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Adaptive Use of Models and Data Collection to Improve Model Predictions for the Purpose of Decision Making

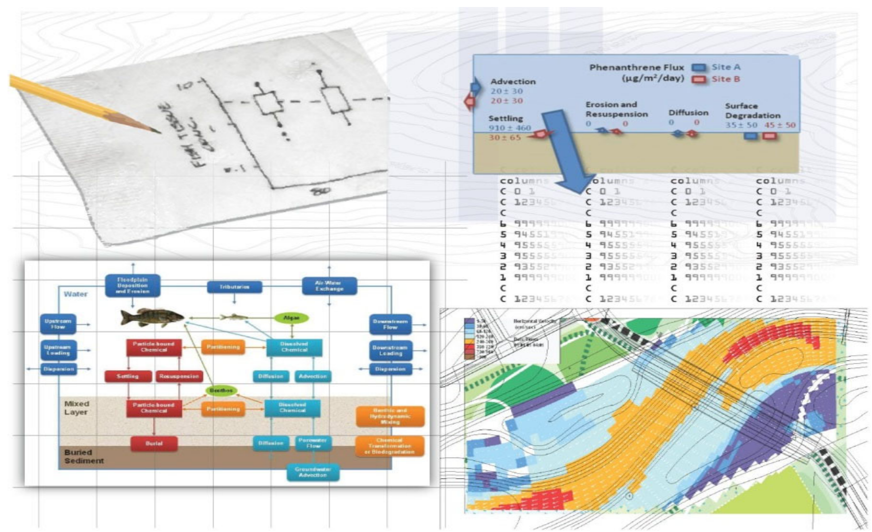
John Wolfe and Tim Dekker

10th International Conference on Remediation of Contaminated Sediments

February 12, 2019, New Orleans, Louisiana

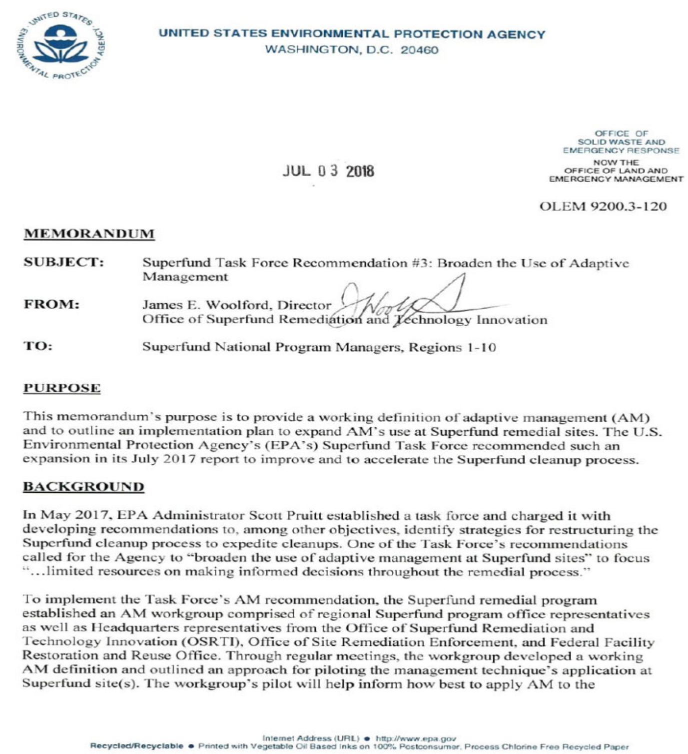
Models vs. Adaptive Management?

- Models are used to evaluate effectiveness of contaminated sediment remedies
- Model predictions are uncertain, especially for recovery after remedy implementation
- EPA supports adaptive management as a way to proceed under uncertainty
- Is adaptive management an alternative to predictive models?



EPA 2017 Task Force Recommendation: “Broaden the Use of Adaptive Management”

- Focus limited resources on making informed decisions throughout the remedial process
- Provide working Adaptive Management definition for Superfund projects
- Conduct Superfund site pilots



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE
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JUL 03 2018

OLEM 9200.3-120

MEMORANDUM

SUBJECT: Superfund Task Force Recommendation #3: Broaden the Use of Adaptive Management

FROM: James E. Woolford, Director
Office of Superfund Remediation and Technology Innovation

TO: Superfund National Program Managers, Regions 1-10

PURPOSE

This memorandum's purpose is to provide a working definition of adaptive management (AM) and to outline an implementation plan to expand AM's use at Superfund remedial sites. The U.S. Environmental Protection Agency's (EPA's) Superfund Task Force recommended such an expansion in its July 2017 report to improve and to accelerate the Superfund cleanup process.

BACKGROUND

In May 2017, EPA Administrator Scott Pruitt established a task force and charged it with developing recommendations to, among other objectives, identify strategies for restructuring the Superfund cleanup process to expedite cleanups. One of the Task Force's recommendations called for the Agency to "broaden the use of adaptive management at Superfund sites" to focus "...limited resources on making informed decisions throughout the remedial process."

To implement the Task Force's AM recommendation, the Superfund remedial program established an AM workgroup comprised of regional Superfund program office representatives as well as Headquarters representatives from the Office of Superfund Remediation and Technology Innovation (OSRTI), Office of Site Remediation Enforcement, and Federal Facility Restoration and Reuse Office. Through regular meetings, the workgroup developed a working AM definition and outlined an approach for piloting the management technique's application at Superfund site(s). The workgroup's pilot will help inform how best to apply AM to the

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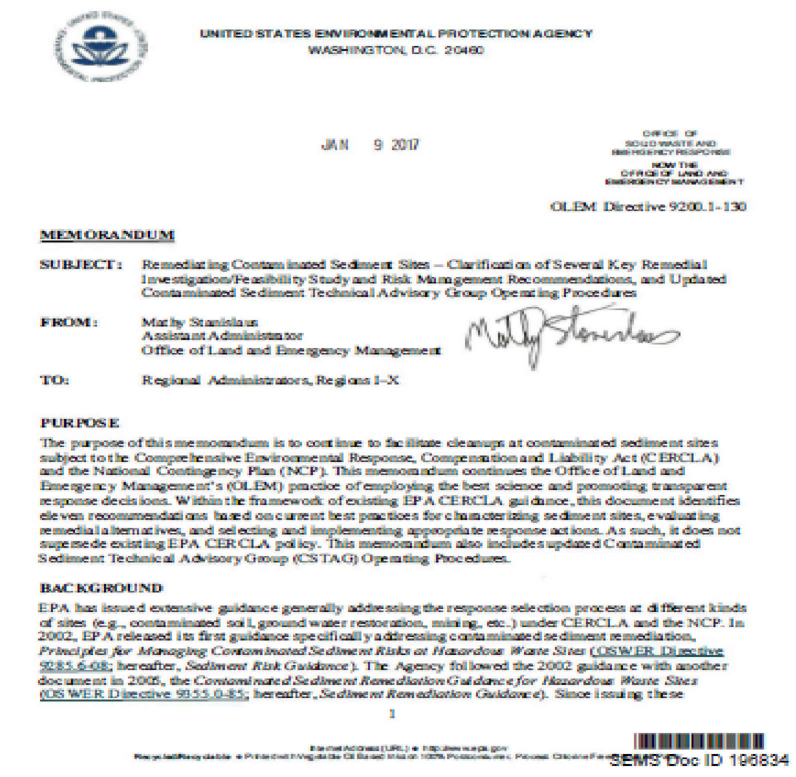
EPA 2018 Clarification of RI/FS Recommendations: "Consider Limitations of Models"

- "***Framework uncertainty*** … and ***parameter uncertainty*** … may limit a model's ability to provide and accurate … depiction of future conditions."
- The use of and comparisons among quantitative endpoints (*e.g.*, time to achieve a sediment or biota endpoint) should be made with a high degree of caution, if at all.



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OLEM Directive 9200.1-130

MEMORANDUM

SUBJECT: Remediating Contaminated Sediment Sites – Clarification of Several Key Remedial Investigation/Feasibility Study and Risk Management Recommendations, and Updated Contaminated Sediment Technical Advisory Group Operating Procedures

FROM: Mathy Stanislaus
Assistant Administrator
Office of Land and Emergency Management

TO: Regional Administrators, Regions I–X

PURPOSE

The purpose of this memorandum is to continue to facilitate cleanups at contaminated sediment sites subject to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Contingency Plan (NCP). This memorandum continues the Office of Land and Emergency Management's (OLEM) practice of employing the best science and promoting transparent response decisions. Within the framework of existing EPA CERCLA guidance, this document identifies eleven recommendations based on current best practices for characterizing sediment sites, evaluating remedial alternatives, and selecting and implementing appropriate response actions. As such, it does not supersede existing EPA CERCLA policy. This memorandum also includes updated Contaminated Sediment Technical Advisory Group (CSTAG) Operating Procedures.

BACKGROUND

EPA has issued extensive guidance generally addressing the response selection process at different kinds of sites (e.g., contaminated soil, ground water restoration, mining, etc.) under CERCLA and the NCP. In 2002, EPA released its first guidance specifically addressing contaminated sediment remediation, *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (OSWER Directive 9285.6-08; hereafter, *Sediment Risk Guidance*). The Agency followed the 2002 guidance with another document in 2005, the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (OSWER Directive 9355.0-85; hereafter, *Sediment Remediation Guidance*). Since issuing these

1

SEMS Doc ID 196834

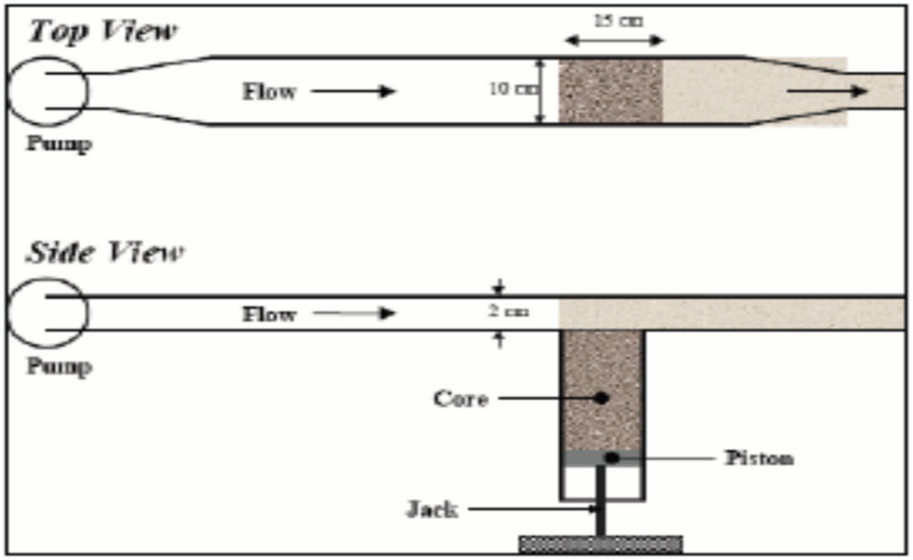
Is Adaptive Management an Alternative to Modeling?

- No, Adaptive Management is a structured and systematic learning process that depends on conceptual modeling and short-term prediction
- Adaptive Management strongly benefits from quantitative modeling, and is aligned with the real capabilities of models:
  - Models are well-suited to ~5-year Adaptive Management cycles
  - Models help identify monitoring methods and data to diagnose outcomes
  - Models can be used to anticipate effects of each round of action and set expectations of what's achievable

What About Model Limitations?
#1. Framework Uncertainties, Natural Systems

- Some complex processes are not completely understood
- We can’t adequately describe them with simple equations
- Notable example:
  – Erodibility of cohesive sediments

Figure 5.5. Schematic illustrating operating principles of SEDFLUME. Pictured are SEDFLUME channel, flow development region, testing section, and sediment core.



ERDC TR-14-9, September 2014

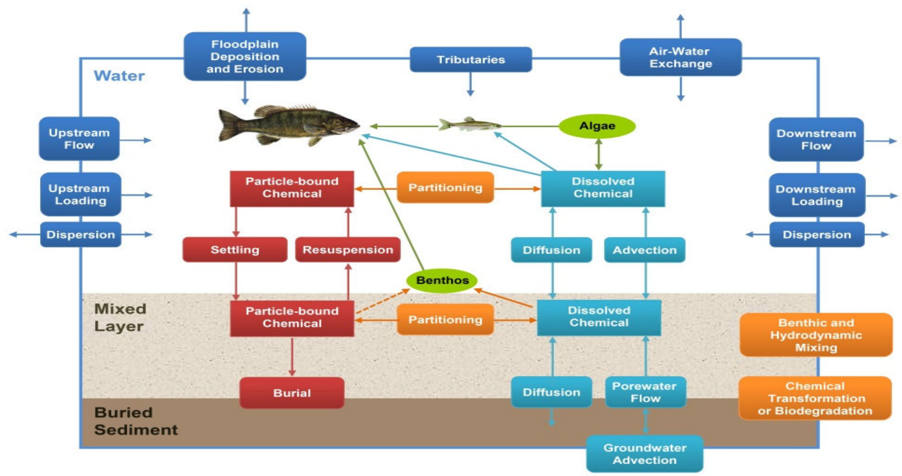
Limitation #2. Framework Uncertainties, Remedies

- Rates of release of contaminants after dredging
  - in suspension,
  - as generated residuals, and
  - in dissolved form
- How far do they go?

dredgingtoday.com

Limitation #3. Parameter Uncertainties

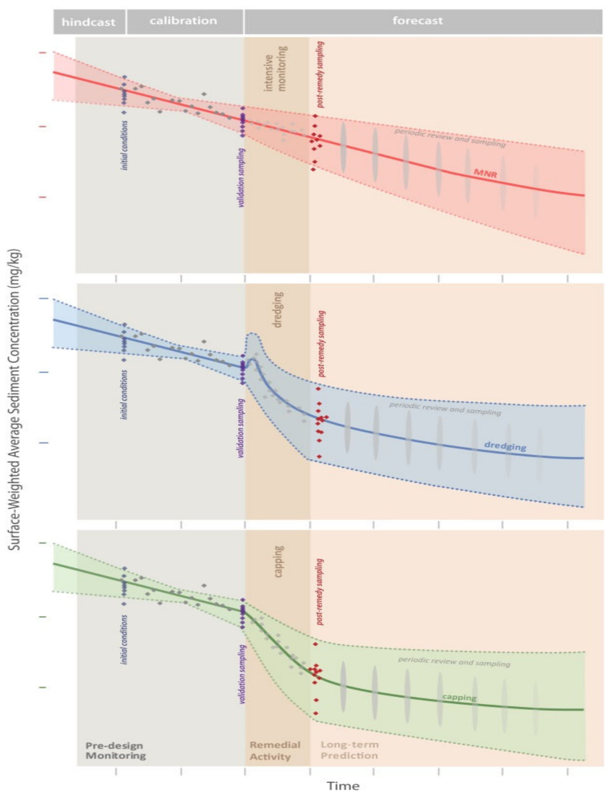
- Even for processes that are relatively well understood, data may be limiting
  - Behavior of chemical may differ in the lab vs. in a natural system
  - Data for calibration may limiting:
    - Long-term contaminant trends in all media
    - Response of system through high flow events
    - Watershed wet-weather loadings/recontamination



USEPA OSRTI SAMS #2

If Models Are So Uncertain, Why Use Them?

- Models are the way we use science to
  - inform data collection,
  - help interpret data, and
  - make predictions.
- There's no obvious substitute for predictive science to support these activities
  - Models can be simpler (conceptual site model) or more complex (numerical mechanistic models)



Adaptive Management of Renewable Resources (Holling and Walters, 1970's – 1980's)

- What fisheries harvest rates are sustainable?
- Can't be predicted in advance and must be learned through management experience
  - Piecemeal experimental components research is not sufficient
  - Systems are complex and dynamic, and to some extent inherently unknowable
- Management offers an opportunity for structured learning about the response of the system

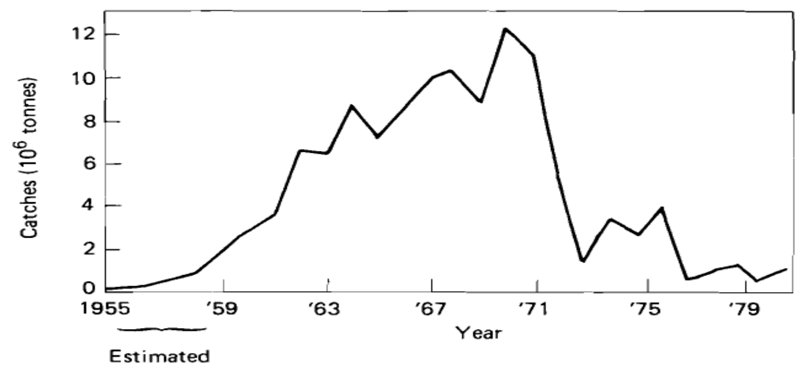


Figure 3.1. Development of the Peruvian anchoveta fishery. The sharp collapse in 1972–73 was apparently associated with a major oceanographic change known as El Niño. (*Figure 2.1* in *Adaptive Management of Renewable Resources.*)

Carl Walters, 1986. Macmillan.

Adaptive Management as a Structured Experiment

- Two approaches:
  - "Active": implement multiple management approaches, as comparative experiments
  - "Passive": implement the plan thought most likely to achieve goals, and learn from that
- <u>What it's not</u>: a trial and error series of actions, followed by *ad hoc* evaluations, retaining those that are judged successful

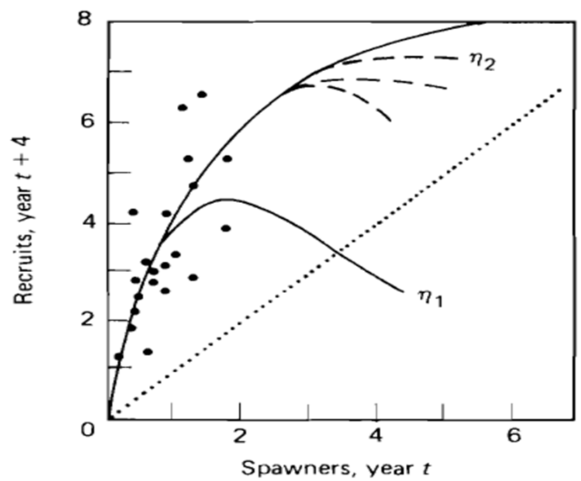


Figure 2.1. Relationship between number of sockeye salmon allowed to spawn in the Fraser River, BC, and number of resulting offspring measured as recruits to the fishery four years later. Data are for 1939–73, omitting every fourth (cycle) year beginning in 1942. The curves η_1 and η_2 are alternative extrapolations of response to increased spawning stock. η_2 predicts higher yields if more fish were allowed to spawn. (*Figure 1.1* in *Adaptive Management of Renewable Resources*.)

Elements of Adaptive Management as Systematic and Structured Learning[1]

- Goals & measurable indicators of progress
- Characterization of risks and uncertainties
- Implementation of remedy
- Systematic monitoring of outcomes
- Feedback loops and iterative decision-making
  - Monitoring → learning → decision-making
- Goal of reducing uncertainty over time

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1 Doremus et al., 2011. Making Good use of Adaptive Management

Where Does Modeling Fit In?

- Systematic learning requires a model to inform data collection and planning
  - To identify key uncertainties
  - To set expectations for actions, taking those uncertainties into account
  - To identify monitoring data that can reduce those uncertainties
  - To facilitate analysis of monitoring data once collected

Identifying Key Uncertainties Up Front

- For parameter uncertainties:
  - For processes that are well understood, evaluate the calibration and do sensitivity analyses
- For framework uncertainties:
  - Functional relationships are not well understood, so possibilities are more various
    - E.g. How much recontamination due to residuals generated by dredging? What factors are the drivers?
    - Credible competing hypotheses, consistent with pilots or data from other sites, should all be treated as possible

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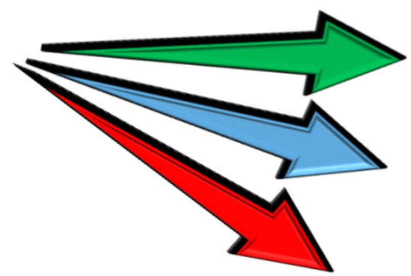
How Complex Do Models Need to Be to Support Adaptive Management?

- Renewable resource literature cautions against too much complexity
  - Simpler models may suffice to identify a range of alternatives consistent with data
  - Some detail may not matter with respect to the management experiment
    - e.g. Effectiveness of operations (e.g. thin sand cover quickly applied) to control residuals
- For adaptive management, models should not be so complex as to limit usefulness as learning tools
- Five-year time frames are well-aligned with needs of adaptive management

The Roles of Models in Planning Adaptation

- Simulate outcomes under full range of credible hypotheses
- Identify monitoring data that can distinguish between alternative outcomes
  - This may include pilot projects
- Use monitoring data to narrow the range of possibilities, improving predictions
- Simulate and implement iterative follow-up actions, if needed to achieve goals
- So models are not just for prognostication
  - also diagnostic, hypothesis testing, and data synthesis roles



Costs and Benefits

- Adaptive Management may not be right for every site It requires:
  - Up-front analysis of uncertainties and their implications
  - Systematic monitoring to support learning and adaptation
  - Periodic reassessments of conceptual models
  - Iterative decision-making and management
- Benefit: better understanding of responses of natural system to remedial action

Conclusions

- Some processes are less well understood, including consequences of active remedies
- Model those processes simply and consider the full range of possibilities
- Monitor, and continuously improve predictions to better achieve goals
- In these ways, models provide critical support for the structured learning that is a goal of adaptive management

Questions?

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