Deriving Sensible, Risk-Based Cleanup Targets

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BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Key Word: Sensible

"marked by the exercise of good judgment or common sense in practical matters" www.cogsci.princeton.edu/cgi-bin/webwn

Often, what makes perfectly good sense to me is non-sense to you.

“Target” is more than just a “number”

- Needs to incorporate a bigger picture of the cleanup (i.e., put in context)
- There are a variety of ways to get to “protective”

Randy Sturgeon – Top Ten Principles for Deriving Sensible Risk-Based CleanupTargets

Todd Bridges – Methods for our Madness

Bridgette DeShields – Case Studies

10. Garbage In, Garbage Out

- Start with a good Conceptual Site Model
- Tie your cleanup target back to the CSM to show how your cleanup will address each of the risk scenarios

9. Engage a range of stakeholders in the “target” development

- Many obstacles on the way to success, find them out early
- Easy to poke holes in others’ ideas, so strive for win-win solutions
- Natural tension between stakeholders (e.g., Trustees and PRPs) can be helpful in deriving “sensible” targets

8. A target that is not understood by the RPM/OSC has little hope of being called "sensible".

- Get to know your RPM/OSC
- May have to spend time teaching them about sediment issues, especially *your* sediment issues
- Just don't tell them they need to learn something!

7. A sensible target today, may not be in the future

- NCP: "….adequately protect human health and the environment, in both the short- and long-term,…."
- Sediment stability, cap longevity, recontamination, acute vs. chronic impacts, changes in the eco-system…

6. Sensible targets must take into account implementability issues

- Can dredging make it as clean as we would like?
- Can I realistically find every bit of sediment above a certain number?
- Are we going to create more problems than we fix?

5. The law of diminishing returns

- Due to uncertainty and unknowns, we will never develop the "perfect" criteria
- At some point, the time to decrease uncertainty through, for example, more studies, causes years of on-going, significant impacts
- At what point does pushing for the most protective cleanup cause delays that cost the environment?

4. Evaluate cost per incremental, additional cleanup

- What is the acceptable risk range for your site?
- What is the difference in cost at varying points in this range?

3. Sensible targets must be measurable so success can be determined

- Measuring attainment of a sediment remediation goal is easy, but what about the expected environmental benefit?
- Do you have an adequate baseline?
- Time to expected outcome?

2. A sensible target that is not explained well becomes non-sense to others

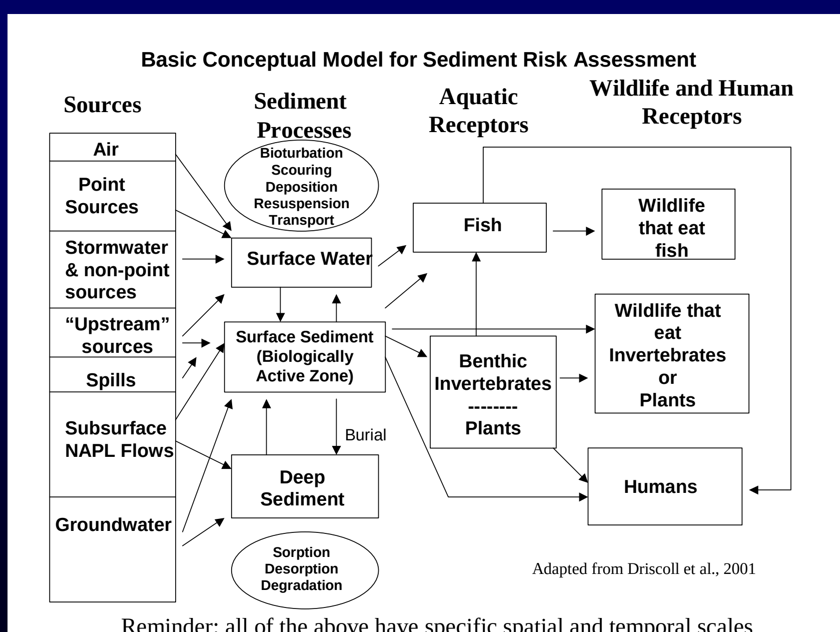
- Clearly tie the sediment remediation goals to the protection of the receptors in the CSM
- Clearly explain how the target will lead to the desired environmental benefit (e.g., lowered fish body burden allowing consumption)

1. Does it pass the RPM/OSC laugh test?

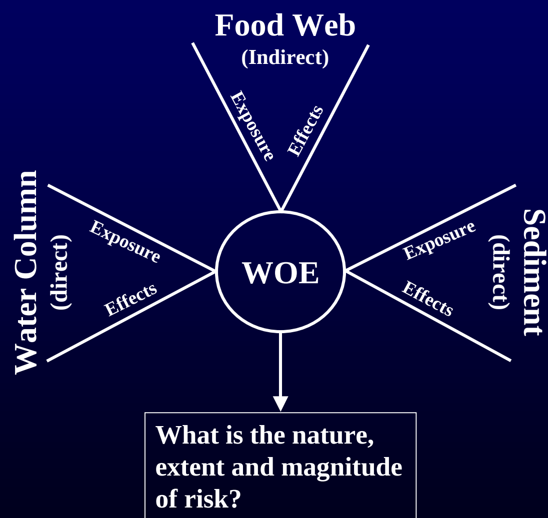
- Has cost been raised to a threshold criteria?
- Is the acceptable risk range between background and an ER-L?
- Is this a restoration project or cleanup project?
- Can the RPM/OSC explain it to someone else?

Developing Technically Sound Cleanup Targets

- Technical soundness
  - Using process-level information about the nature of risks (what, where, when and how they are occurring) to develop a scientifically credible and logical basis for reducing those risks
  - Draws upon the RI
  - Focuses on pathways



Lines and Weight of Evidence in Sediment Assessment



Clean-up Targets for Direct-Sediment Risks

- Risks defined using some combination of toxicity tests, SQGs, benthic community structure, and exposure data
  - Spatial extent of exposure, effect and risk
  - Duration/persistence of conditions

Spatial and Temporal Extent

- Defining the spatial distribution of exposure, effect, and risk
  - Site conditions, e.g., heterogeneity
- How persistent are the conditions?
  - Seasonal differences in toxicity
    - Changes in binding phases, AVS
    - Groundwater interactions
    - Other stresses
  - STD- sedimentation, transformation, degradation

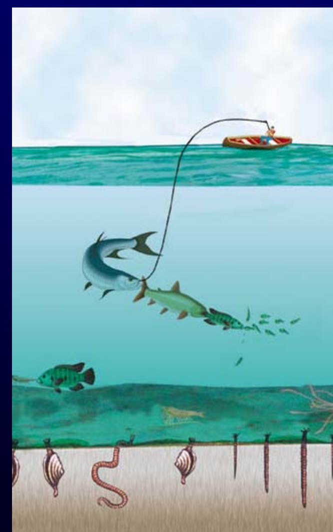
Gunpowder River APG Sampling Map
V. Emery, 1998

Clean-up Targets for Direct-Water Column Risks

- Exposures to dissolved or particulate-associated contaminant
  - Mediated through flux from the sediment bed
    - Chemical diffusion, groundwater advection, bioturbation, sediment resuspension and transport
  - A sensible cleanup target and remedy will match the exposure drivers to the management action
    - What is the exposure through the cap or after a sediment transport event?

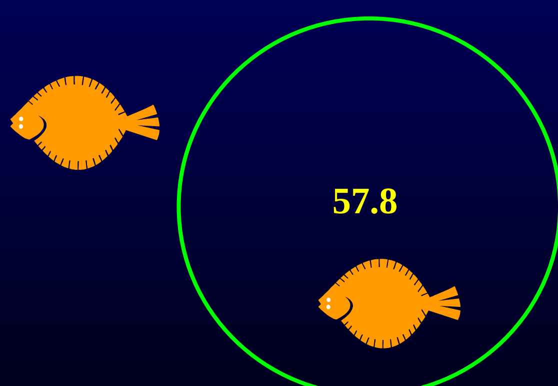
Clean-up Targets for Indirect-Food Web Risks

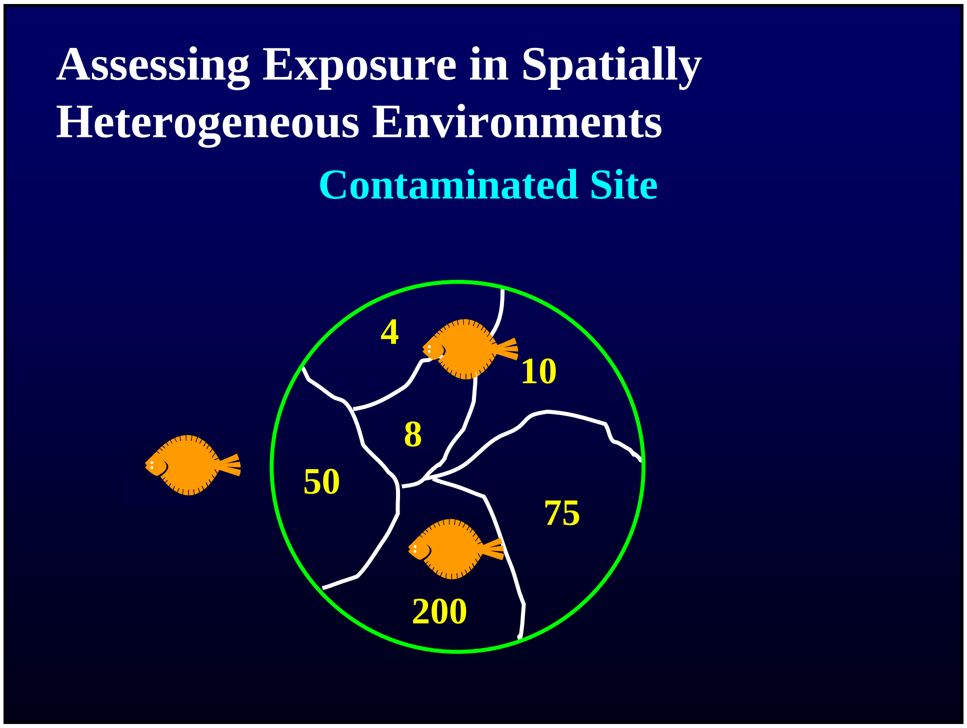
- Information to connect risks to the sediment
  - Field collected tissue
  - BSAFs, BAFs
    - Borrowed
    - Derived from site data
  - Bioaccumulation models
    - Steady-state
    - Time-varying

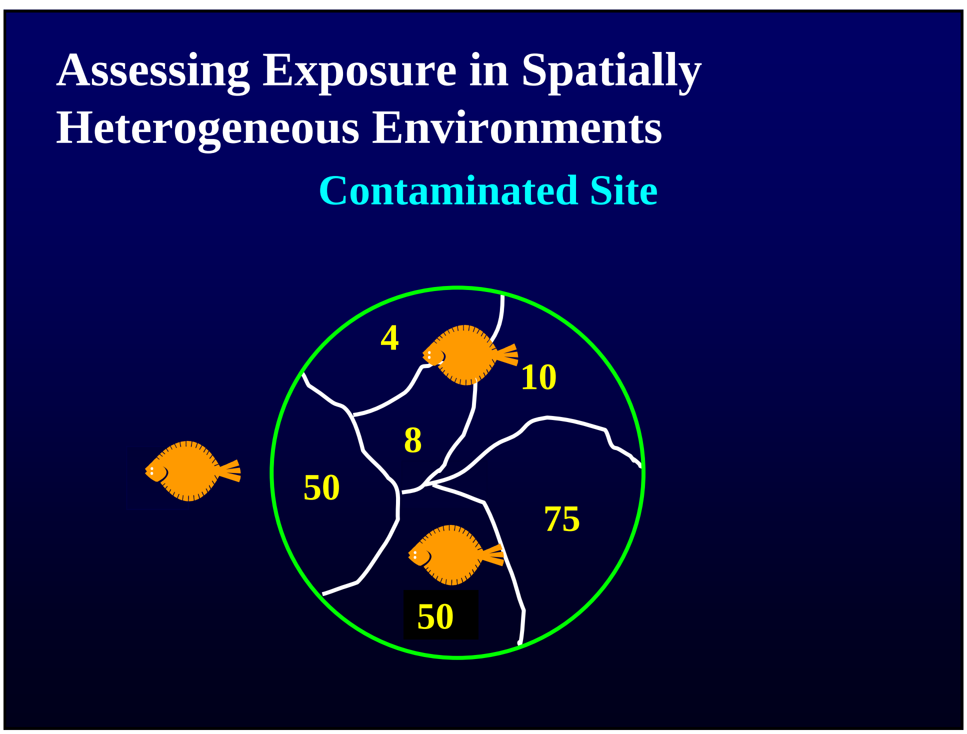


Assessing Exposure in Spatially Heterogeneous Environments

Contaminated Site

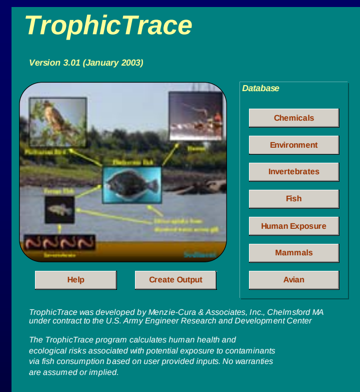



Assessing Exposure in Spatially Heterogeneous Environments
Contaminated Site
4
10
8
50
75
200


Assessing Exposure in Spatially Heterogeneous Environments
Contaminated Site
4
10
8
50
75
50

TrophicTrace

- Microsoft® Excel Add-In
- Estimate risks to fish, wildlife, humans
- Steady-state bioaccumulation model based on Gobas (1993 and 1995) for organics



- Uptake and trophic transfer of inorganics are modeled using empirical BCFs or Trophic Transfer Factors (TTF)
- www.wes.army.mil/el/dots

FishRand-Migration

Spatial Submodel
- •Habitat size
- •Fish abundance
- •Foraging area
- •Size of the site
- •Sediment concentrations
- •Water concentrations

Output: Time-varying (monthly) sediment and water concentrations to which fish are exposed

Bioaccumulation Submodel
- •Lipid content
- •Body weight
- •Food web characteristics
- •Physical-chemical properties of contaminant

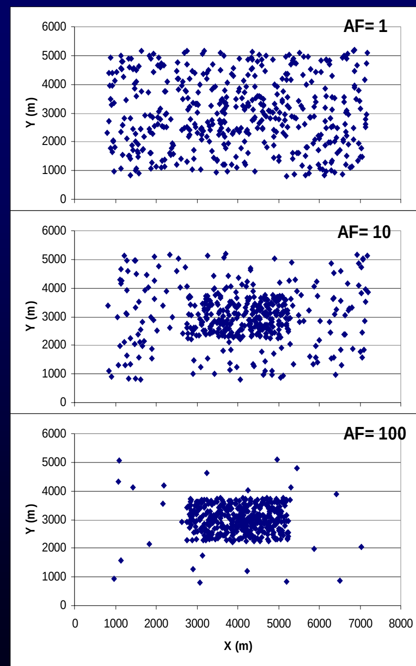
$$\frac{dC_f}{dt} = k_1 * C_{wd} + k_d * C_{diet} - (k_2 + k_e + k_m + k_g) * C_{fish}$$

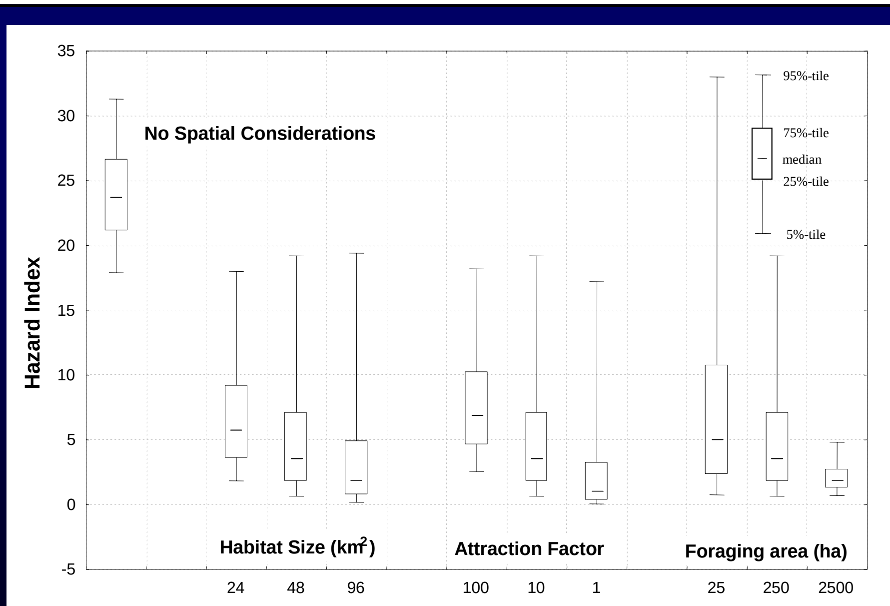
Output: Time-varying (monthly) predicted fish tissue concentrations

Risk Submodel
- •Human exposure parameters
- •Body weight
- •Fish ingestion rate
- •exposure duration
- •toxicity estimates

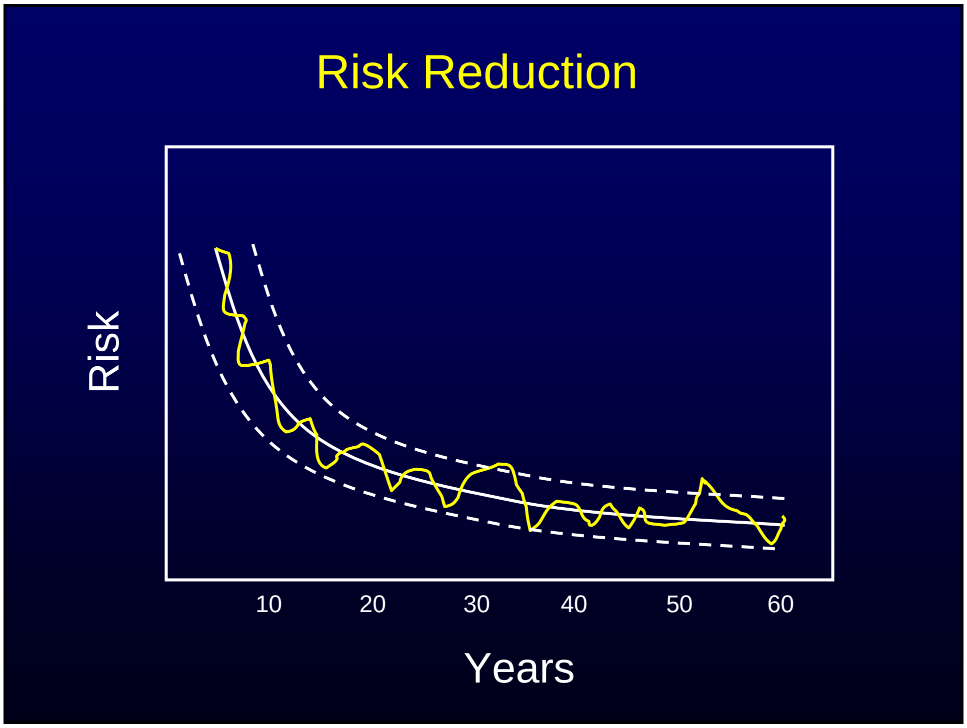
Spatial Issues in Exposure Assessment

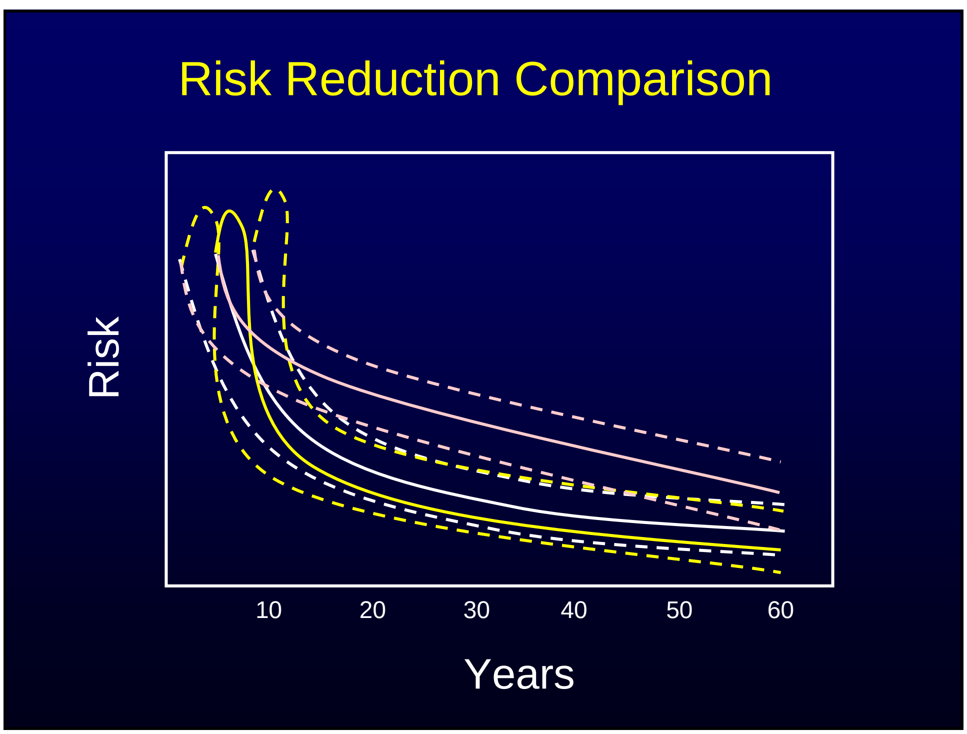
- Most sites are relatively small and heterogeneous
- Fish mobility varies among species
  - Many recreational and commercial species range over large areas
- How to account for variable habitat quality and use within a site?





Linkov, I., D. Burmistrov, J. Cura, T.S. Bridges. 2002. Risk-Based Management of Contaminated Sediments: Consideration of Spatial and Temporal Patterns in Exposure Modeling. *Environmental Science and Technology* 36:238-246.


Risk Reduction
Risk
10
20
30
40
50
60
Years


Risk Reduction Comparison
Risk
10
20
30
40
50
60
Years

Tidal Wetland in South San Francisco Bay

- Arsenic and zinc in marsh surface and marsh slough sediments
- Upland areas are remediated
- Surface water and groundwater contained/controlled

Tidal Wetland in South San Francisco Bay

- Endangered species:
  - clapper rail, forages in sloughs (invertebrates and fish)
  - salt marsh harvest mouse, forages on marsh surface (pickleweed)
- Rare marsh habitat

Ecological Risk Results

- As and Zn concentrations in sediment and water are not routinely elevated above ambient levels or above levels of potential concern
- Population studies showed the marsh supports robust populations of plants, invertebrates, fish, birds and small mammals
- Hazard quotients over 1 predicted for both background and site-related concentrations (potential for impacts on individuals).

ERA Conclusions & FS Approach

- No population-level risks
- Could be some risk to individual T&E species
- Next step: develop cleanup levels and identify remedial action zones
- Conduct Habitat Equivalency Analysis (HEA) for compensatory restoration
- Approach: incorporate restoration (wetland offset) as alternative in FS and carry into ROD

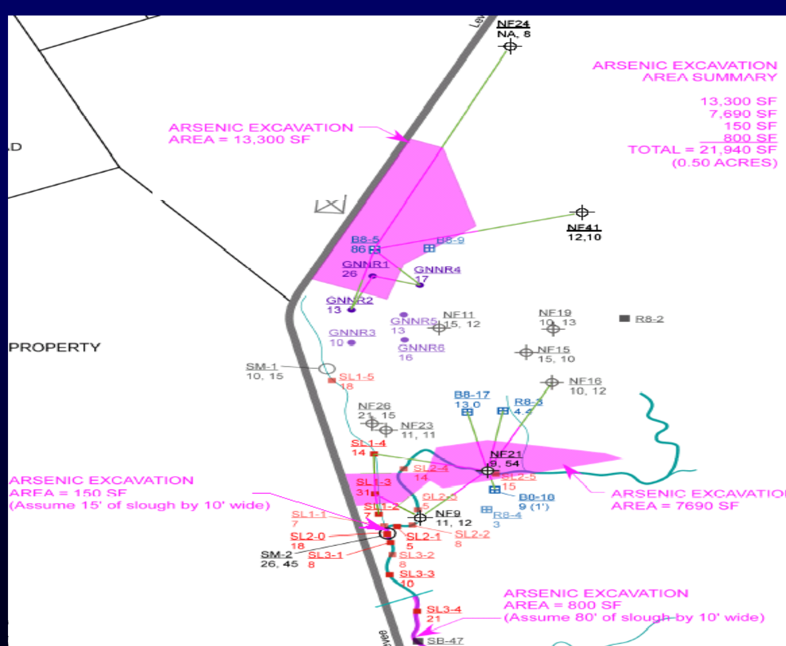
6. Sensible targets must take into account implementability

Estimation of Final Target Levels (mg/kg dry weight)

COC	Risk-Based Eco-threshold SMHM (low/high)	Risk-Based Eco-threshold CCR (low/high)	Max. Reference Marsh Conc.	Max. Reference Slough Conc.	SF Bay Ambient Level	Final Target Low Level (marsh/ slough)	Final Target High Level (marsh/ slough)
Arsenic	2.7/39	14/57	24	16	15	***24/16***	***39***
Zinc	197/8,430	23/227	201	107	158	***201/158***	***227***

Low targets are based on ambient/reference concentrations
High targets are lowest of high risk-based thresholds

Remedial areas based on low value and by area (marsh vs. slough)



Feasibility Study Framework

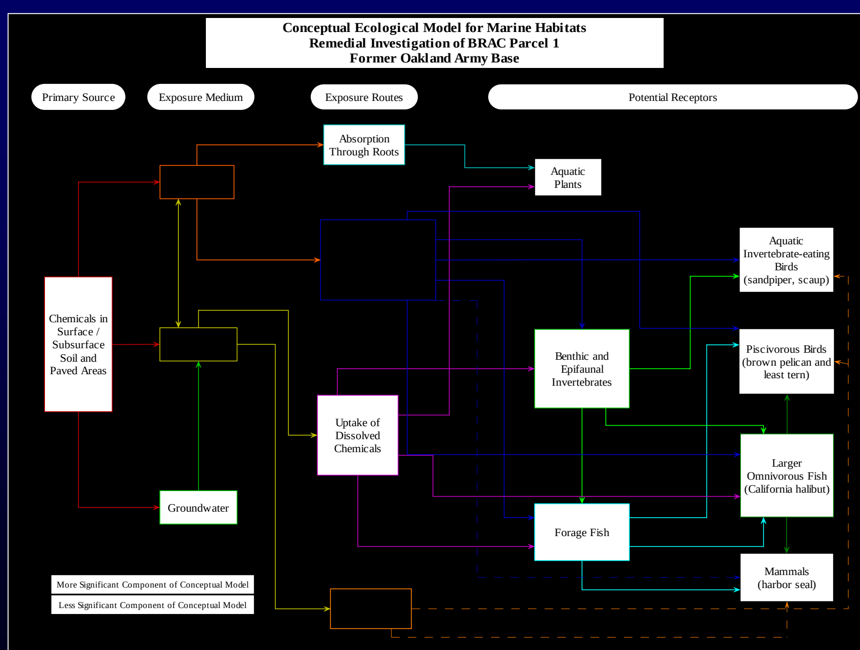
- Other aspects that made RPM/trustees comfortable
  - Source removed/controlled
  - Surface sediment concentrations getting lower due to deposition (natural recovery)
  - Habitat of high value
- FS and ROD
  - Monitored NR (erosion monitoring)
  - Restoration (wetland offset) as part of remedy and incorporated into ROD

Compensatory Restoration in Lieu of Habitat Destruction

- Final acreage:
  - As marsh surface: 0.48 acres
  - Zn marsh surface: 0.40 acres
  - As sloughs: 0.02 acres
  - Zn sloughs 0 acres
  - ***Total acreage: 0.90 acres***
- HEA showed roughly 0.7 acres owed (rounded to 1 acre for simplicity)

Oakland Army Base

- Former landfill and historic discharge from stormwater outfalls
- Area of concern: marine sediments offshore of parcel
- Chemicals of concern: PCBs and DDT
- Species of interest:
  - Intertidal: sandpiper; forages on invertebrates, small home range
  - Subtidal: least tern, lesser scaup, and pelican; forage on invertebrates and fish, larger home ranges

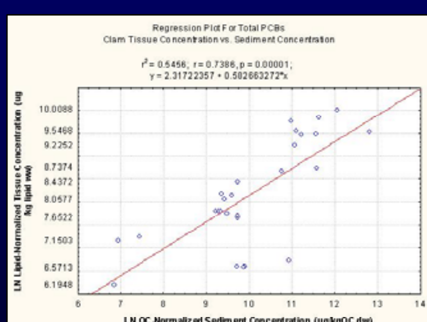


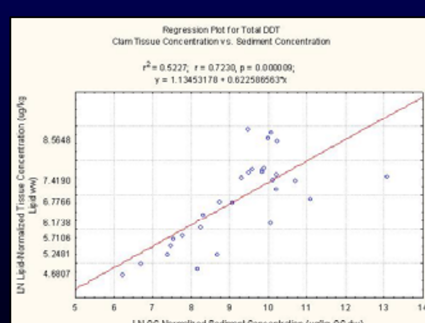
Cleanup Levels: General Approach

- Developed for wildlife receptors but considered protective of all receptors.
- Risk drivers chosen based on exceedance of Low Risk-Based Level for marine receptors, consideration of ambient/background levels and uncertainties.
- The primary route of exposure for each receptor/risk driver used to develop the cleanup level.
- Site-specific bioaccumulation data were used .
- The lower estimates of foraging ranges were used.
- Average of the high and low intake rates were used.

Combined conservative & average assumptions

Site-Specific BSAFs





Final Cleanup Levels

- Targets developed for each receptor and risk driver:
  - High TRV used to develop High target
  - Low TRV used to develop Low target
- Moderate target = Geomean of High and Low
- For each chemical risk driver, the target for the receptor with the lowest targets (i.e., the highest risks) was selected as the final cleanup level

Final Cleanup Levels

- Cleanup levels were normalized to TOC content of sediments because of :
  - strong relationship between bioavailability and TOC shown in bioaccumulation tests
  - wide range of TOC in the sediments.
- Separate cleanup levels were developed for risk drivers in the intertidal and subtidal zones because of foraging differences:
  - Sandpiper forages within the intertidal zone.
  - Least tern, brown pelican, and lesser scaup forage within the subtidal zone.

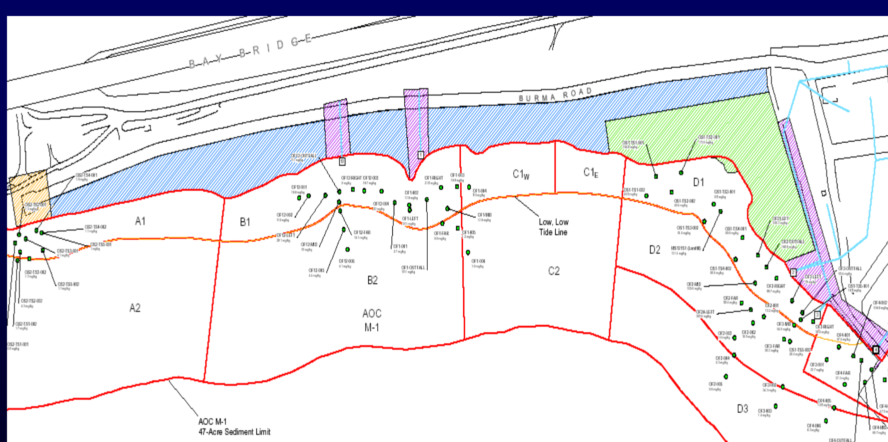
10. Tie your cleanup target back to the CSM

Final Step: Calculate Area-Weighted Concentrations

- Based on cleanup levels and technology limitations, remedial zones were developed
  - Agencies were comfortable with remedial approach
  - Agencies were uncomfortable with cleanup levels
- Pre-remediation concentrations and theoretical post-remediation concentrations were calculated and compared
- Purpose: to see if planned remediation not only achieved CLs, but reduced average concentrations to ambient (since entire Bay is impaired for the COCs).

9. Engage stakeholders in the "target" development

Post-Remedial Scenario



5. The law of diminishing returns
6. Evaluate cost per incremental added cleanup

Results

- Post-remediation concentrations were below SF Bay Ambient
- Next Steps
  - Frame cleanup levels and FS evaluation
  - Specify limitations on the use of the cleanup levels
  - Finalize the FS and begin Remedial Design

1. Does it pass the RPM laugh test?

Conclusions

- **Remember the "Top Ten Principles"**
- **Sensible targets are made in relation to a CSM and exposure pathways**

- **There is much room for improvement in how uncertainty is addressed in the process**
- **The specifics of the site will play a dominant role**