

# **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**

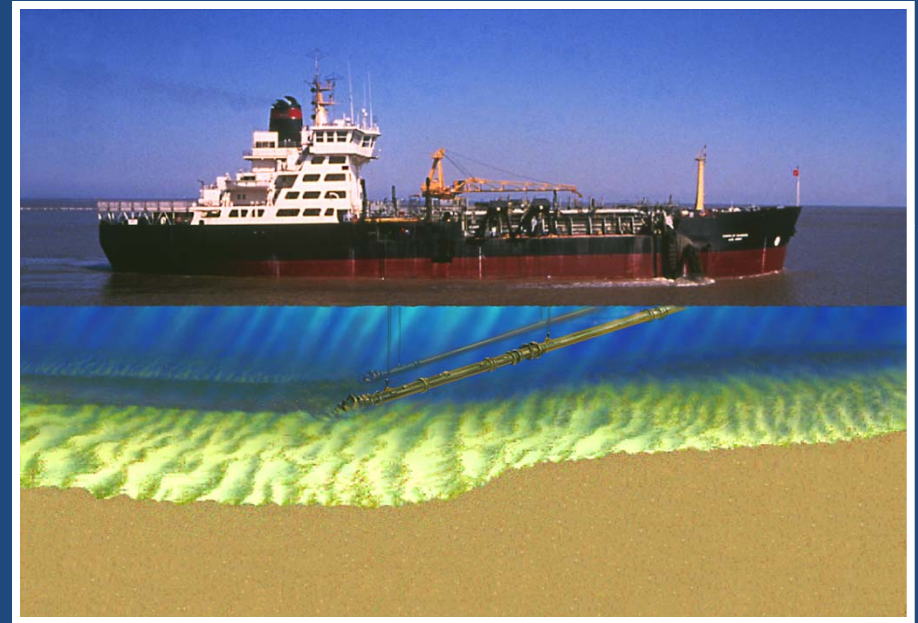
**April 4, 2012**

# Introduction

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

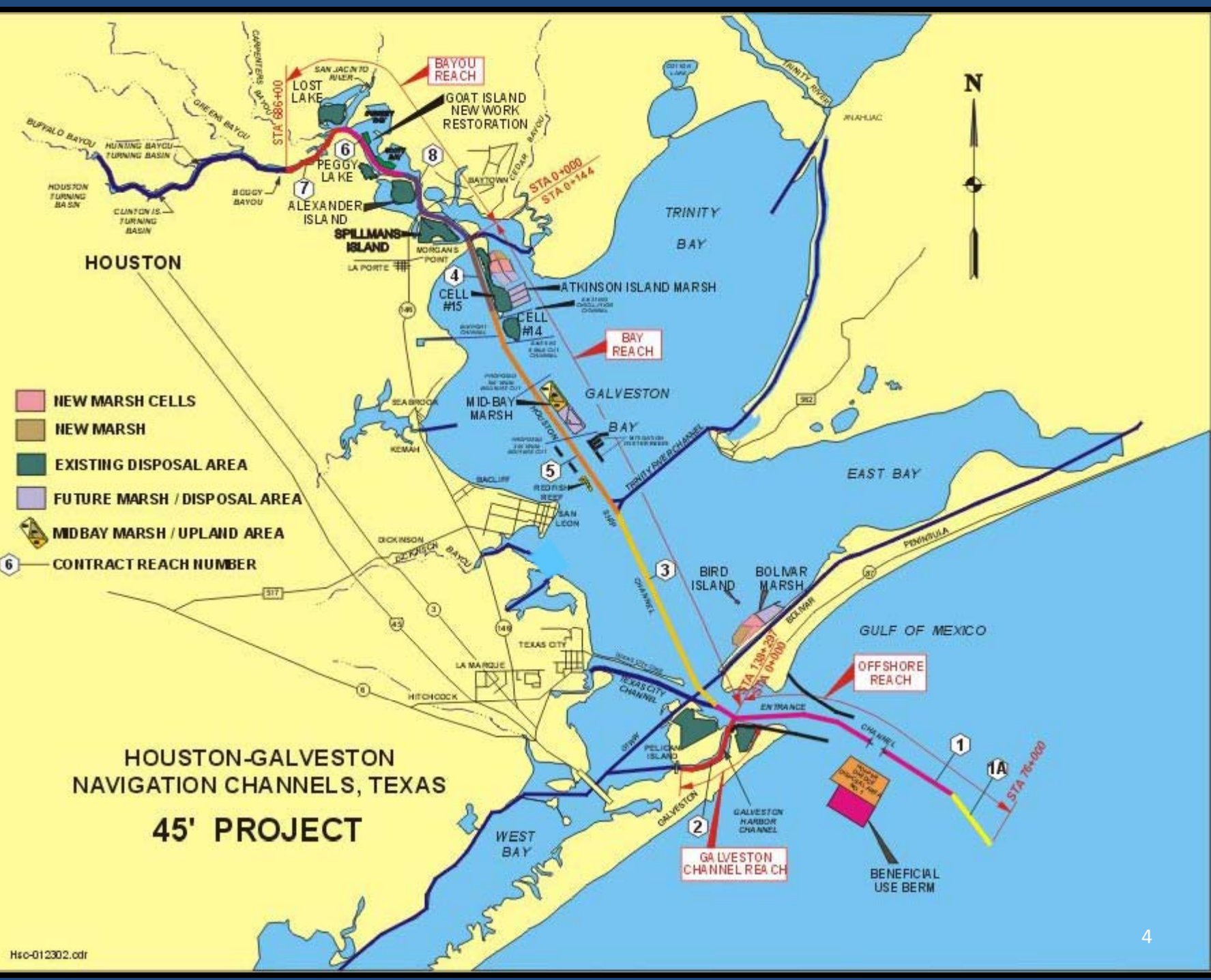
# Dredging Project Overview

- 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)

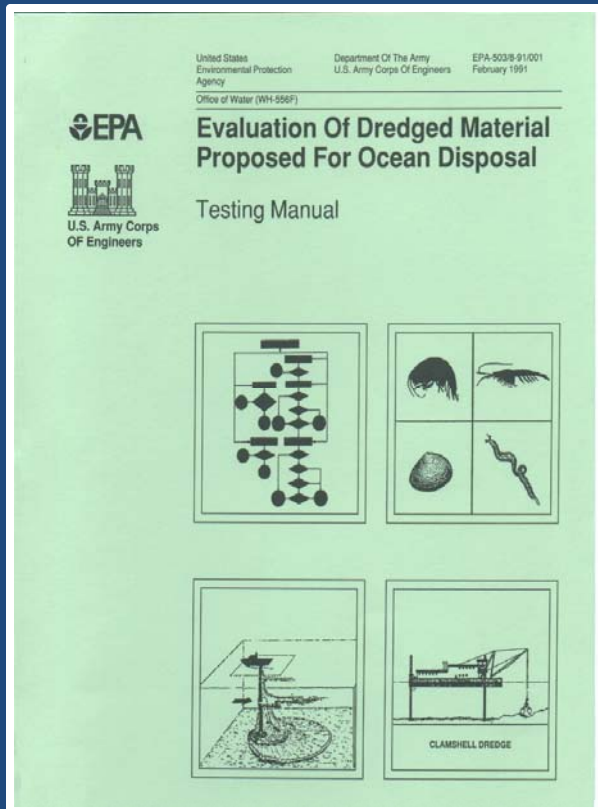


# HOUSTON-GALVESTON NAVIGATION CHANNELS, TEXAS 45' PROJECT

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



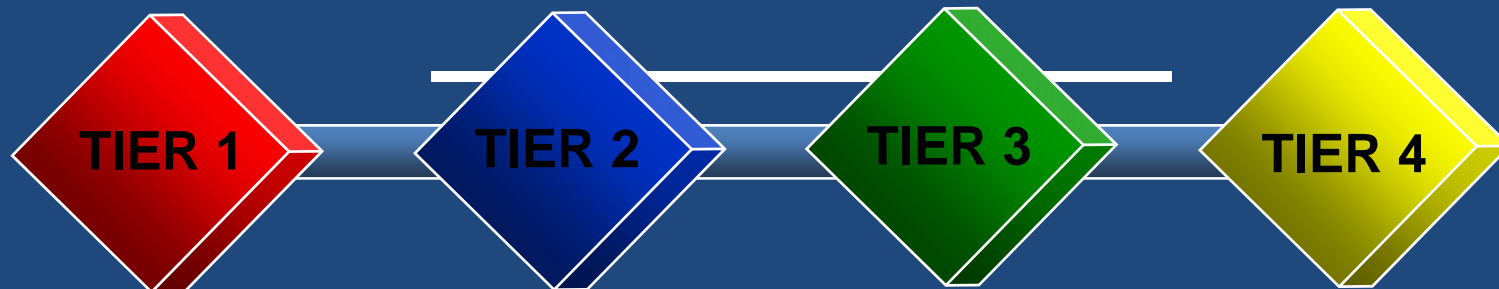
# Ocean Testing Manual



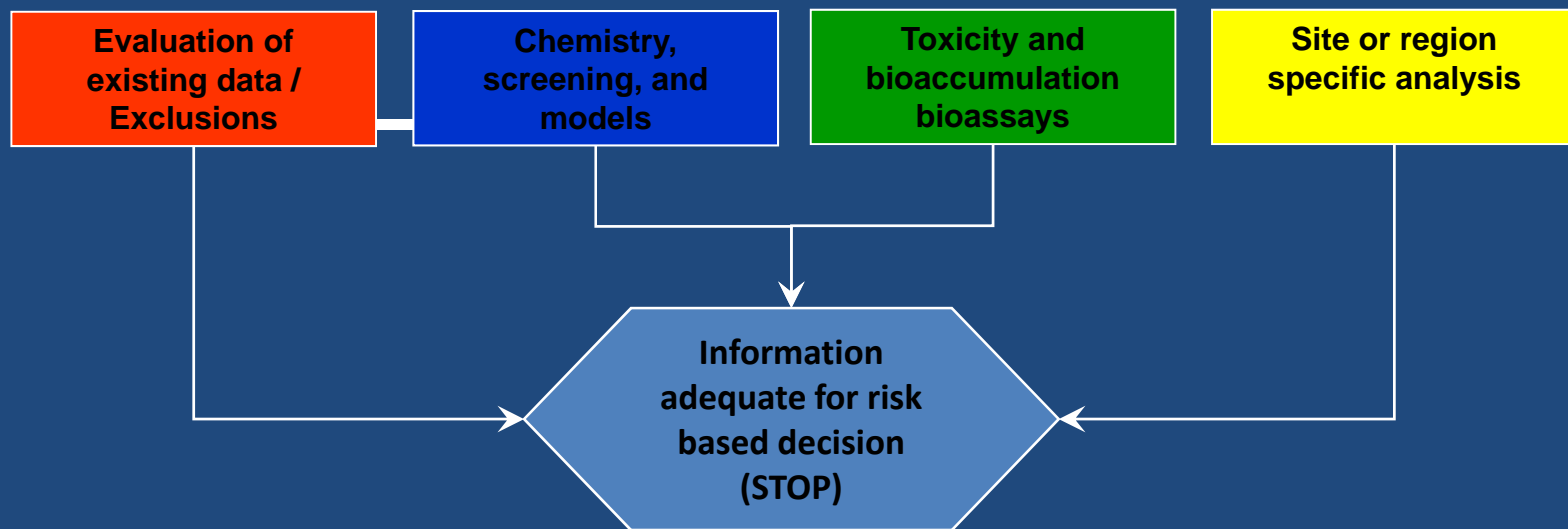
- Addresses MPRSA
  - Jointly regulated by USEPA and USACE
- Originally developed in 1977, updated in 1991
- Tiered Approach:
  - Effects-based testing
  - Bioaccumulation
  - Comparison to reference

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



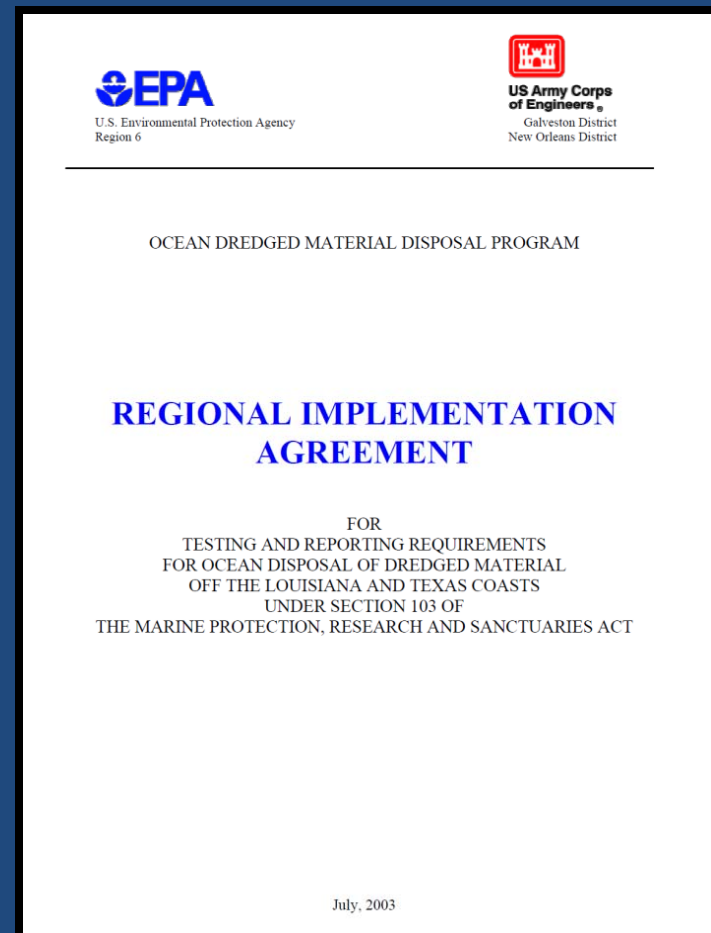
Tiered process → follow as far as necessary to make decision



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)



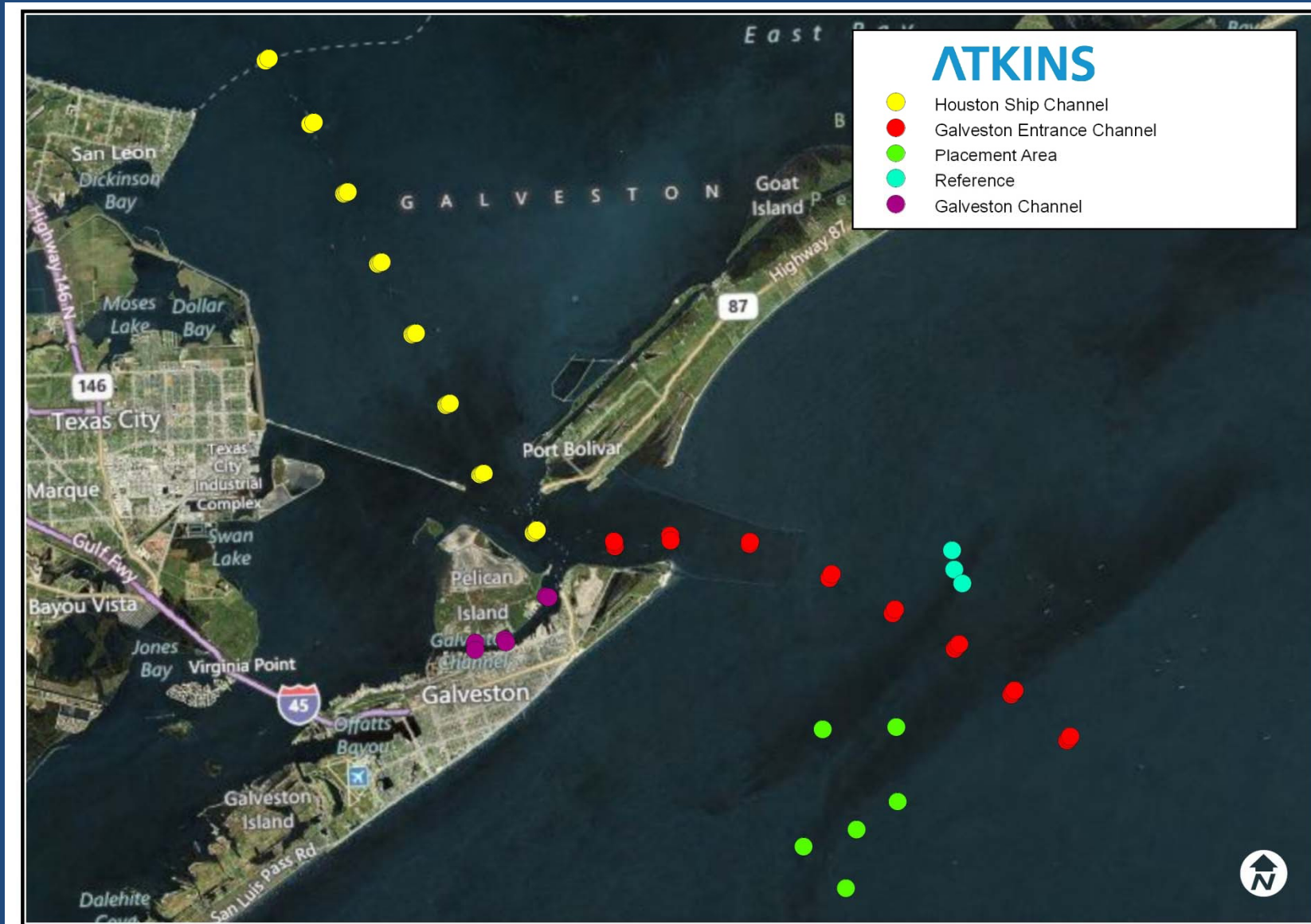
# Analysis and Evaluation Approach

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

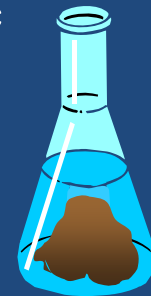
Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD) and Related Compounds (2004) Vol 2, Chap 3. Average concentration in sediments was 5.31 ± 5.83 pg/g.

# Suspended Particulate Phase Bioassay

## Test Design

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

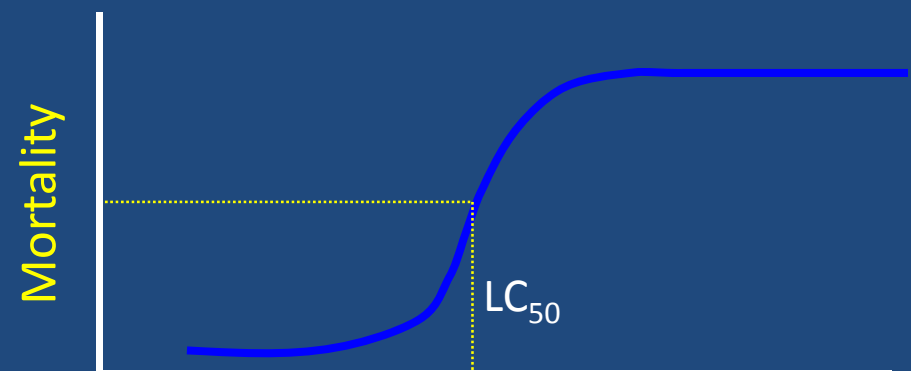
4 parts water \*  
1 part DM  
(volume)



*Americamysis bahia*



*Menidia beryllina*



0



10



50



100

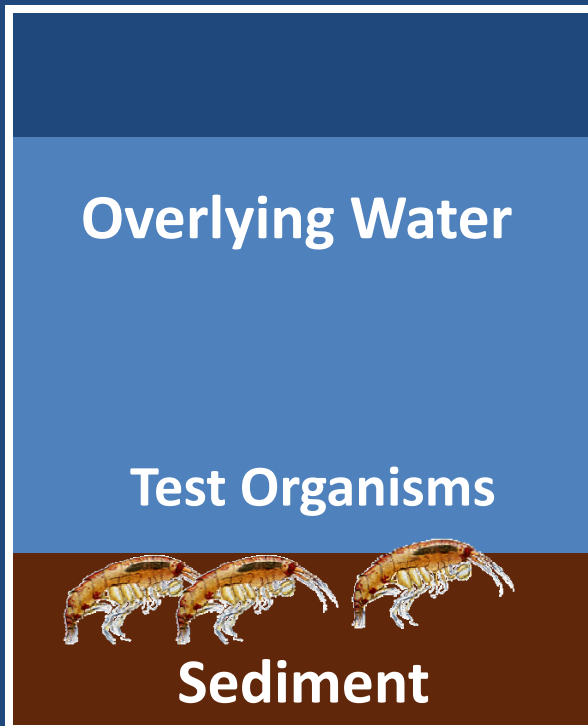
Percent Elutriate

## 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*

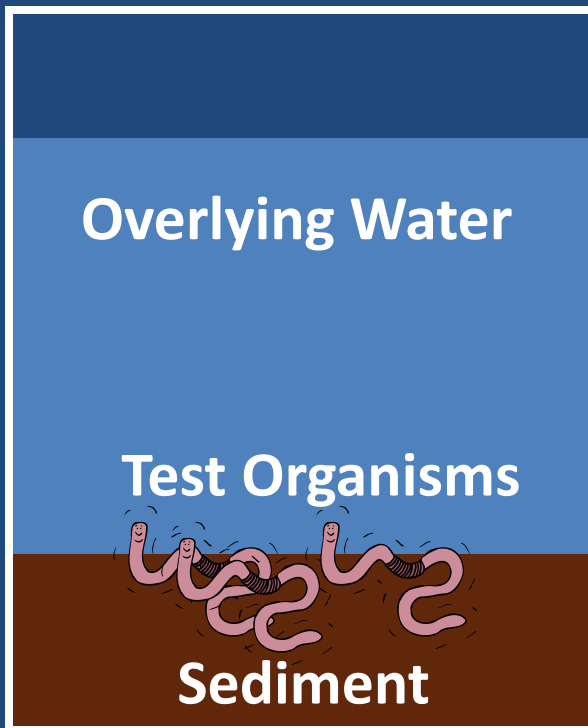
# Results – Benthic Toxicity Bioassay Survival (10-day)

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

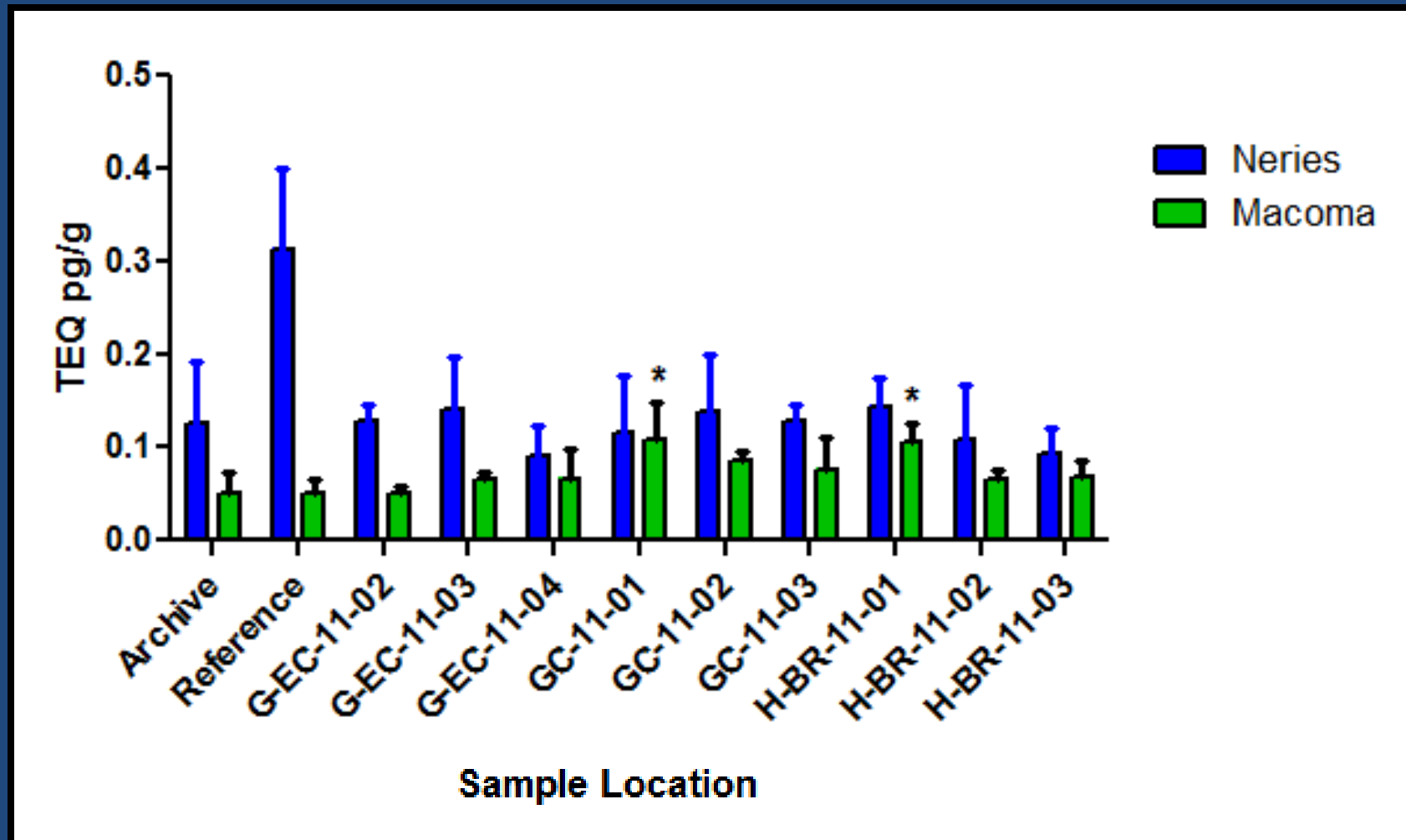


*Nereis virens*

# 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)
<b>Bivalve</b>		
<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
<b>Worm</b>		
<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**

<b>Study</b>	<b>Range (pg/g ww)</b>
<b>Bivalve</b>	
<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

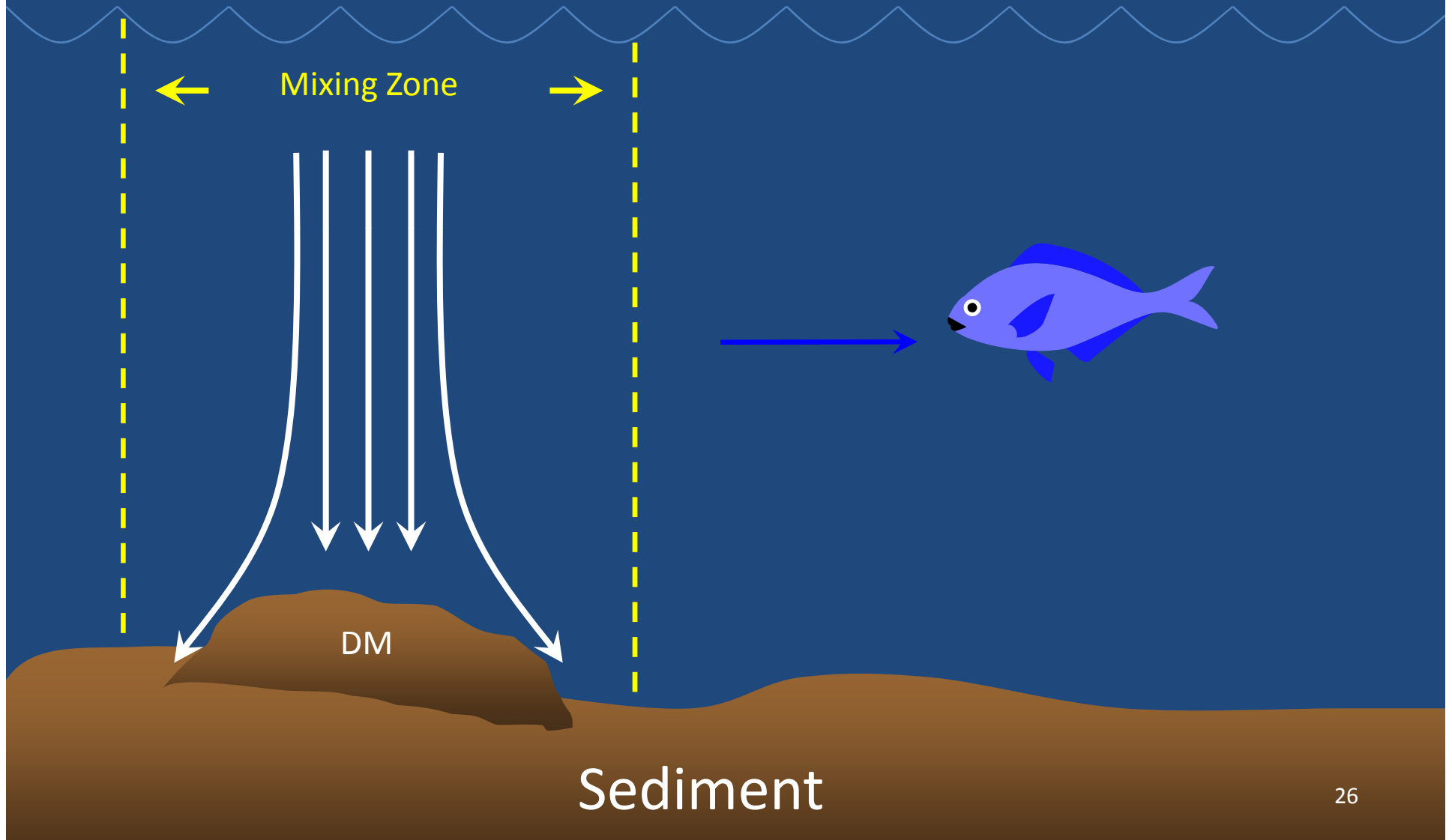


# Additional Discussions

# Elutriate Data Analysis

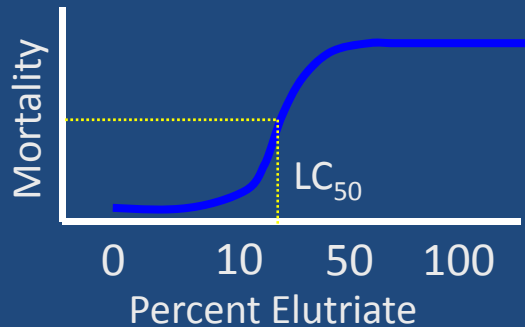
Must meet LPC after  
4 hours of mixing

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

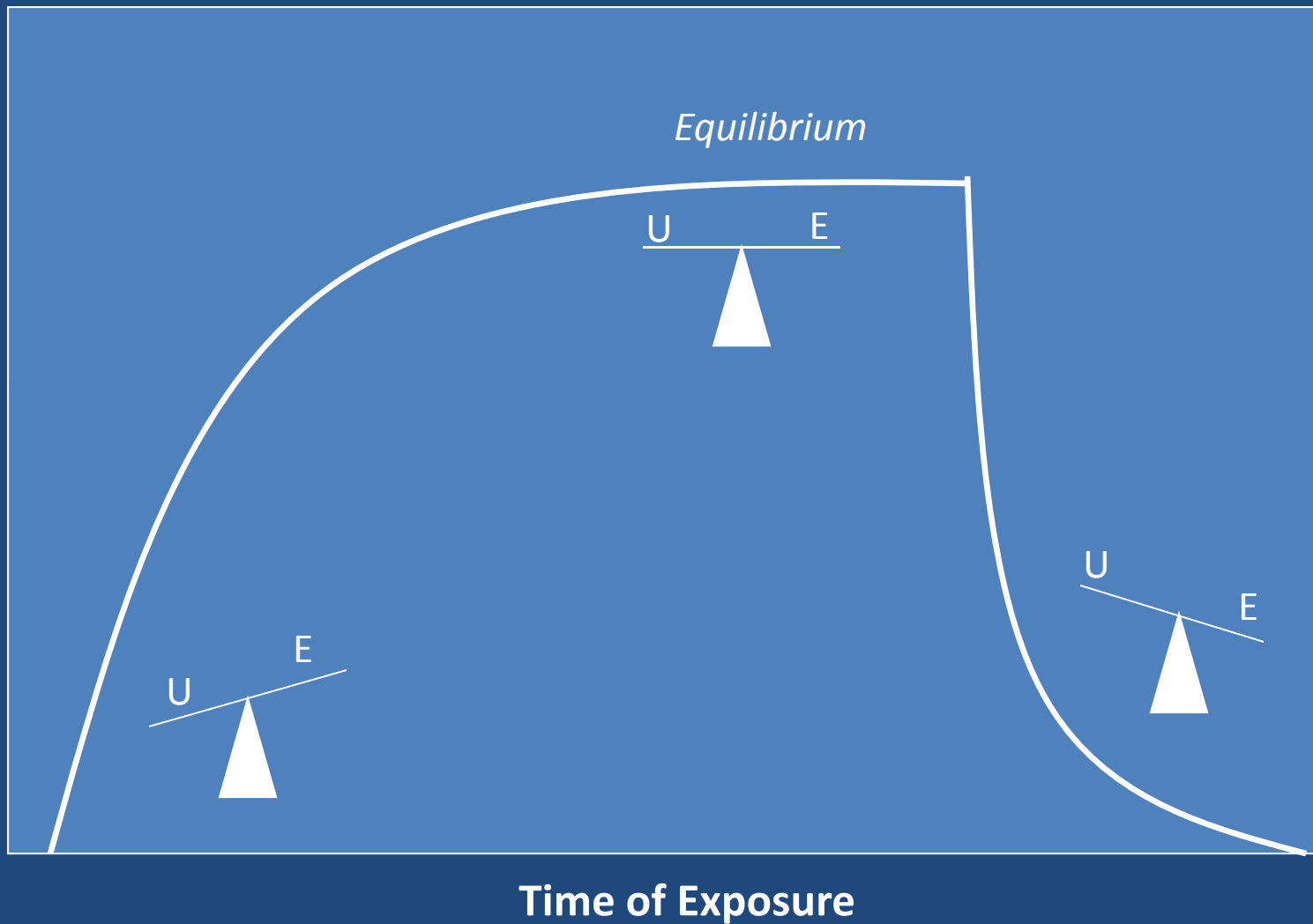
## Lipid Normalized Results - *M. nasuta* Bioaccumulation (28-day) Dioxin/Furans TEQs (pg/g)

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
  - ( $TSS_{95\%} = 2.99 / k_e$ )

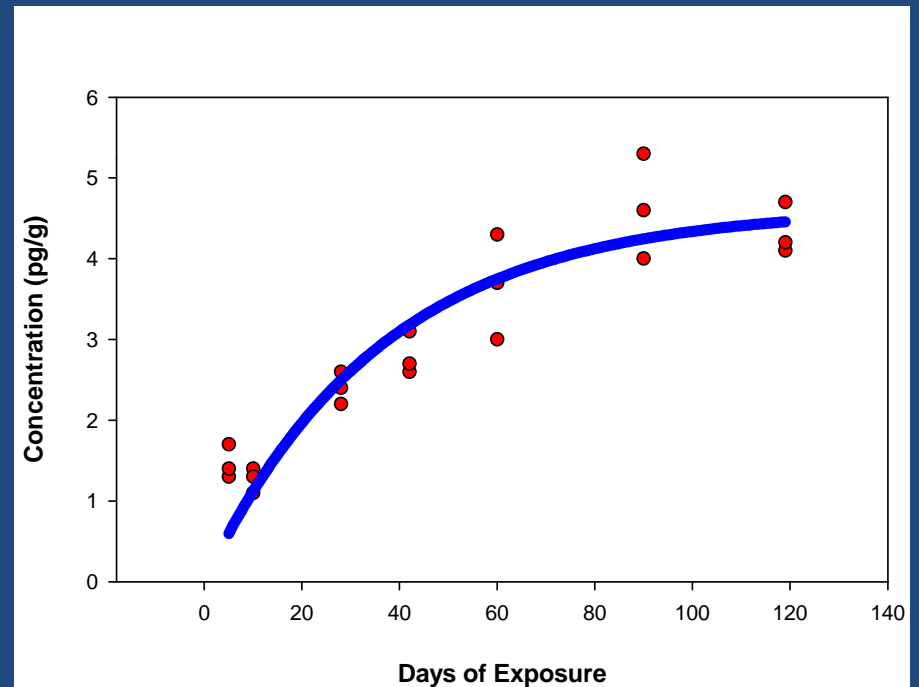
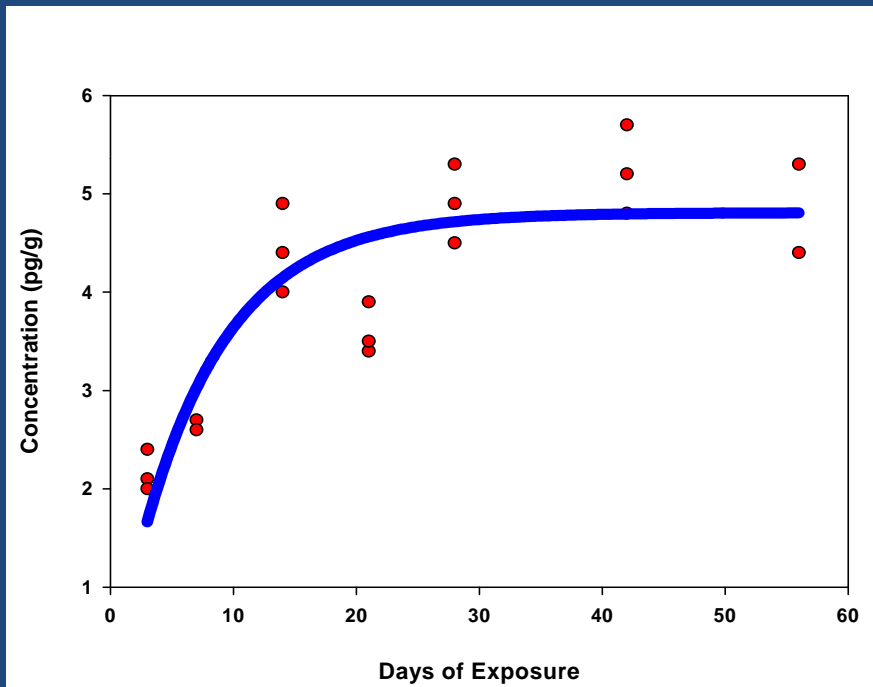
Concentration in Animal



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.erdc.usace.army.mil/elpubs/pdf/trel10-2.pdf](http://el.erdc.usace.army.mil/elpubs/pdf/trel10-2.pdf)