Risk-Informed Decision Making

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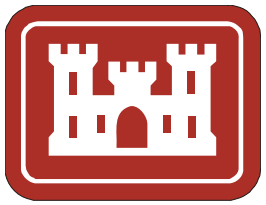
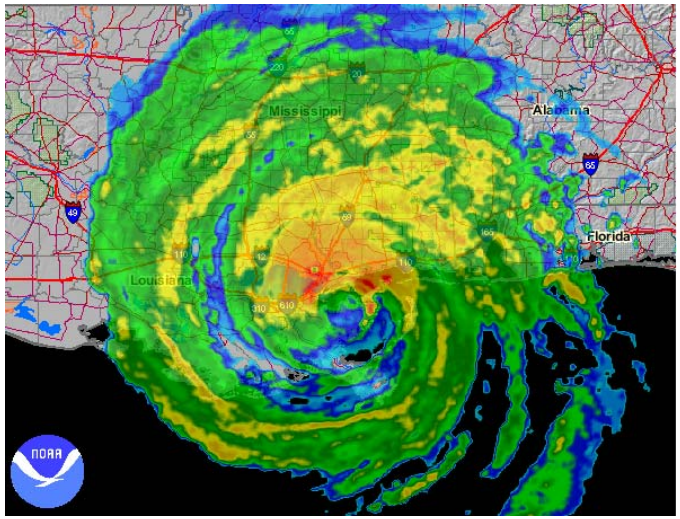


What is a risk-informed decision?

- A risk management decision that can be justified in terms of quantitative evidence about risk reduction, where
  - *risk* is the likelihood for all relevant adverse impacts
  - uncertainties are explicitly considered and processes are implemented to manage them
  - the investment is commensurate with the magnitude of the risks



"Transforming Practice to Apply Risk-Informed Decision Making." T.S. Bridges 2007
"Transforming the Corps into a Risk Managing Organization." D. Moser, T. Bridges, S. Cone, Y. Haimes, B. Harper, L. Shabman, C. Yoe. 2007

Risk Defined

Risk: The likelihood or probability for an adverse outcome

- Examples
  - Likelihood that a family picnic will be spoiled by inclement weather
  - Probability of injury resulting from a car accident
  - Likelihood that you will spend more than necessary on your next car purchase (or dredging project)

Our *Systems*

- We build and manage systems to achieve specific objectives
  - Navigation system:
    - locks, dams, channels
  - Reservoir system:
    - structures and operating procedures
  - Flood risk reduction system:
    - Structural, nonstructural, ecosystem features
  - Ecosystem features comprising a restoration project

The USACE Navigation Mission:

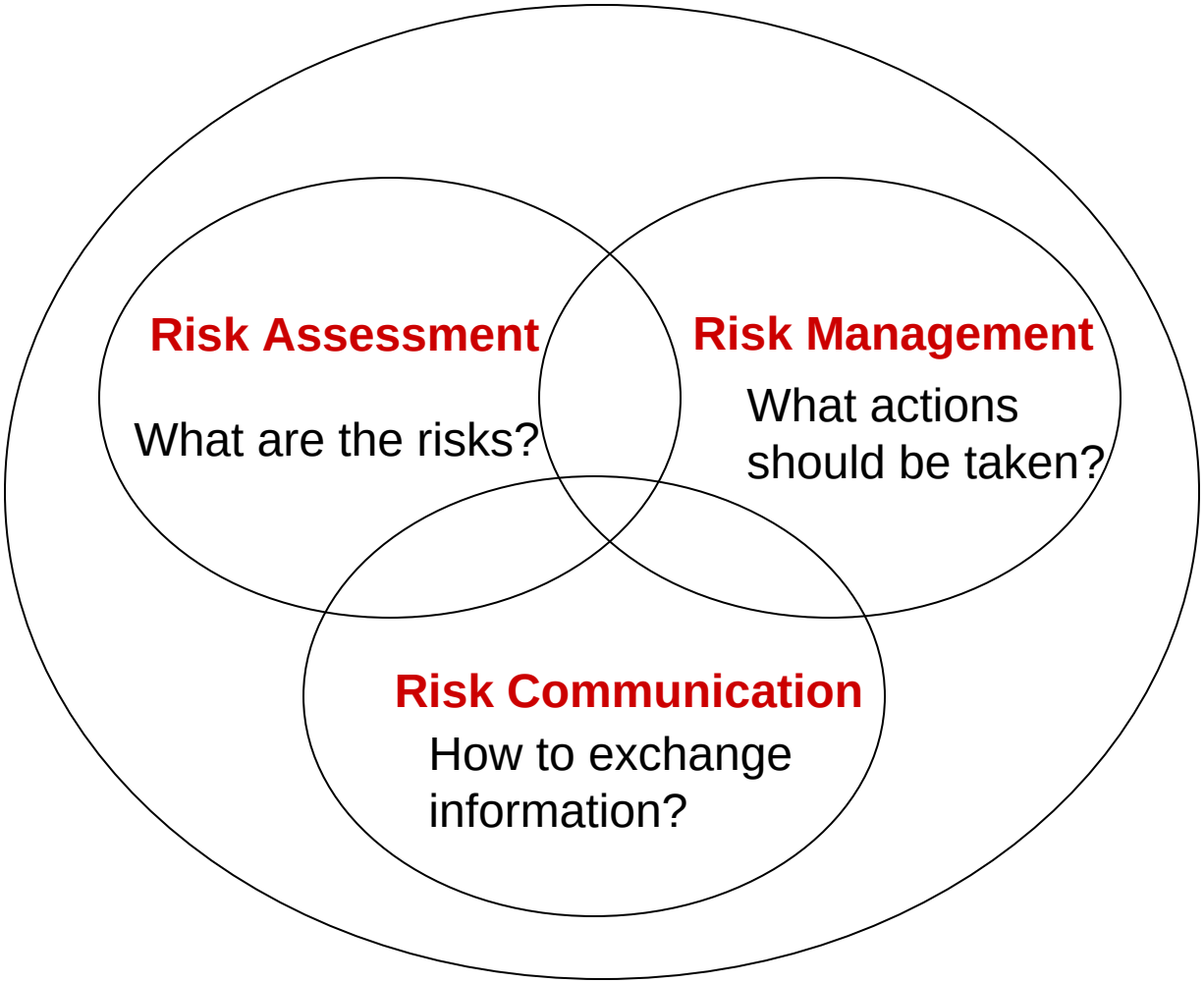
To provide safe, reliable, efficient, effective and environmentally sustainable waterborne transportation systems for movement of commerce, national security needs, and recreation

- Observations
  - The Corps' navigation mission involves multiple objectives
  - Managing the risks relevant to these objectives requires making tradeoffs

What risks are we concerned about?

- Economic losses associated with reduced performance of a channel
- Environmental impacts associated with dredging
- Environmental impacts associated with DM placement, disposal, or beneficial use
- Navigation accidents
- Unnecessary costs for the dredging program
- Environmental impacts associated with contaminated sediments when dredging must be deferred

Risk Analysis



Risk-Informed Decision Making

- *Risk Assessment*: an approach to developing an understanding of the processes shaping the scope and nature of risks and uncertainties that is sufficient to support decision making
  - What is the risk?
  - Why and how are the risks occurring?
  - What is the uncertainty associated with the risk estimate?

Risk-Informed Decision Making

- *Risk Management*: a process to evaluate, select, implement, monitor and modify actions to alter levels of risk
  - What are my decision alternatives?
  - How will I evaluate the performance of those decision alternatives?
  - How do the decision alternatives differ in terms of risks?
  - What are the tradeoffs in terms of costs, benefits, and risks among the alternatives?

Risk-Informed Decision Making

- *Risk Communication*: exchange of information about risks that supports deliberation and decision-making
  - Why are we communicating?
  - With whom are we communicating?
  - How will we communicate?
  - What are we communicating?

The Multidimensional Nature of Risk

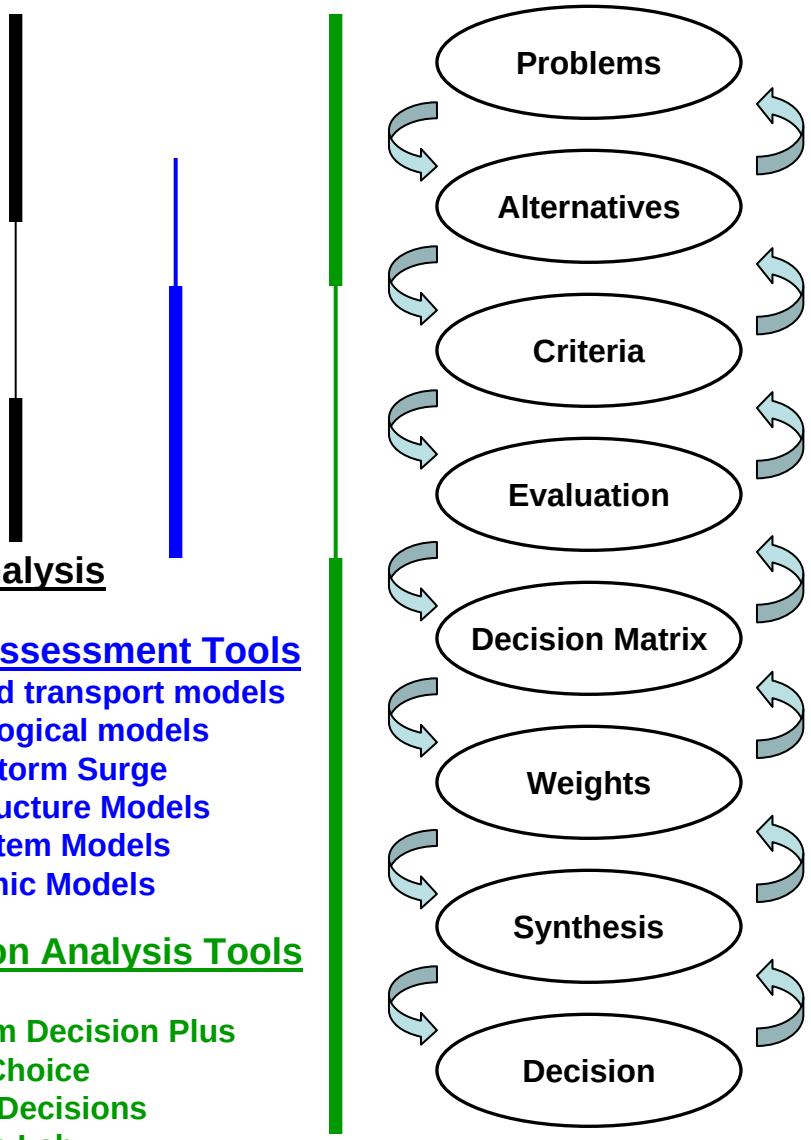
- Two aspects
  - Diverse nature of the outcomes of interest
    - Could include: human health and safety, economics, environmental impacts, affects on social systems, etc.
  - Human dimensions
    - Human responses to risk are a function of human values, risk perceptions and risk attitudes

Risk-Informed Decision Making

- An approach for structuring and analyzing risk-decision problems
- Emphasis given to:
  - Defining the problem
  - Establishing explicit objectives
  - Defining metrics for evaluating alternative solutions/plans
  - Incorporating human values and risk attitudes
    - Through weighting and utility functions
  - Ranking plans based on quantitative scores derived from metrics
    - Using multi-attribute utility theory

Risk-Informed Decision Making

Risk and Decision Analysis Framework



Scenario Analysis

Risk Assessment Tools

- Fate and transport models
- Toxicological models
- Wave/Storm Surge
- Infrastructure Models
- Ecosystem Models
- Economic Models

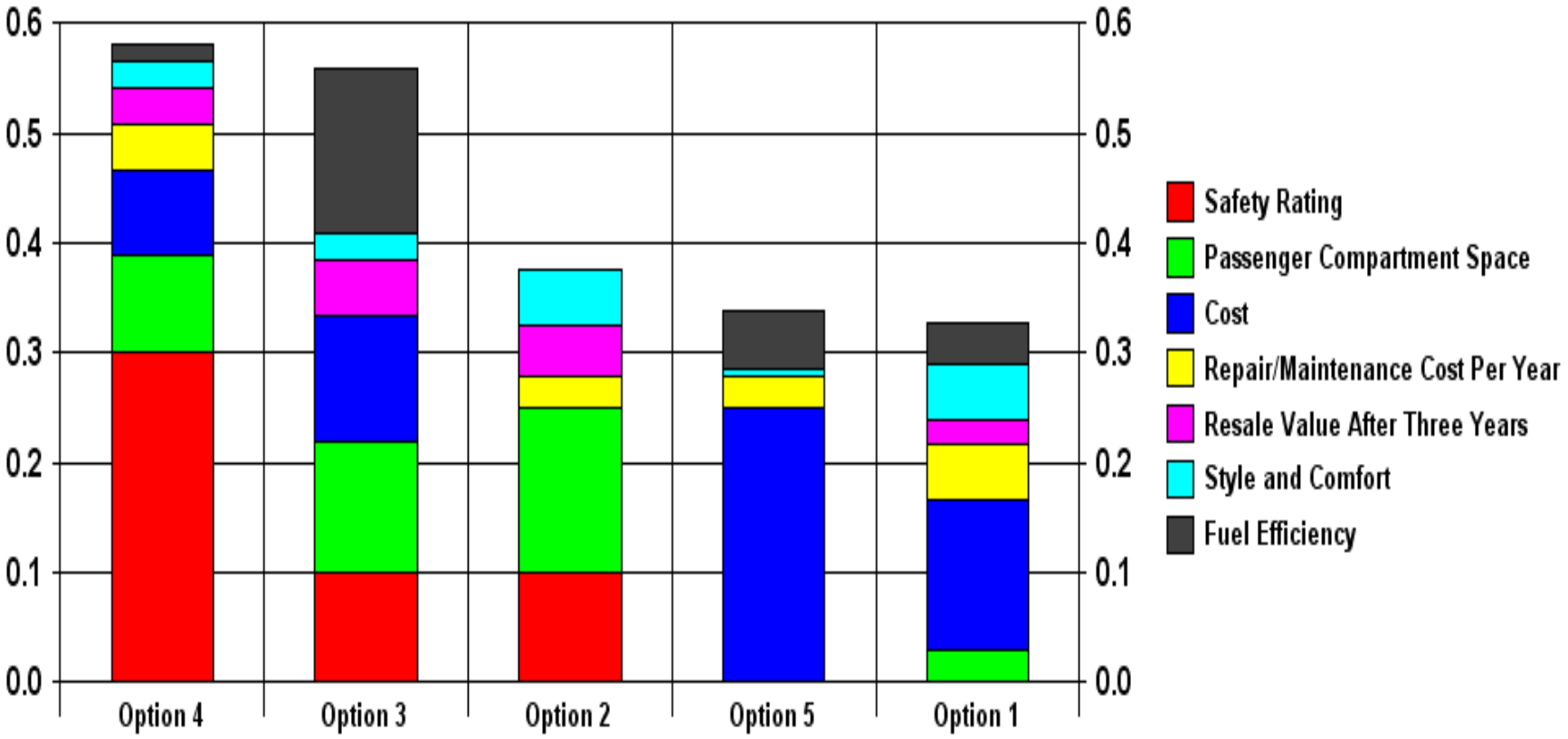
Decision Analysis Tools

- MAUT
- Criterium Decision Plus
- Expert Choice
- Logical Decisions
- Decision Lab

A Familiar Decision: Buying a Car

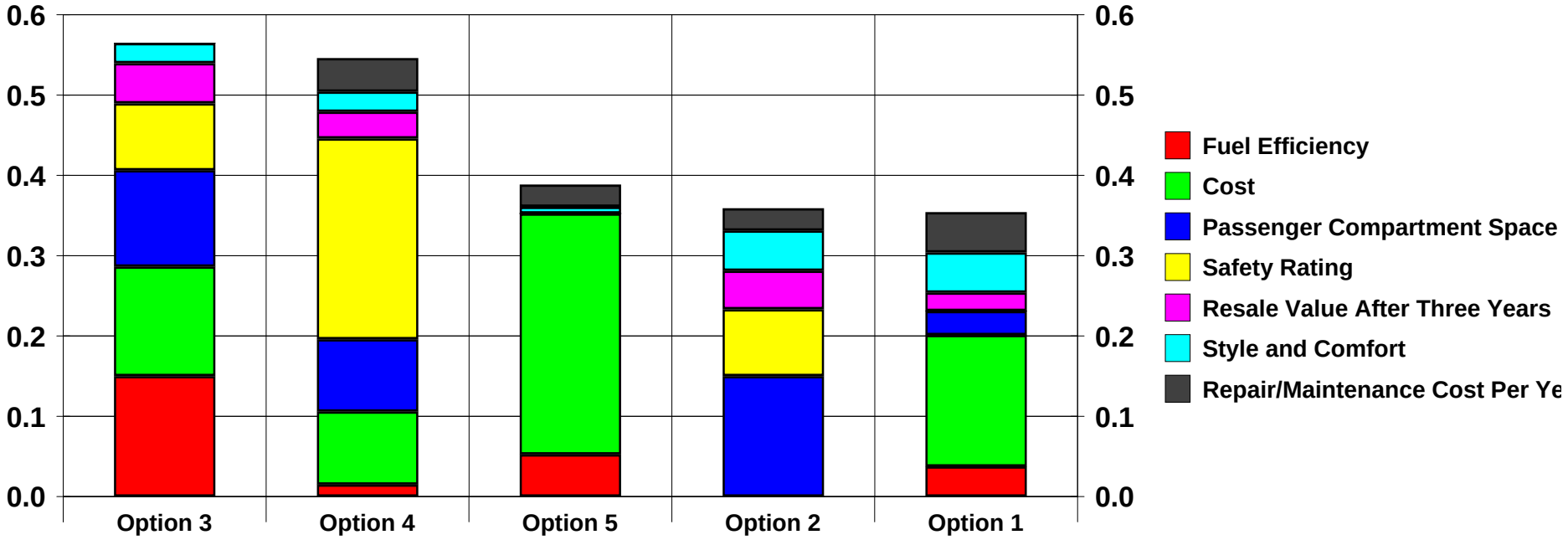
Metric (Weight)	Units	Cars				
		Option 1	Option 2	Option 3	Option 4	Option 5
Cost (25)	Dollars	27,000	45,000	30,000	35,000	12,000
Resale Value After Three Years (5)	% of Original Value	44	56	57	49	33
Repair/Maintenance Cost Per Year (5)	Dollars	100	500	1,000	250	500
Fuel Efficiency (15)	MPG	30	25	45	27	32
Passenger Compartment Space (15)	ft^3	150	170	165	160	145
Style and Comfort (5)	Qualitative	Finest	Finest	Average	Average	Poor
Safety Rating (30)	NHTSA Safety Rating	2	3	3	5	2

Ranking and Contributions by Metric



Ranking Sensitivity to Weight Allocation

Cost: 25 to 30 Safety: 30 to 25

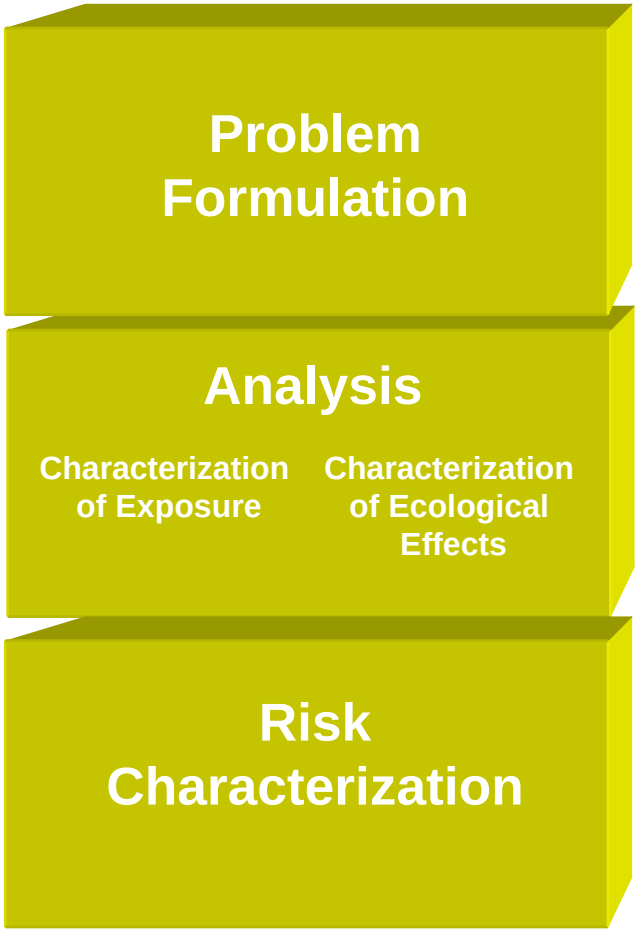


Environmental Risk Assessment

Components of ERA

- Problem Formulation
- Analysis
  - Characterization of Exposure
  - Characterization of Ecological Effects
- Risk Characterization

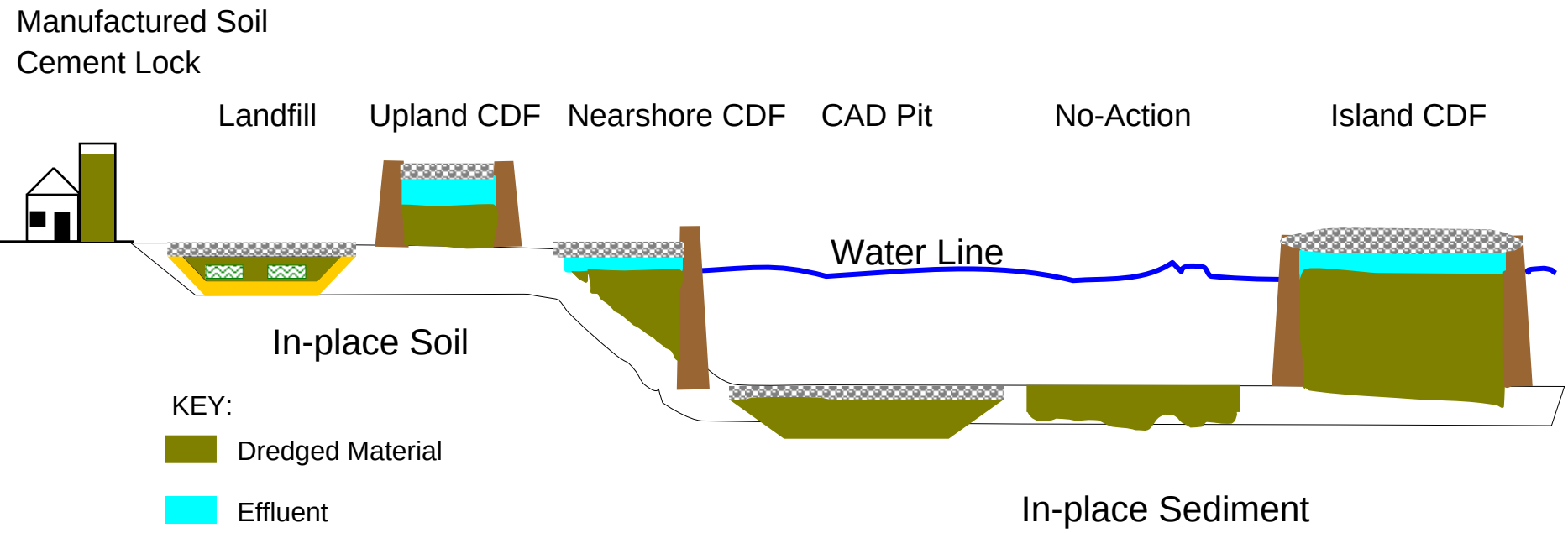
There are approaches for evaluating risks for other objectives



Existing Guidance

- **U.S. Army Corps of Engineers. 1999. Risk Assessment Handbook Volume I: Human Health Evaluation. EM 200-1-4 http://www.usace.army.mil/inet/usace-docs/eng-manuals/em200-1-4/toc.htm**
- **U.S. Army Corps of Engineers. 1996. Risk Assessment Handbook Volume II: Environmental Evaluation. EM 200-1-4 http://www.usace.army.mil/inet/usace-docs/eng-manuals/em200-1-4vol2/**
- **Cura, J.J., Heiger-Bernays, W., Bridges, T.S., and D.W. Moore. (1999). Ecological and human health risk assessment guidance for aquatic environments. Technical Report DOER-4, US Army Corps of Engineers, Engineer Research and Development Center, Dredging Operations and Environmental Research Program, December. http://el.erdc.usace.army.mil/dots/doer/pdf/trdoer4.pdf**
- **U.S. Environmental Protection Agency (USEPA). (1989). Risk Assessment Guidance for Superfund, Volume 1 – Human Health Evaluation Manual, Part A, Interim Final. EPA/540/1-89/0002. Publication 9285.7-01A. Office of Emergency and Remedial Response, Washington, D.C. http://www.epa.gov/superfund/programs/risk/tooltrad.htm#gdec**
- **U. S. Environmental Protection Agency. (USEPA). (1997a). Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (interim final). Environmental Response Team, Edison, NJ. http://www.epa.gov/superfund/programs/risk/tooltrad.htm#gdec**
- **United States Environmental Protection Agency (USEPA). (1998). Guidelines for Ecological Risk Assessment. USEPA EPA/630/R095/002F 01 APRIL 1998. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, 175 pp. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460**

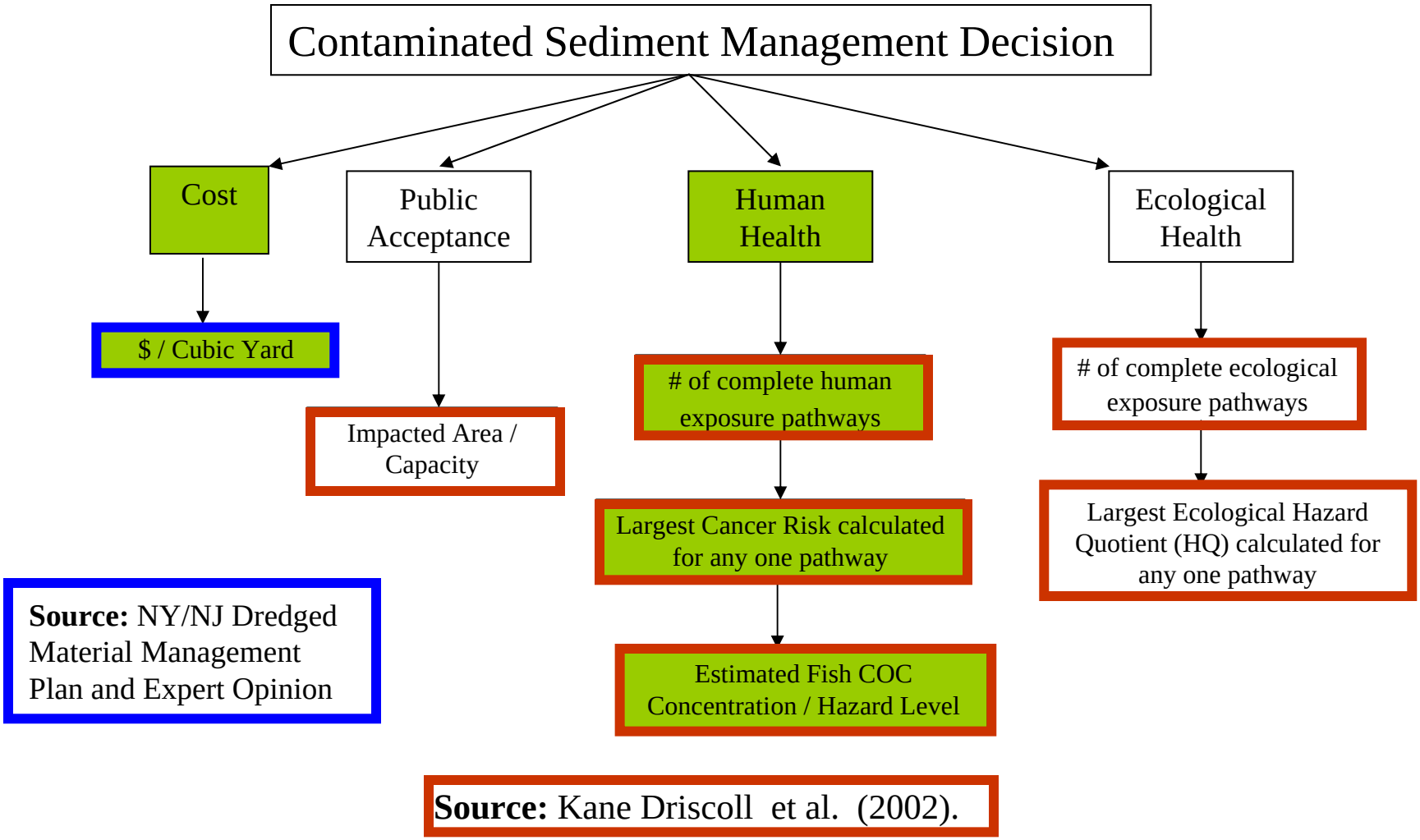
Comparing Alternatives



Kane Driscoll, S.B., W.T. Wickwire, J.J. Cura, D.J. Vorhees, C.L. Butler, D.W. Moore, T.S. Bridges. 2002. A comparative screening-level ecological and human health risk assessment for dredged material management alternatives in New York/New Jersey Harbor. *International Journal of Human and Ecological Risk Assessment* 8: 603-626.

G. A. Kiker, T. S. Bridges, J. B. Kim. 2008. Integrating Comparative Risk Assessment with Multi-Criteria Decision Analysis to Manage Contaminated Sediments: An Example From New York/New Jersey Harbor. *Human and Ecological Risk Assessment* 14:495-511.

Decision Criteria: NY/NJ Harbor



Criteria Levels for Each NY DM Alternative

	Cost	*Public Acceptability*	*Ecological Risk*		*Human Health Risk*		
DM Alternatives	($/CY)	Impacted Area/Capacity (acres / MCY)	Ecological Exposure Pathways	Magnitude of Ecological HQ	Human Exposure Pathways	Magnitude of Maximum Cancer Risk	Estimated Fish COC / Risk Level
CAD	5-29	4400	23	680	18	2.8 E -5	28
Island CDF	25-35	980	38	2100	24	9.2 E -5	92
Near-shore CDF	15-25	**6500**	38	900	24	3.8 E -5	38
Upland CDF	20-25	**6500**	38	900	24	3.8 E -5	38
Landfill	29-70	0	0	0	21	3.2 E –4	0
No Action	**0-5**	0	**41**	**5200**	12	2.2 E –4	**220**
Cement-Lock	**54-75**	0	14	0.00002	**25**	2.0 E -5	0
Manufactured Soil	54-60	750	18	8.7	22	**1.0 E –3**	0

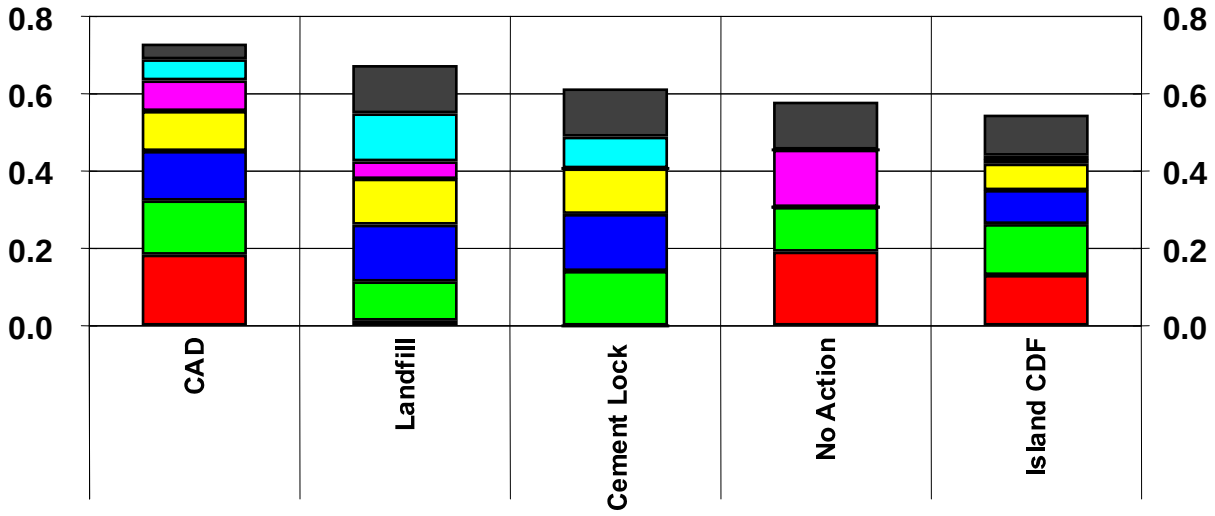
Blue Text: Most Acceptable Value

Red Text: Least Acceptable Value

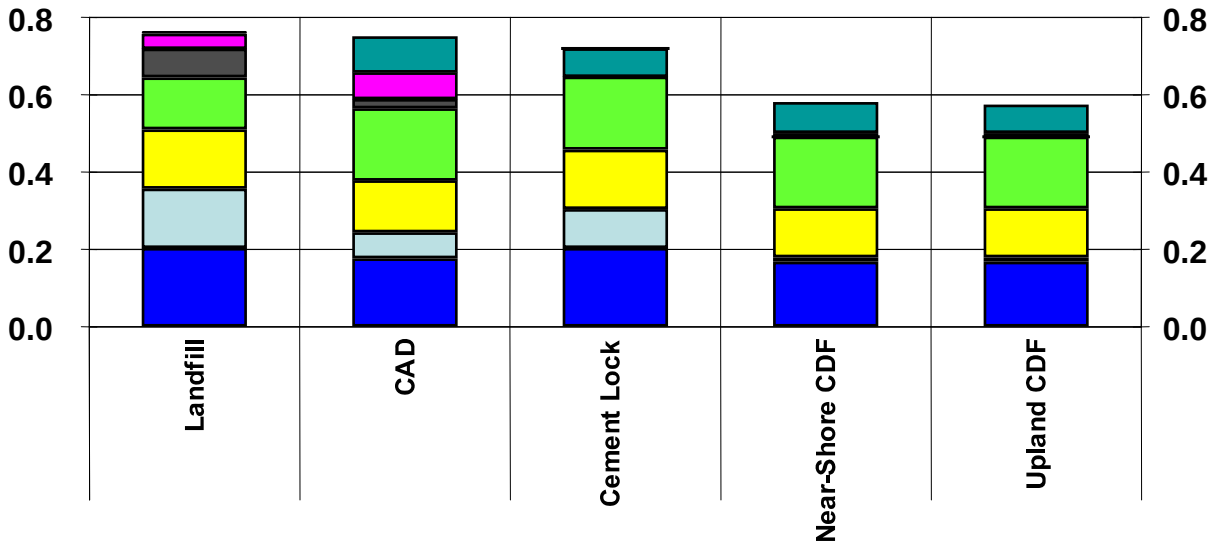
USACE/EPA Survey Results: Criteria Weights (%)

	EPA	USACE
Public Acceptability	7.4	12.5
Ecological Health	35.6	27.1
Human Health	47.0	40.7
Cost	10.0	19.7

Criteria Contributions to Decision Score



USACE weighting



EPA weighting

- Cost
- Maximum Cancer Probability (Non-Barge Worker)
- Ecological Hazard Quotient
- Est. COC Conc in Fish / Risk-based Conc
- Complete Human Health Exposure Pathways
- Complete Ecological Exposure Pathways
- Ratio of Impacted Area to Facility Capacity

Adaptive Management

- Uncertainty is inherent to planning, design, construction, and O&M
- Adaptive management requires a framework for collecting and using information that results from:
  - Implementing a plan
  - Monitoring the performance of the plan
  - Learning
- The RIDM provides a suitable approach

The Path Forward

- 3 principles relevant to transforming practice
  - RIDM is based upon a comprehensive assessment of risks
  - Deliberation is essential to the successful resolution of risk-decision problems
  - Transforming practice requires commitment to change, experimentation, and learning