116 - 0.138
<i>M. nasuta</i>	Houston Ship Channel	0.051	0.049	0.066 - 0.105
	Galveston Entrance Channel	0.051	0.049	0.051 - 0.067
	Galveston Channel	0.051	0.049	0.076 - 0.107

Results - Bioaccumulation (28-day) Dioxin/Furans TEQs (pg/g)



Dioxin Evaluation Team: EPA Region 6, EPA Region 2, and ERDC

- **Low levels of dioxins/furans (0.04 to 0.24 pg/g ww TEQ) were accumulated from project sediments, consistent with the sediment chemistry data**
- **TEQs of dioxins/furans accumulated by test organisms exposed to project sediment were comparable statistically to levels accumulated by organisms exposed to reference sediment**
- **Macoma in 2 test sediments (H-BR-11-01 and GC-11-01) was significantly greater than reference**

Next

Comparison of Statistically Significant TEQs Dioxins/Furans accumulated by *N. virens* and *M. nasuta* This Study to Ambient Coastal Concentrations

Study	Central Tendency (pg/g ww)	Range (pg/g ww)
Bivalve		
<i>M. nasuta</i> , all sites, this study	0.07 (median)	0.041 - 0.15
<i>M. nasuta</i> , GC-11-01, this study	0.11 (mean)	0.07 - 0.15
<i>M. nasuta</i> , H-BR-11-01, this study	0.11 (mean)	0.09 - 0.14
<i>M. nasuta</i> , GC-11-01, this study with SS correction factor (Kennedy, 2010)	NA	0.12 - 0.33
<i>M. nasuta</i> , H-BR-11-01, this study with SS correction factor (Kennedy, 2010)	NA	0.12 - 0.33
bivalve, SAD/Reg 4, S. Atlantic Bight	NA	0.32 - 0.36
bivalve, SAD/Reg 4, N. Gulf of Mexico	NA	0.16 - 0.19
Oysters, Karouna-Renier, 2007, Pensacola Bay, FL	0.9 (mean)	0.29 - 5.9
Worm		
<i>N. virens</i> , all sites, this study	0.12 (median)	0.05 - 0.24
<i>N. virens</i> , SAD/Reg 4, S. Atlantic Bight	NA	0.18 - 0.44
Polychaete, SAD/Reg 4, N. Gulf of Mexico	NA	0.31 - 0.63

Comparison of Statistically Significant TEQs Dioxins/Furans accumulated by *N. virens* and *M. nasuta* This Study to Ambient Coastal Concentrations

Study	Range (pg/g ww)
Bivalve	
<i>M. nasuta</i> , all sites, this study	0.041 – 0.15
<i>M. nasuta</i> , GC-11-01, this study	0.07 – 0.15
<i>M. nasuta</i> , H-BR-11-01, this study	0.09 – 0.14
bivalve, SAD/Reg 4, S. Atlantic Bight	0.32 – 0.36
bivalve, SAD/Reg 4, N. Gulf of Mexico	0.16 – 0.19

Joint US EPA and USACE Conclusion:

“Based on the above, the Dioxin Technical Team find these dioxin/furan levels reflect normal ambient concentrations and pose no regulatory concern specific to CFR 227.27. Further, absent a change in conditions, these data indicate that there is no need for future dioxin and furan testing in these project sediments.”

Take Home Messages

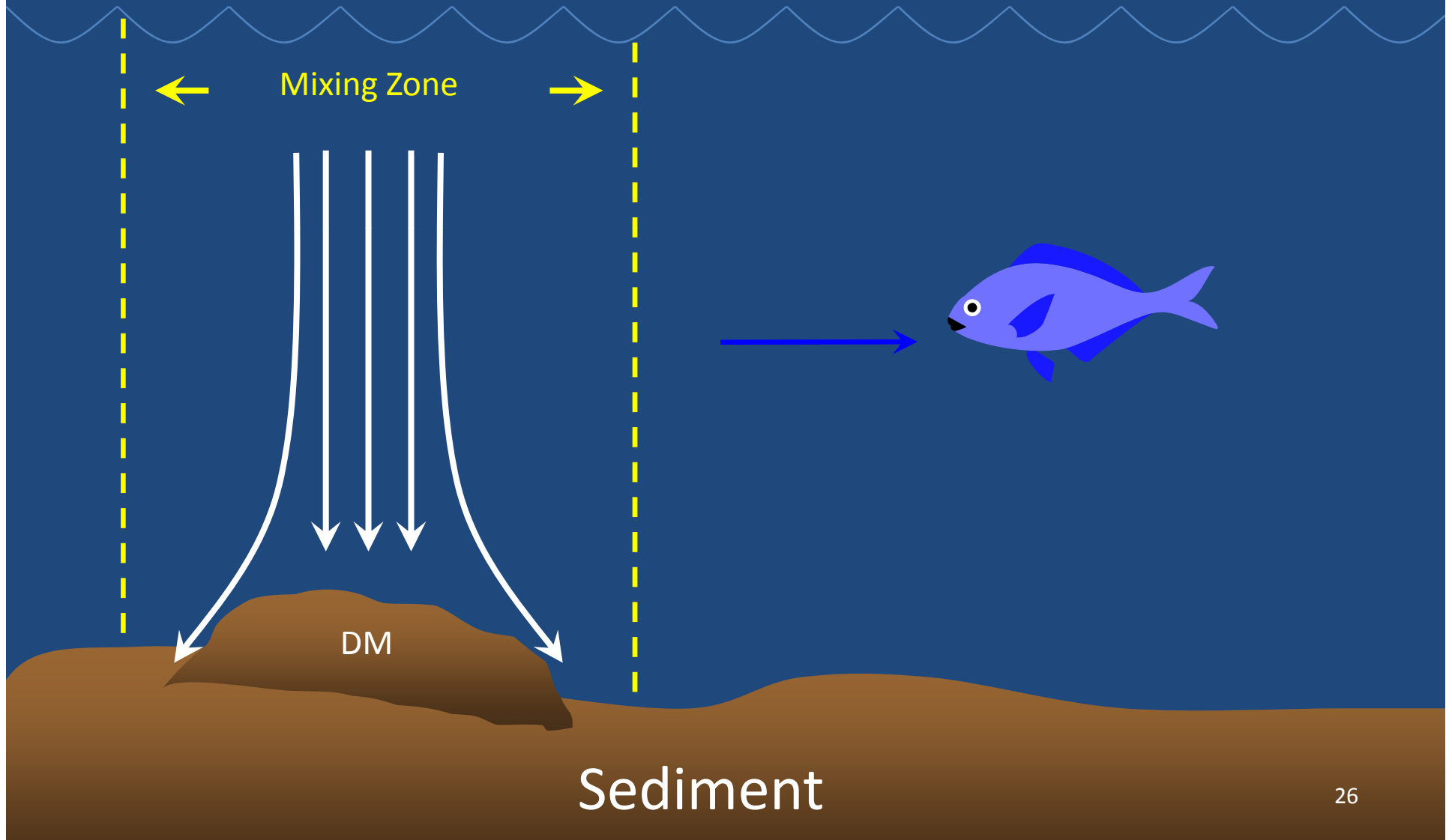
1. HSC maintenance dredging of sediments and placed upland, beneficial use, and ODMDS
2. Dredged material evaluation (Joint EPA/USACE National and Regional Guidance) is “effects-based”
3. Evaluation Results and Interpretation
 - Chemistry results = CoCs detected at low levels but only used to interpret bioassay results
 - Toxicity = no significant effects as determined using elutriate and benthic toxicity bioassay
 - Bioaccumulation = accumulation of dioxin/furan from these sediments reflected ambient Gulf of Mexico conditions

Additional Discussions

Elutriate Data Analysis

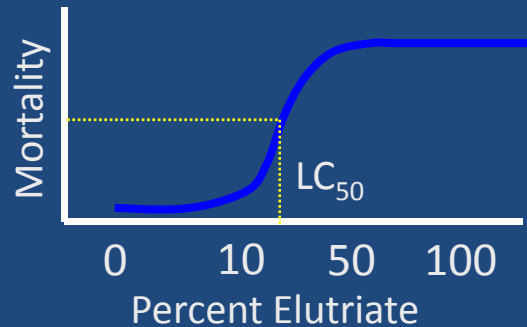
Must meet LPC after
4 hours of mixing

Must meet LPC/WQS at all times



Elutriate Data Analysis Example

1. Determine LC_{50}



LC50 is 40%

Multiply 40% by 0.01 to determine maximum allowable concentration
 $(40\% \times 0.01) = 0.4\%$

2. Model dilution of effluent from CDF or DM in mixing zone



Model demonstrates DM outside of mixing zone will be less than 0.1% and will be less than 0.1% within the mixing zone after 4 hours



**DM will be diluted to lower concentration (0.1%) than maximum allowable concentration (0.4%)
Dredged material elutriate does not exceed WQC or LPC**

Lipid Normalized Results - *N. virens* Bioaccumulation (28-day) Dioxin/Furans TEQs (pg/g)

Test Organism	Location	Analysis	Sample Type		
			Archive	Ref	Sample
<i>N. virens</i>	Houston Ship Channel	Total TEQ	0.124	0.314	0.092 - 0.144
		Total TEQ (lipid normal)	68.9	197	35.3 - 76.8
	Galveston Entrance Channel	Total TEQ	0.124	0.314	0.089 - 0.128
		Total TEQ (lipid normal)	68.9	197	36.0 - 58.2
	Galveston Channel	Total TEQ	0.124	0.314	0.116 - 0.138
		Total TEQ (lipid normal)	68.9	197	49.8 - 76.8

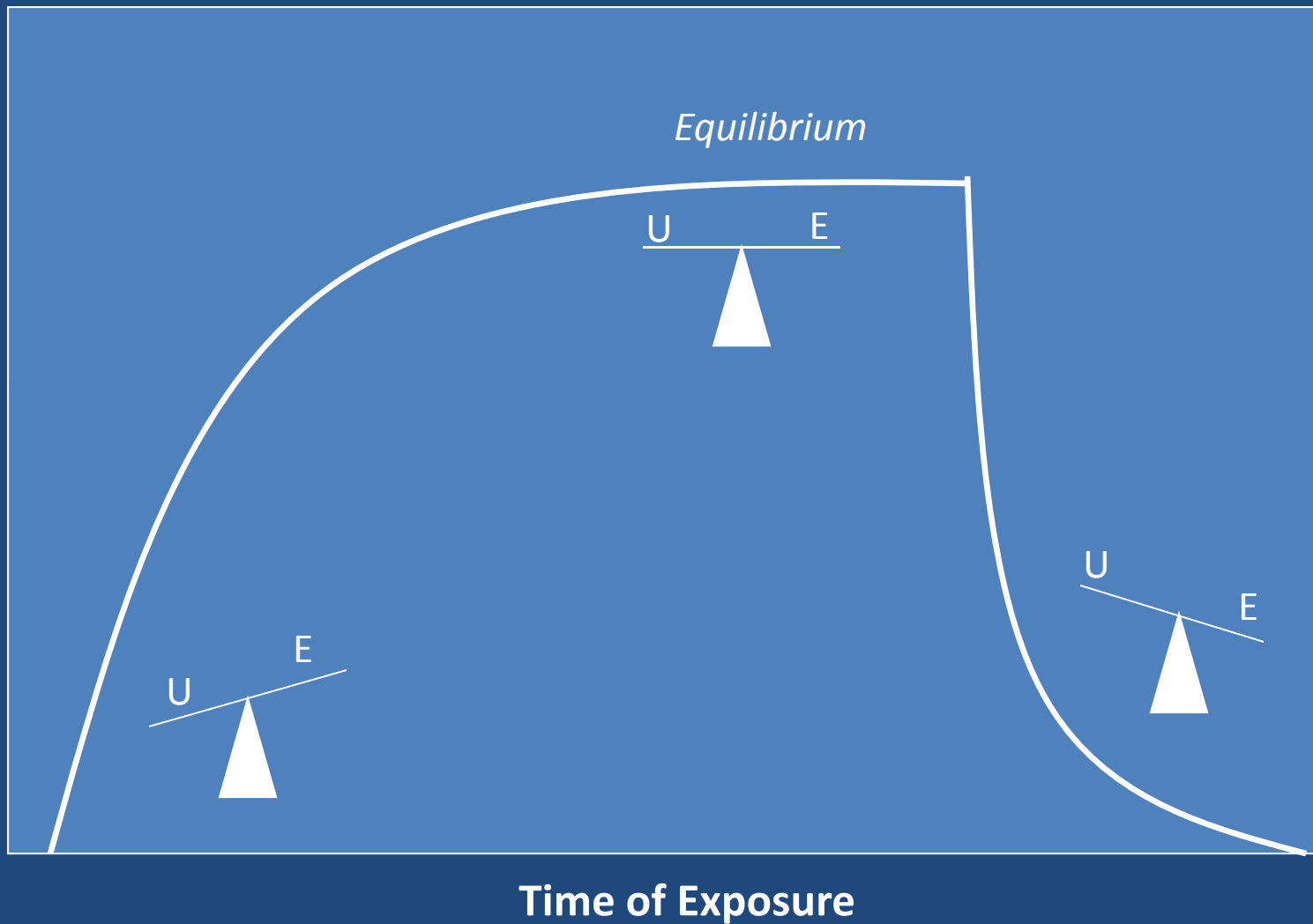
Lipid Normalized Results - *M. nasuta* Bioaccumulation (28-day) Dioxin/Furans TEQs (pg/g)

Test Organism	Location	Analysis	Sample Type		
			Archive	Ref	Sample
<i>M. nasuta</i>	Houston Ship Channel	Total TEQ	0.051	0.049	0.066 - 0.105
		Total TEQ (lipid normal)	65.4	70.9	104 - 183
	Galveston Entrance Channel	Total TEQ	0.051	0.049	0.051 - 0.067
		Total TEQ (lipid normal)	65.4	70.9	75.3 - 108
	Galveston Channel	Total TEQ	0.051	0.049	0.076 - 0.107
		Total TEQ (lipid normal)	65.4	70.9	130 - 156

Steady State Condition

- Definition: Constant tissue residue resulting from equal compound flux into and out of an organism
 - Compound-specific and increase with k_{ow}
 - Concentration is the maximum (V_{max} , B_{max} , SS)
 - Determined through nonlinear regression or statistically
- Time-to-steady state (TSS)
 - a function of compound elimination
 - ($TSS_{95\%} = 2.99 / k_e$)

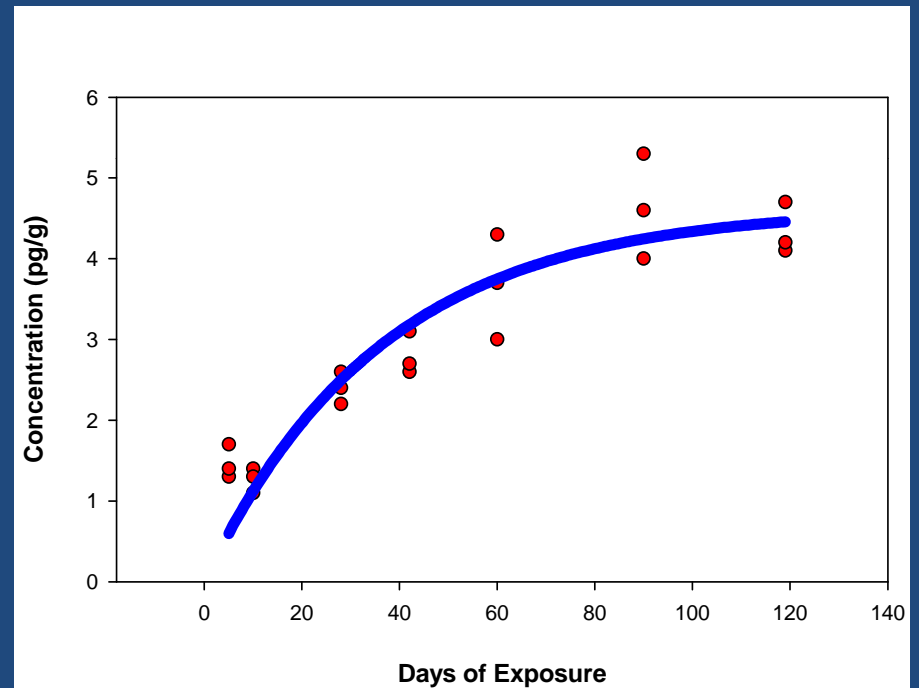
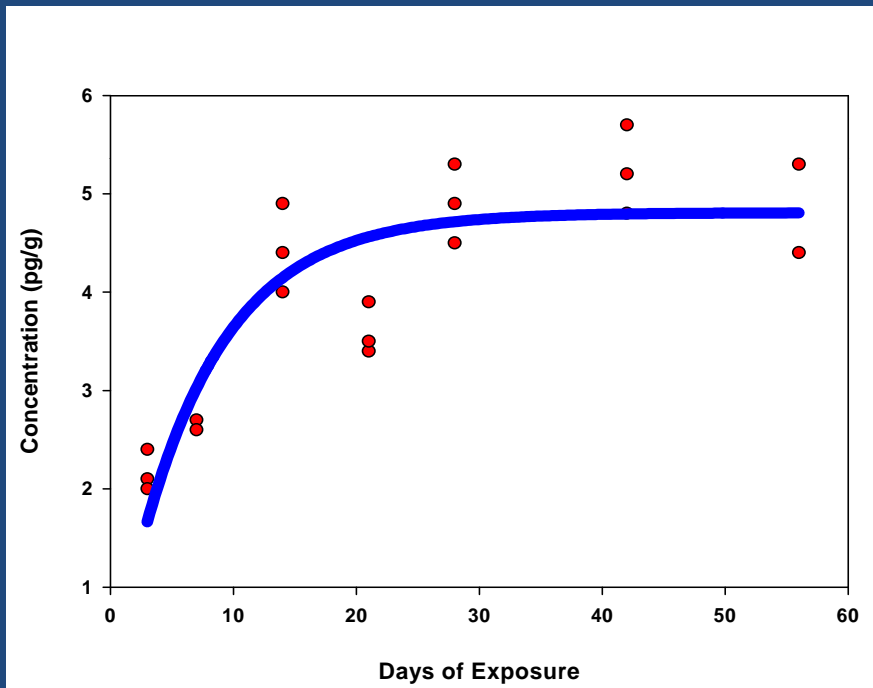
Concentration in Animal



Rate constants K_u and K_e describe uptake rates and elimination rates unique to chemicals and systems

Steady State Condition

- Obtaining steady state for 2,3,7,8 TCDF



- 28 days of exposure adequate for *Nereis* (by both methods)
- Uptake and elimination slower for *Macoma* (80% steady state not achieved by day 28)

Kennedy and Steevens, 2010. Determining steady-state tissue residues for invertebrates in contaminated sediment. el.erc.usace.army.mil/elpubs/pdf/trel10-2.pdf