# Overview of risk assessment for metals and contaminants of emerging concern (CECs)

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Contaminants Workgroup Meeting
Albemarle-Pamlico National Estuary Partnership
October 21, 2014

# Introduction to Risk Assessment

Several slides borrowed from Society of Environmental Toxicology and Chemistry (SETAC)
http://www.setac.org/

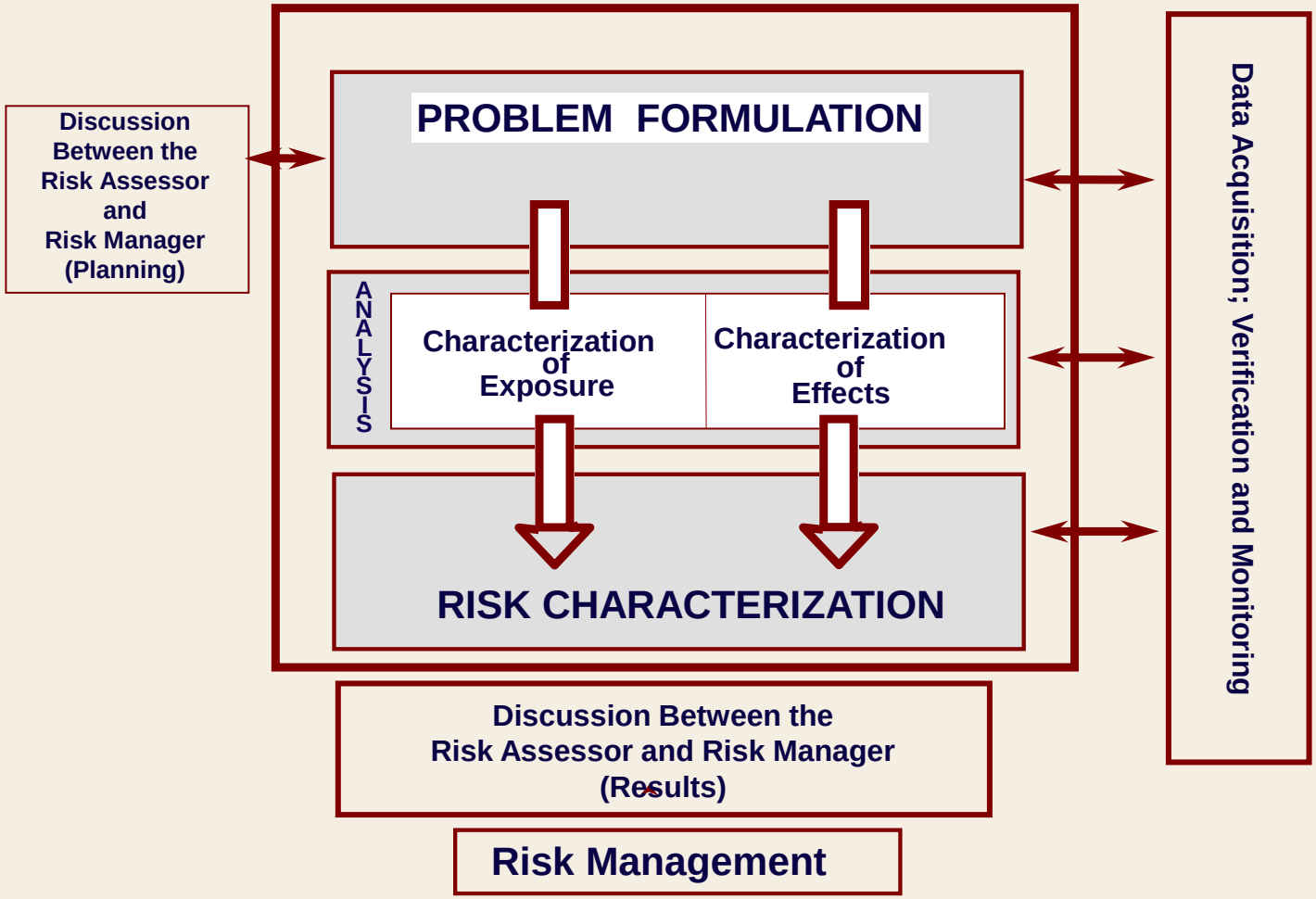
# Risk assessment requires recognition and integration of effects and exposure

Risk assessment is defined as a process that evaluates the likelihood that adverse effects may occur or are occurring as a result of exposure to one or more stressors

EPA Risk Assessment Forum

1992

# EPA's Framework for Ecological Risk Assessment



# Problem formulation

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- Determine what specific attribute(s) of the entity is potentially at risk and important to protect (survival, growth, reproduction, biodiversity, etc.)
  - Ecological relevance
  - Susceptibility to stressors
  - Relevance to management goals

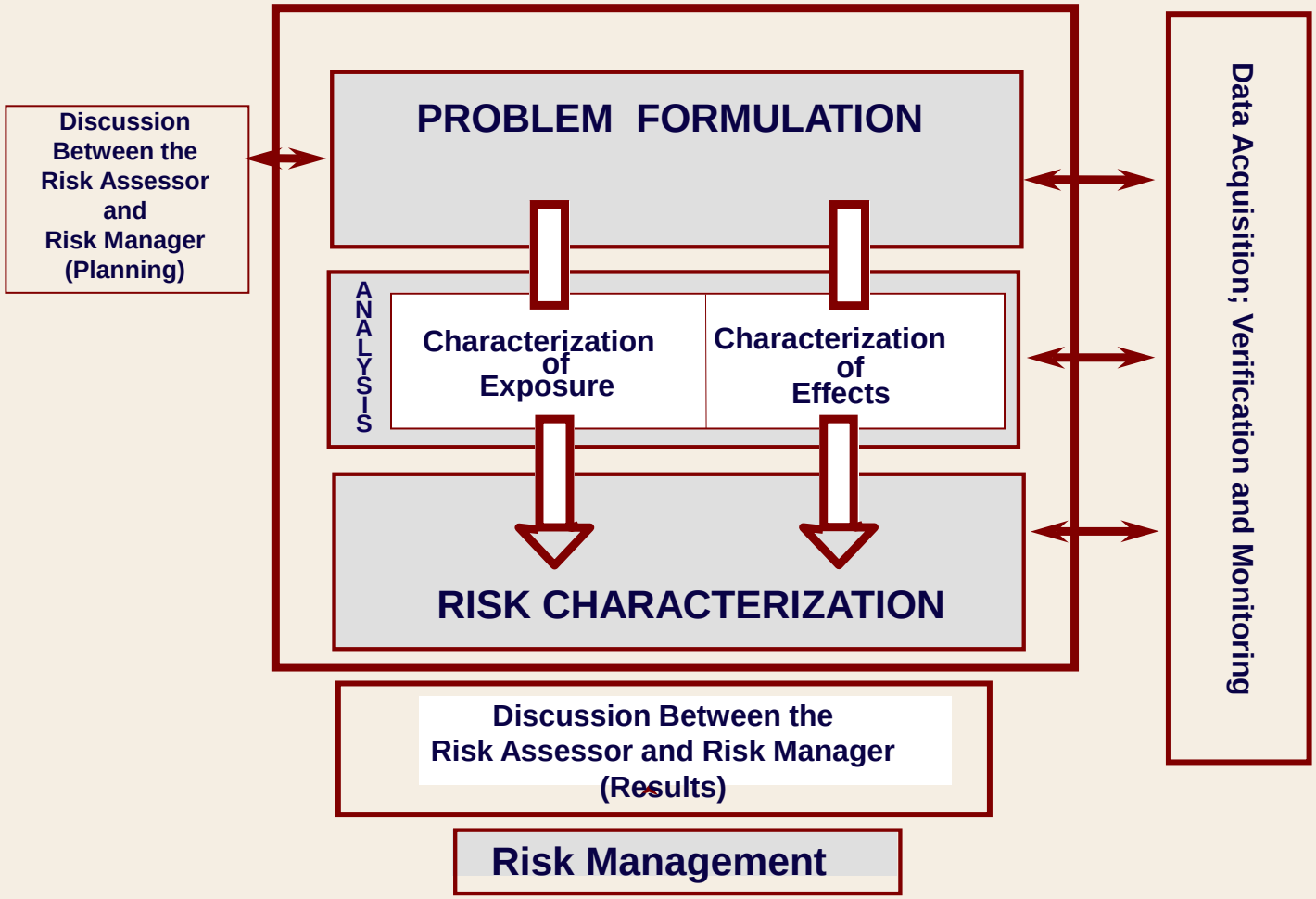
# Problem formulation

- Most critical part of risk assessment; from earliest stages, context and parameters must be aligned with decisions to be made
- Requires blend of technical/science input and an array of value-based attributes outside of science
- Context and parameters established determine how the remainder of the assessment is conducted

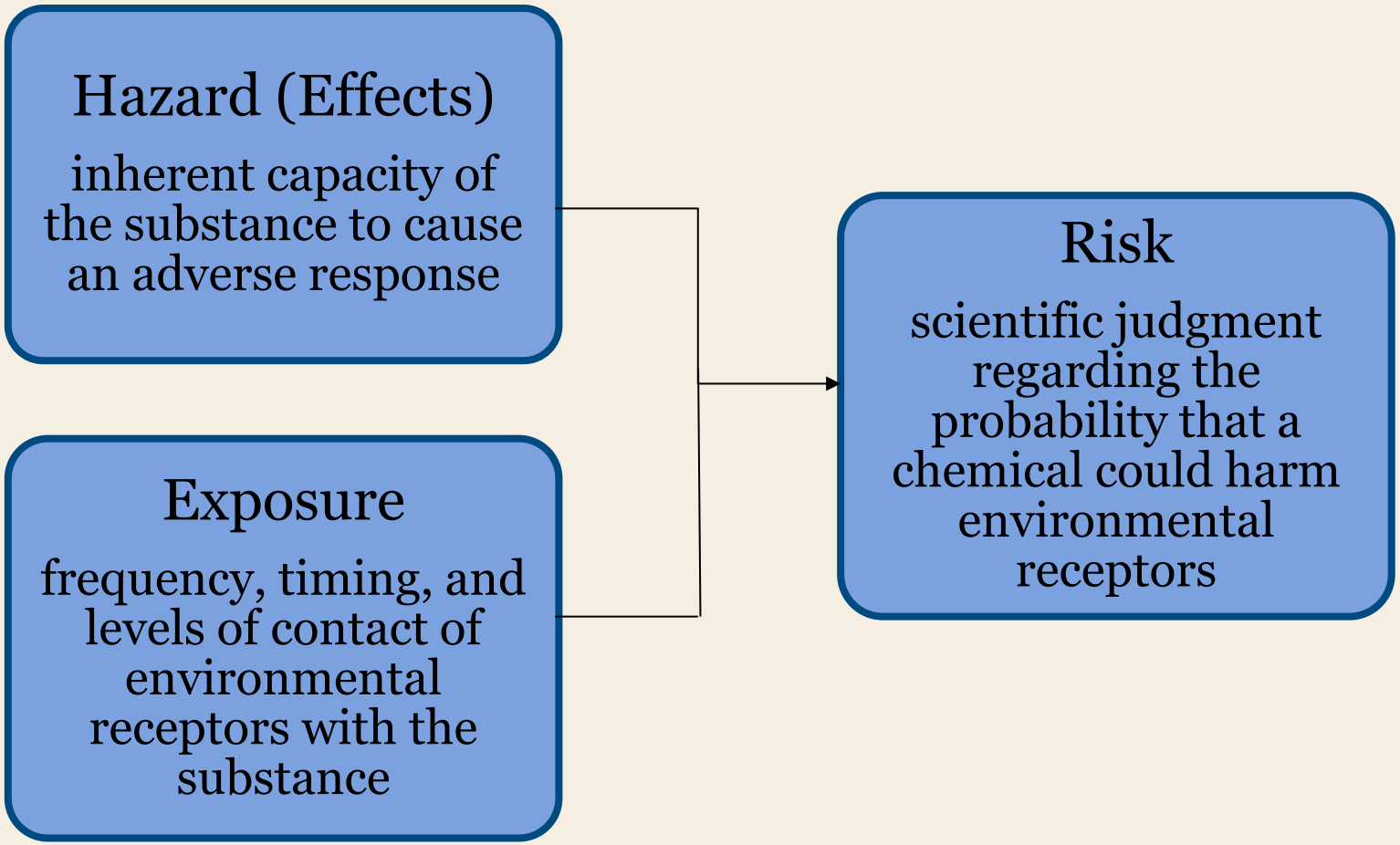
# Additional Considerations

- Timeframe / time constraints – use existing data or collect new?
- Level of complexity – screening or advanced?
- Match data needs with decisions to be made

# EPA's Framework for Ecological Risk Assessment



# Three Key Concepts



# Exposure Assessment

- Exposure occurs through contact with a chemical
- Various routes of exposure (e.g., sediment and pore water, and overlying water)
- The concentration of the chemical and the extent of the contact are important components of exposure assessment
- Measured or modeled

# Effects Assessment

- Provides an understanding of the potential for the chemical to cause adverse effects to humans and plant and animal life

- How does the chemical impact…
  - survival (or mortality)
  - growth (mass, length, etc.) over time
  - reproduction (e.g., eggs produced, eggs hatched, seeds produced)
  - behavior (e.g., avoidance, lethargy)
- Can be site-specific studies
- Can be literature-based estimates of effect

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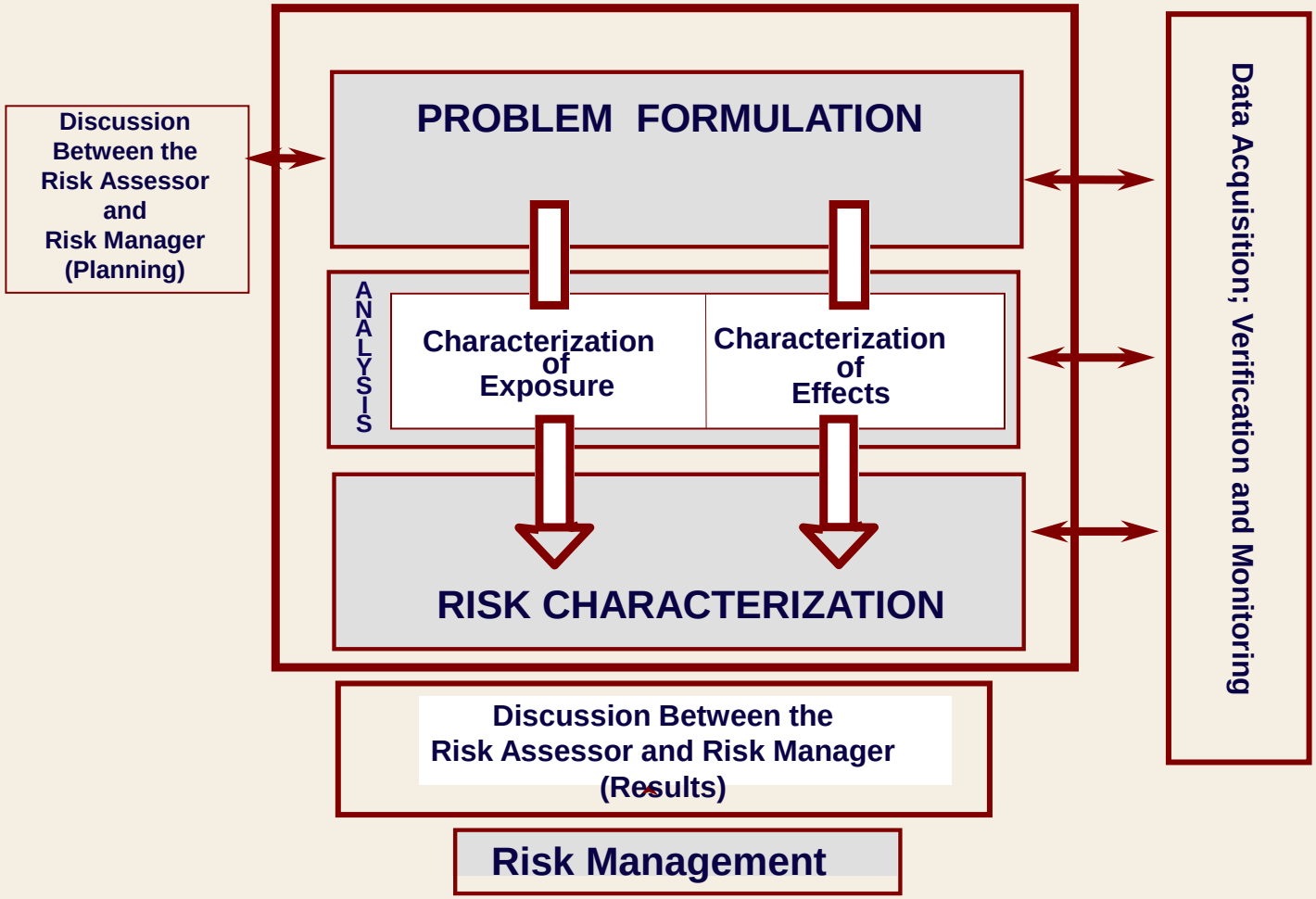


# Risk Characterization - Deterministic Approach

$$HQ = Exposure_{(mg/kg)} / TRV_{(mg/kg)}$$

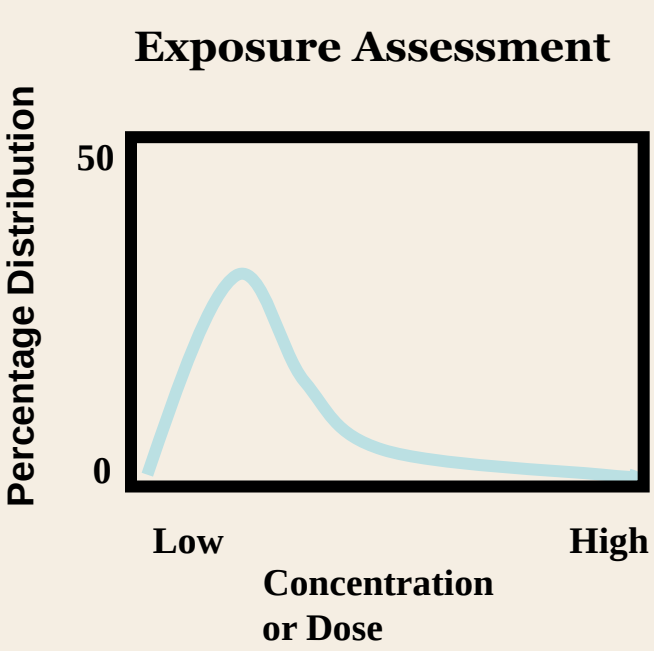
Pros

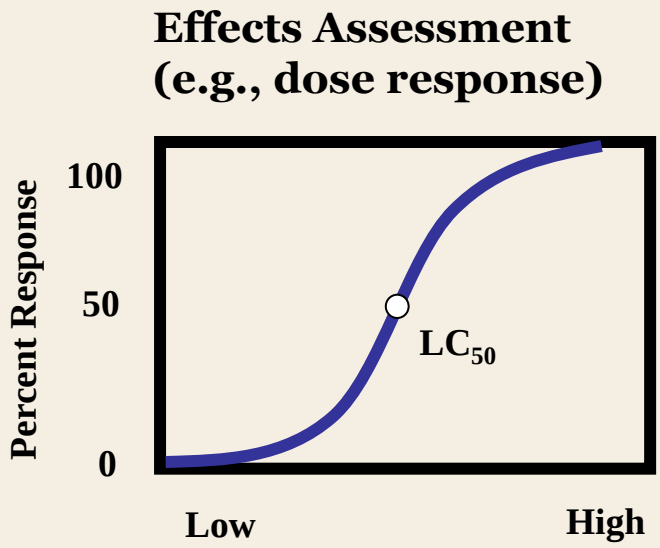
- Relatively simple
- Focuses on a safe levels of exposure
- Can be used to determine what is "safe"
- Likely protective

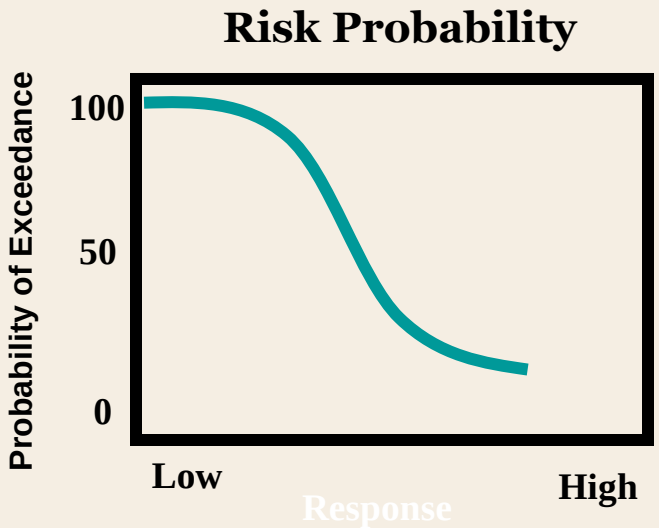
Cons

- Confound uncertainty
- Single concentration used
- Exposure is uniform
- Likely not predictive

# Exposure and Effects Assessment



# Is this a Risk Assessment?

Elevated levels of copper have been detected in sediments of an Albemarle Sound tributary.

**No** –
this is simply a piece of information that may be relevant to exposure.

We know nothing yet about receptors and potential for effects.

# Is this a Risk Assessment?

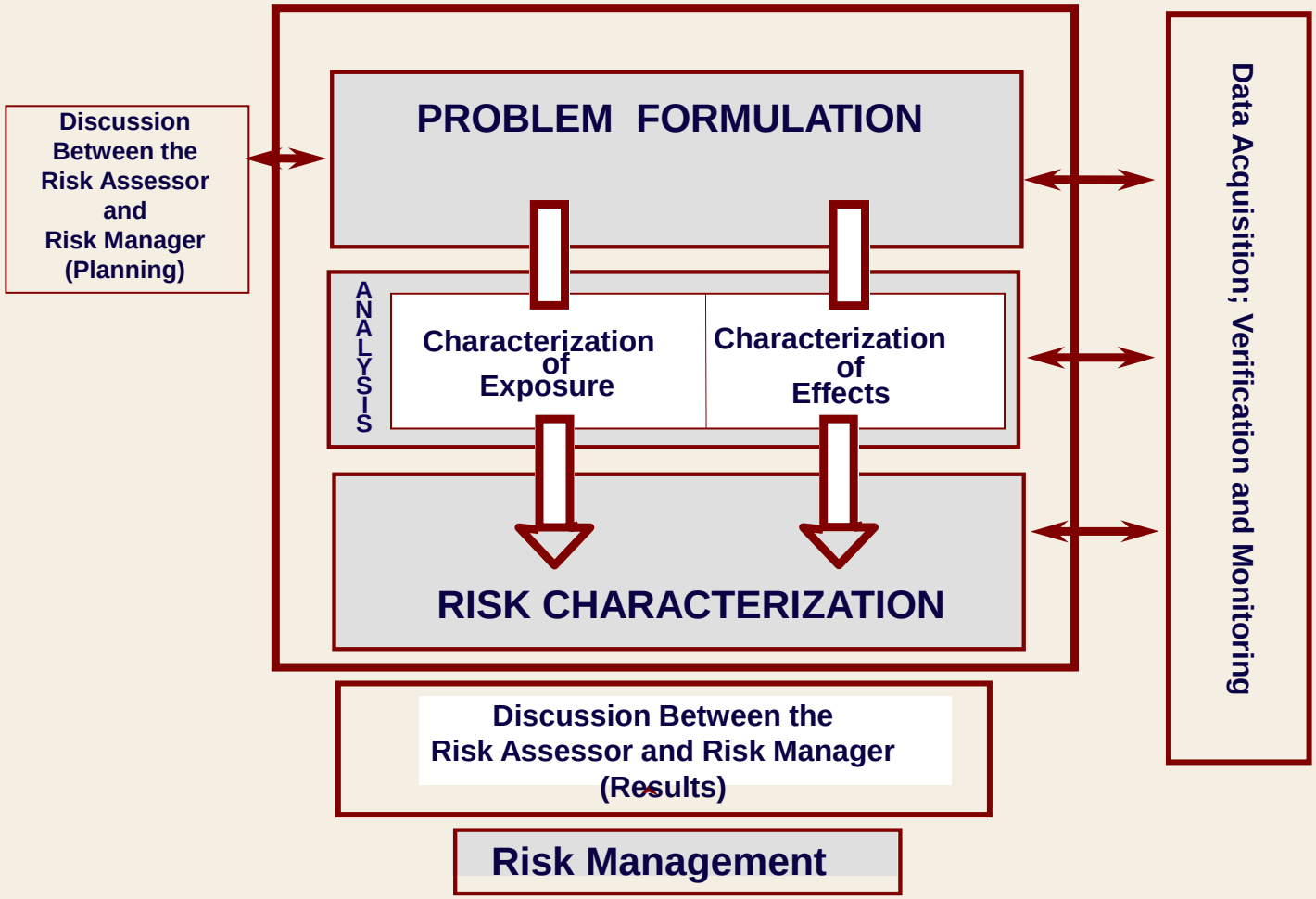
McDonald et al. published a 149 mg/kg "probable effects concentration" of copper in whole sediment; a concentration above which adverse effects to sediment-dwelling organisms may be expected

**No** –

this is simply a piece of information that may be relevant to effects.

We haven't considered the condition of the local estuarine sediments

# EPA's Framework for Ecological Risk Assessment



# For Task A2.5

"Facilitate risk assessments of heavy metals and other toxic contaminants in sediments"

Problem formulation questions:

- Endpoints (ecological, human health)
- Effects of interest
- Geography
- Temporal scale

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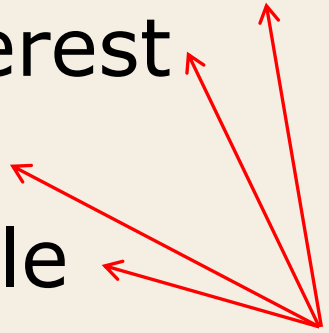


This is where we should start

# For Task A2.5 (*after* problem formulation step)

## Exposure Data – see memo on website

- Riggs SR et al. 1993. Heavy Metals In Organic-rich Muds of the Albemarle Sound Estuarine System. Albemarle-Pamlico Estuarine Study, Report 93-02, Raleigh, NC.
- Hyland JL, et al. 2000. Sediment quality of North Carolina estuaries: An integrative assessment of sediment contamination, toxicity, and condition of benthic fauna. *J. Aquatic Ecosystem Stress & Recovery* 8:107-124.
- USEPA. 2012. National Coastal Condition Report IV. EPA-842-R-10-003, Office of Research and Development/Office of Water, Washington, DC. [three earlier assessments too]
- USGS. Report in progress on 2012 sediment sampling in Albemarle Sound

# Riggs et al. 1989

- 153 samples in Pamlico system, 1988
- Sediments near known point sources enriched up to 14 times in As, Cd, Cr, Cu, F, Hg, Ni, P, Pb, and Zn compared to other portions of the Pamlico estuarine system
- Ten regions of the Pamlico River estuarine system defined as areas of concern (enrichment of one or more metals by a factor of two times the trimmed mean for the Pamlico system)

# Riggs et al. 1993

- 198 samples in Albemarle system, 1991-92
- 18 contaminated areas of concern identified
- NPDES permitted point source discharges appear to be the major contributors of enriched trace elements to bottom sediments

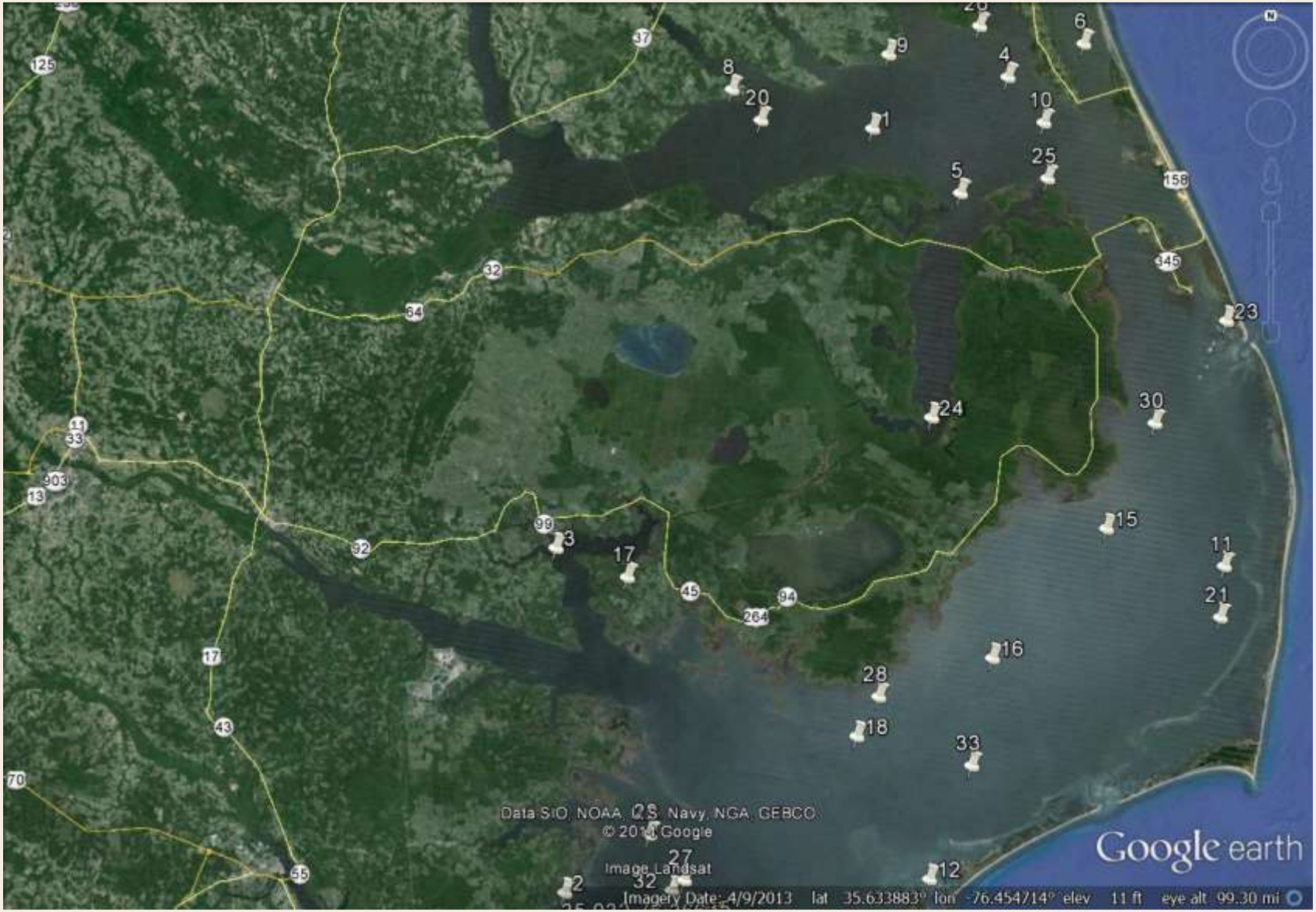
# Hyland et al. 2000

- Sediment quality via chemistry, toxicity, and community structure
- 175 stations sampled coast-wide 1994–97
- Probabilistic sampling design
- 54 ± 7% of surveyed area had high sediment quality (healthy benthos and low sediment contamination and toxicity)
- 46% showed evidence of significant stress in one or more components
- 19% of area showed evidence of an impaired benthos coupled to significant pollution exposure (contamination, toxicity, or both)

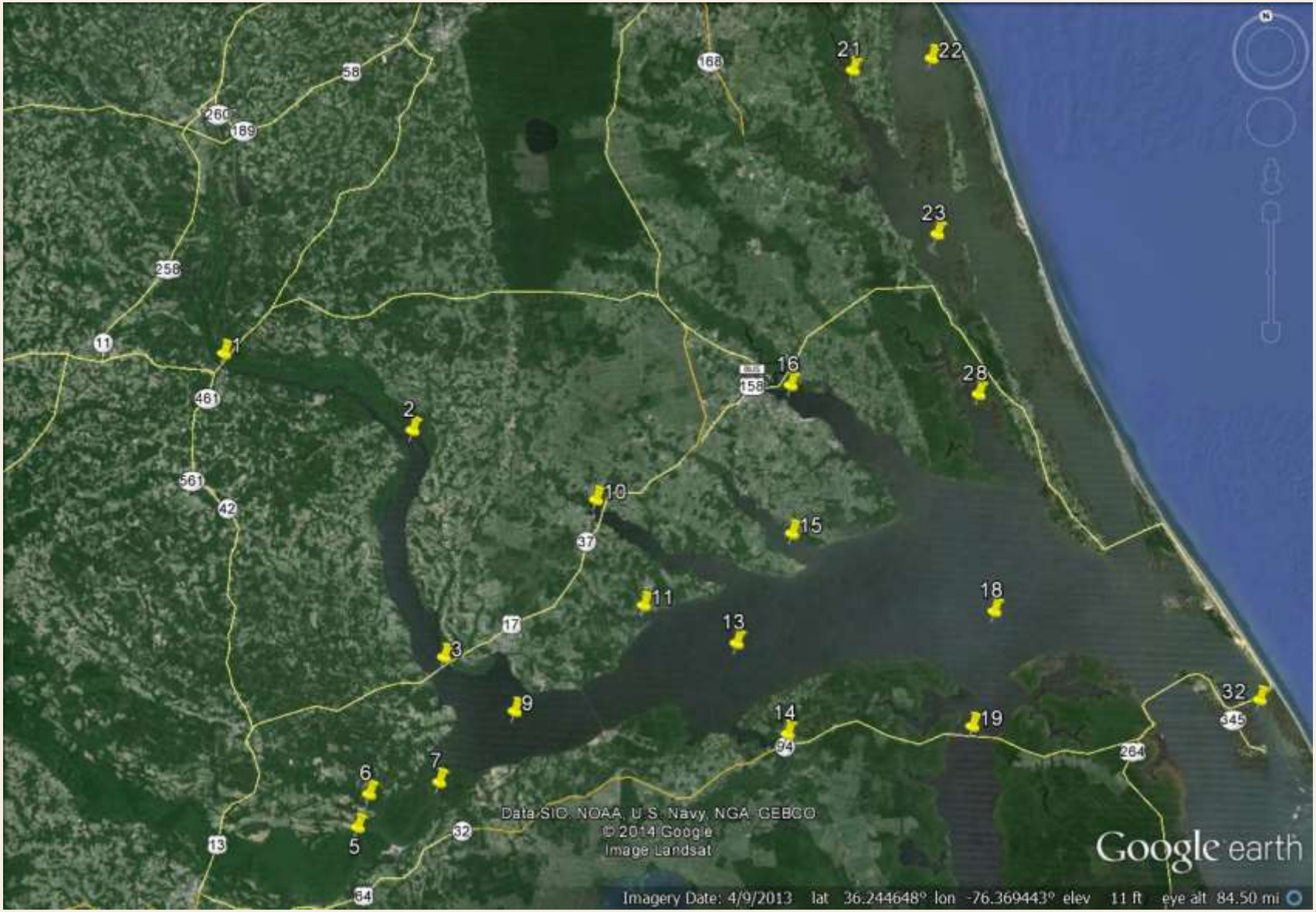
# USEPA National Coastal Condition

- Most recent report 2012, data from 2004
- Sampling 2010, planned for 2015
- Sediment chemistry, community structure, toxicity testing
- Variable number of stations each time
- Data available for 2004 sampling on-line

# USEPA – samples collected 2004



# USGS – samples collected 2012



# For Task A2.5

## Effects Data – can develop a similar memo

- Results of local benthic community assessments (structure, toxicity, chemical contaminants)

- Literature-based estimates of safe versus hazardous concentrations by chemical

  - Burgess RM, et al. 2013. Critical Review: Mechanistic sediment quality guidelines based on contaminant bioavailability: equilibrium partitioning sediment benchmarks. Environ Toxicol Chem 32: 102-114.
  - Field LJ, et. al. 2002. Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environ Toxicol Chem 21: 1993-2005.
  - MacDonald DD, et al. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam Toxicol 39: 20-31.
  - USEPA. 2012. National Coastal Condition Report IV. EPA-842-R-10-003, Office of Research and Development/Office of Water, Washington, DC. [three earlier assessments too, with data for NC]