Workshop Report: Advancing the Art of Analyzing Risks and Benefits of Dredged Material Management

James D. Wilson

May 2002 • Discussion Paper 02–16

RESOURCES
FOR THE FUTURE

Resources for the Future
1616 P Street, NW
Washington, D.C. 20036
Telephone: 202–328–5000
Fax: 202–939–3460
Internet: http://www.rff.org

Workshop Report: Advancing the Art of Analyzing Risks and Benefits of Dredged Material Management

James D. Wilson

Abstract

The U.S. Army Corps of Engineers has been delegated responsibility for assuring the navigability of waters designated for that purpose in the United States. Dredging is among the activities required to fulfill this responsibility. In some places, the Corps finds difficulty in carrying out dredging projects because it lacks spaces where the sediments that must be removed ("dredged materials") can be placed or otherwise managed. In these cases, the public has expressed concerns about the impacts of dredged materials on the environment, either underwater or on land ("upland"). Thus, the Corps often finds it necessary to be able to evaluate and describe the costs or risks and the benefits of the possible alternatives that may be available. Scientists and engineers at the Engineer Research and Development Center (ERDC) in Vicksburg, MS, are responsible for advising Corps District and Division project managers concerning methods to evaluate these risks and benefits. The ERDC asked Resources for the Future (RFF) to organize a workshop for key management and technical people within the Corps and selected outside experts to explore directions the Corps might take in order to improve those methods.

Key Words: dredging, risk, benefit, cost, analysis, characterization, accidents, mixtures, sediments, non-use benefits, decision tools

Contents

Workshop Report: Advancing the Art of Analyzing Risks and Benefits of Dredged Material Management

James D. Wilson

Summary

Resources for the Future (RFF), in conjunction with the U.S. Army Corps of Engineers Waterways Experiment Station (Vicksburg, MS), organized a workshop that addressed possible new directions for analysis of risks and benefits of various possibilities for managing dredged materials. Participants included six Corps staff associated with the navigation dredging program, three EPA staff (two with the office that oversees ocean dumping, one from research), three experts who consult for the Corps, and four experts on risk and cost-benefit analysis who had no prior contact with the dredging program. The workshop was held in Tilghman Island, MD, October 31 - November 2, 2001.

One impetus for the workshop was a perception that the Corps' methods and practices for risk/cost/benefit characterization may need improvement. In particular, analysts and some senior managers feel the need for methods that provide non-technical people an understanding of the real differences among decision alternatives. Some participants also expressed a hope that improved and consistent characterization methods might help address the problem of inconsistencies among different Corps Districts.

Principal Observations:

- An unsustainable drain exists on senior management and technical resources available for dealing with "problem" navigation dredging projects. It occurs primarily because significantly contaminated sediments are not usually encountered in navigation channels (a few harbors excepted), and thus few project managers learn how to manage them effectively. Both methodologic and cultural / management barriers stand in the way of diminishing this drain. One principal problem seems to be getting project managers to call for help sooner rather than later. Another situation causing resource drains is "out of process" decisions.

- For normal projects, the decision analytic process and associated methods used by the Corps serves project managers well. Further, the Corps' economic and risk analysis practices are

generally satisfactory, and the technical staff can adequately assess risks and benefits associated with both normal and contaminated-sediment projects.

- The Corps' navigation dredging program seems to lack adequate understanding of non-market costs and benefits that may accrue from different ways to manage dredged materials, although the techniques for estimating these costs and benefits are well known to Corps economists. The Corps does not attempt to estimate non-use benefits. Nevertheless, although the navigation dredging program has evolved a rough understanding of the non-use values associated with its materials management options, it may benefit from a better understanding of these values.
- The approach used for risk assessment is excellent. However, health risk assessment methods have limitations, and confusion exists regarding appropriate standards for contaminants in sediments, especially regarding consumption of fish and seafood that may be or become contaminated from dredged materials. The Corps does lack systematic methods for assessing and characterizing accident risks .
- The Corps may lack the necessary methods for characterizing and presenting consequences of different options.
- Among management / cultural issues to consider, different levels of performance among Districts burdened with highly-visible “problem” projects may suggest a need for altering what is expected of senior management. The “stovepipe” organizational ethos of the Corps seems to inhibit the ability of project managers to learn how to deal with surprises.

Recommended Directions

1. *Develop a new project management framework for "problem" projects, especially when public involvement occurs.*
2. *Increase the Corps' knowledge of stakeholders (the public and others) and their values, both local and national.*

3. *Continue to upgrade project managers' skills (including cultivating relations with stakeholders).*

4. *Evaluate methodologic needs and identify ways to fill them, particularly,*
    - *risk-cost tradeoff for internal planning,*
    - *communications plans, methods, tools*
    - *food safety standards for non-commercial fish and shellfish.*

5. *Evaluate utility to the Corps of*
    - *adjusting requirements (job) of senior management positions in navigation dredging.*
    - *Long-term forward planning for foreseeable materials management problems*

6. *Develop plans for working with USDA and EPA over the long term to reduce sediment inputs to navigable streams.*

7. *Consider reviewing the appropriateness of judging value of navigation dredging projects only by a differential in direct "use" benefits.*

8. *Build communication and public participation efforts into all projects that deal with contaminated sediments, matching the level of effort to the issues involved.*

Introduction

Resources for the Future (RFF), in conjunction with the U.S. Army Corps of Engineers Waterways Experiment Station (Vicksburg, MS), organized a workshop that addressed possible new directions for analysis of risks and benefits of various possibilities for managing dredged materials. This report describes the program, key findings, and recommendations from that workshop. The Corps commissioned the workshop because it finds itself using senior management and technical resources at an unsustainable rate in the navigation dredging program. In addition, in too many cases it spends too much money on the dredging projects themselves. Both of these require unnecessary expenditure of public resources. They occur because of difficulties in identifying acceptable ways to manage dredged materials, ways that maximize effectiveness of public spending while also meeting the various needs of the affected public. The Corps' intent is to improve its risk/benefit analytical methods in order to: a) reduce transaction costs during materials management decisionmaking, b) head off—to the extent possible—out-of-process decisions, and c) enhance consistency of decisionmaking across Regions and Districts.

Description of the Program

The Workshop was held October 31 to November 2, 2001, at the Tilghman Island Inn, Tilghman Island, MD. The agenda for the workshop appears as Appendix I. As may be apparent from the small number of presentations, the workshop was designed to allow ample time for discussion. Appendix II lists the names, affiliations, and addresses of the participants.

The workshop was divided into four phases. In the first phase (first morning), representatives of the Corps (Headquarters, ERDC, and the Seattle District) described the problems that often face dredging project managers in order to supply context for later discussions. In the second phase (first afternoon, second morning), four experts on various kinds of economic and risk analysis gave presentations on and led discussions about analytical technologies that may be useful to the Corps in solving the problems described. The third phase consisted of a discussion of integrative methods, including three presentations on mathematical model-based approaches. The final phase consisted of a closing discussion on possible solutions the Corps may want to consider.

The Problem

The overall context for the workshop was described first by Joe Wilson, who oversees Corps dredging programs. His stated goal for the workshop was to suggest some directions the Corps might pursue to improve efficiency in the dredging program. Bob Engler, of the Waterways Experimental Station, led a discussion of the regulatory and institutional constraints under which the program operates. John Wakeman of the Corps' Seattle district described experience developing a dredged materials management plan that involved extensive public input.

Fulfillment of the Corps' responsibility to maintain navigable waterways requires that some of them be dredged more or less often. In some places—for example, the mouth of the Mississippi River—dredging is almost continuous, while other waterways are dredged only infrequently. Much of the dredging itself is now contracted to private firms; project management and oversight is carried out by people in Corps District Offices. Nationally, Corps project managers oversee 200-300 projects per year, roughly two per manager per year.[1] Some of these require a few weeks' work, some take years. Most (more than 80%) are routine and demand little attention from senior managers. A few (approximately five at any one time) of these projects are large, lengthy, troublesome, and demand extensive analyses and senior management attention. Almost always at issue in these controversies is how to manage the materials dredged from the shipping channels. In the remaining 40-50 projects per year, contamination raises concerns that take these projects out of the realm of the ordinary, that require some expert analytical support and disproportionate attention from district- and division-level management. One participant noted that projects pose problems when a project manager encounters something out of his experience that he doesn't know how to handle. An example: routine analysis of sediments identifies an unsuspected pocket of contamination; such sediments must be managed differently from "clean" sediments. In planning its dredging program, the Corps works with EPA

and appropriate state environmental agencies. All seafloor placement options require approval by EPA's Marine Pollution Control Branch. In general, the Corps follows standard EPA methods for evaluating risks that may be posed by different management options.

One of the Corps' goals is to provide district-level project managers and their technical support people with tools that will simplify the identification of satisfactory ways to manage problem sediments, including facilitating their work with EPA and state officials.

Another source of vexation for the Corps is "out of process" dredged-material management decisions. The Corps has procedurally embraced the National Environmental Policy Act and has put in place procedures and practices for dredged-material management decisions that comply with the provisions of that act. Occasionally, however, interested parties will short-circuit the standard process by appealing to political leaders (typically state governors), who then make decisions that otherwise limit viable management alternatives. For example, Maryland Governor Paris Glendening recently prohibited some forms of aquatic management within that state's boundaries. Such short-circuiting often contributes to high-profile, troublesome decisions (for example, the problems in New York harbor), and sometimes complicates the intermediate-level materials management decisions.

Corps policy requires that project managers select the least costly, practicable, and environmentally acceptable alternative available for managing dredged materials. In accord with this policy, preferred management practices have changed over the years. In the past, preferred methods included placing dredged material in oceanic waters, into deep inland waters away from navigation channels, or onto low-lying land near the channels. Now, the first of these alternatives is limited, by international treaty, to sediments that do not include "contaminants." (Identifying "contamination" is, naturally, sometimes contentious.)

All management alternatives, either in waters or upland, are subject to constraints by various laws, including the Clean Water and Resource Conservation and Recovery acts, and

---

[1] For instance, in FY2001, the Corps' roster of work listed 105 identified assignments for its own dredges, some of which may have encompassed more than one "project." It also let 149 contracts for navigation dredging projects.

sometimes the Endangered Species, Magnuson-Stephens Fisheries Conservation and Management, Fisheries and Waters Coordination, and Rivers and Harbors acts. Various state laws and regulations also constrain management decisions.

Placing dredged materials back underwater, whether inland or at sea, sometimes raises concerns over effects on bottom-dwelling biota; the Corps is sponsoring considerable research intended to help evaluate such impacts. Such concerns bring into deliberations over dredged material-management decisions the Marine Fisheries Service (part of NOAA). If wildlife habitat is a concern, especially if habitat of an endangered species is at issue, the U.S. Fish and Wildlife Service enters the action. [2]

(Joe Wilson described one project, at the mouth of the Columbia River, in which dredged materials were being used to create a sandbar near the mouth that would provide nesting habitat for the endangered Least Tern. However, the Marine Fisheries Service objected on the grounds that these birds would feed heavily on fingerling salmon — also endangered — as the fish crossed shallows on their way from the river into the Pacific Ocean. A compromise was reached, in which a Least Tern-suitable sand bar was created a dozen miles inland, too far away for the endangered birds to feast on endangered fish.)

The criteria for acceptability of water quality, etc., in the Clean Water Act and state laws are often narratives, and thus subject to differing interpretations. This sometimes leads to protracted deliberations over proposed materials-management plans.

Because unrestricted open-water disposal of dredged materials is allowed only if the sediments are not "contaminated," once it is determined that sediments meet the requisite standards or have undergone the necessary tests, and appropriate areas for placing the materials

[2] Note that the Corps has some responsibilities for overseeing or carrying out dredging projects whose object is removal of contaminated sediments, rather than maintenance of navigation channels. Examples include the harbor in New Bedford, MA, and the proposed project on the upper Hudson River, NY. These projects are subject to RCRA and/or CERCLA, as well as the Clean Water Act and various state laws, and always require substantial analysis and management resources. They are not managed by Corps district personnel, who manage navigation-dredging projects; a parallel organization exists. On occasion, substantial cost savings can be achieved when both decontamination and navigation goals can be attained within a single project, as was the case in a recent Navy project at the Bremerton, WA, harbor.

are available, dredging-project decisions are usually made with little need for sophisticated analysis or management assistance.

Some concern was also expressed over variability in decisionmaking among different Corps Districts.

Analytical Methods

Methods of analysis that may be of interest to the Corps' navigation dredging program were described by four speakers. Alan Krupnick (RFF) introduced the concepts of market and nonmarket benefits and use- and non-use valuations, and described some methods for valuing nonmarket benefits. (He also introduced an approach to integration of analyses for decisionmakingthat is discussed below.) Jerry Cura (Menzie-Cura and Associates) outlined a comprehensive scheme for evaluating environmental risks posed by dredged materials that is organized around identifying potential routes of exposure. This approach was developed for the Corps by Menzie-Cura and is beginning to be used in the field. (Cura also summarized results of a review of the literature regarding "comparative risk assessment" methods.) Brent Finley (Exponent) described an analysis he and some colleagues made of the risks posed by accidents during a waste-site cleanup that included dredging as one step.[3] Resha Putzrath (Georgetown Risk Group) spoke on the problems of estimating dose-response functions for mixtures, emphasizing that knowledge of interaction terms can be inferred more easily than standard approaches imply.

Economic methods

Krupnick noted that dredging projects may bring nonmarket benefits. For example, removing contaminants that accumulate from sediments could reduce the concentrations of these contaminants in fish, allowing fish advisories to be removed and increasing the amount of sport (or subsistence) fishing that would be permitted. Another example: increasing Least Tern

[3] P. K. Scott, A. Pittignano, and B. L. Finley, 2001. Evaluation of the physical hazards associated with two remedial alternatives at a Superfund site. *Risk Analysis* 21(1): 53-61. For another example of this kind of analysis, see: http://www.hudsonvoice.com/auxiliary/APP_E.pdf

nesting habitat may draw birdwatchers. To those catching fish or watching birds, these represent "use" benefits; however, they also could bring "non-use" benefits to those in the public who positively value less-contaminated fish or more Least Terns, but who themselves would not go fishing or watching.

In cases such as these, the value of "use" benefits may be estimated by calculating such things as increased spending on gasoline for travel to the sites, reduced food costs captured by substituting caught fish for groceries, etc. The methods used to make these estimates are straightforward economic analyses.

Estimating the "non-use" values is generally more difficult, and sometimes surrounded by controversy. Nevertheless, there exists a strong body of empirical evidence that non-use values are quite real, and sometimes large. Most methods for making such estimates rely on surveys; the reliability of resulting estimates depends heavily on details of the survey design and data interpretation. Enough work has now been done to allow experts to understand the limitations of particular studies, and to be able to test conclusions.

Krupnick suggested that understanding relevant non-use benefit values may be of interest to the Corps, not necessarily because they would factor into individual project analyses, but because having this knowledge would increase understanding of what the public actually wants and needs. He outlined a program that would provide this knowledge for the Corps.

(It turned out that discussion at the workshop was based on an incorrect premise, namely that the Corps of Engineers has a policy against including non-use and non-market values in judging benefits from navigation dredging projects. Instead, the Corps treats benefits from dredging projects differently, depending on whether the source of the funding is national or local. For federally funded projects, the Corps defines as benefits of dredging projects the market value of the commerce that is maintained by keeping shipping channels open, and uses standard, market-based economic methods to evaluate these "use" benefits. In most cases, projects relying on such funds go forward only when the magnitude of these benefits exceeds the estimated project costs. However, when local entities—port districts, etc.—choose to supplement federal funds, nonmarket and non-use benefits may be taken into account when comparing costs and benefits. The evident unfamiliarity of workshop participants with these methods may be because projects involving nonfederal funds are relatively uncommon.)

In many federal programs, human health risks contribute significantly to estimates of both costs and benefits. However, these are not significant in analyses of navigation dredging projects. The only health risks taken into account in decisions regarding management of dredged materials are those posed to the general public (as evaluated using conventional EPA methods); Corps participants said that few projects materially alter risk to humans.

Ecological risk methods

Cura's approach to evaluating risks from dredged materials can be summarized in a decision-tree chart of initially daunting complexity.[4] However, this complexity arises from the different kinds of management options that may, in principle, be chosen for projects in general. Any comprehensive scheme such as this must permit for ocean or inland disposal , upland placement, treatment or not, etc. Ruling out any management option greatly simplifies the assessment task. Further, because the number of relevant exposure pathways for humans or other species are actually few, assessments based on the approach are conceptually not difficult. Difficulties principally concern obtaining useful data.

Cura indicated that present methods of ecological risk analysis can provide quantifiable risk estimates.

Methods for evaluating accident risks to human health

Finley characterized these methods as straightforward, but tedious to implement. The project tasks must be analyzed in fine detail, identifying the numbers of workers, kind of work, and duration of each job; accident statistics can be used to estimate risk given these data. Limited experience suggests that most of the risk is associated with jobs of longest duration, probably a consequence of similar injury rates among different jobs in construction and similar activities.

In discussion, it was brought out that because pay rates for different jobs include differentials for accident risk, the risks to workers directly associated with dredging are accounted for as costs in normal cost-benefit analyses. (This will not be true, however, if

[4] For a description, see Cura, J. J., W. Heiger-Bernays, T. S. Bridges, and D. W. Moore. 1999. *Ecological and Human Health Risk Assessment Guidance for Aquatic Environments*. Prepared for U.S. Army Corps of Engineers. Technical Report DOER-4, December 1999.

increased risk is posed to people not employed in the project. For example, transport of sediments on public highways may increase risks to the public in a locale because of increased traffic on certain roads.) However, in cases where one management option is much more dangerous to those involved in dredging than others, it is valid to identify this danger in deliberations. An example of such a difference was noted: barging dredged materials into the open ocean off San Francisco Bay poses much greater risks to barge workers than similar transport inside the Golden Gate.

Chronic human health risk methods

Likely pathways by which members of the public can be exposed to contaminants in dredged materials are basically two: through uptake into fish and other seafood, and by leaching or draining from upland sites into drinking water. (Other pathways also exist; see, for example, the USACE/EPA technical framework document, available on the U.S. Department of Transportation's Web page.) In theory, direct exposure to contaminants can occur if upland sites are not properly managed; today's practices essentially prevent such exposure.

Seafood-borne contaminants raise concern primarily from chemicals that are poorly water-soluble but not insoluble, and thus make their way into water and build up in animal tissues. These come primarily from three classes: heavy hydrocarbons (PAHs, largely derived from oil), chlorocarbons (PCBs, "dioxins," DDT, *etc*.)and salts of a few heavy metals (lead, cadmium, mercury), but there are others as well (for example, alkyl phenols). There is a clear trend toward analyzing for an increasing number of specific contaminants. (See the Corps' *Inland Testing Manual*.)

Risks posed by ingestion of contaminated seafood are usually characterized by comparing measured or projected concentrations in the food to levels judged safe. Identifying such levels starts with evaluation of results from toxicology studies (or, rarely, epidemiology studies) using standard methods to infer a lifetime-average daily intake of the contaminant judged to pose a negligible risk when ingested at that rate. These negligible-risk levels go under several names, including "Tolerable Daily Intake" and "Reference Dose." Numerical values of these indices are compiled in several places, for example by the nonprofit Toxicology Excellence for Risk Assessment (http://www.tera.org/ITER/), which lists values calculated by EPA, Health

Canada, and other organizations. Maximum safe concentrations in foods are then calculated by dividing this number by the estimated lifetime daily average intake of the food, usually as inferred from USDA statistics. Food and Drug Administration (FDA) uses this procedure to set Action Levels for contaminants in commercial seafood (and other foods), as do states that develop consumption warnings, etc. FDA has published action levels for a few of the more common contaminants; the Corps uses these whenever possible.

In discussion, reference was made to criticisms of FDA's action levels, on the grounds that FDA is required to weigh risks and benefits when setting these levels. In fact, the procedure used to calculate all reference dose and comparable indices includes the same implicit risk-benefit tradeoff that was incorporated when it was developed half a century ago. The Corps should prefer the FDA action levels as the basis for its actions whenever possible, since they are intended to apply to seafood eaten by the general public. When there is evidence that a specific group of people consumes a particular seafood resource at a rate dramatically greater than that of the general population, subpopulation-specific safety criteria should be considered.

Human exposure from contaminants in dredged materials is almost invariably to mixtures, not single compounds. Putzrath pointed out that standard EPA methods for assessing risks to mixtures make assumptions that limit their ability to assess risks accurately. The most commonly used methods, such as hazard index and toxicity equivalency factors, assume that: 1) the chemicals act by the same mechanism/mode of action, and 2) no interactions occur, even when it is known or expected that the chemicals might interact at some level of exposure. This fault will likely pose problems for dredged materials when either: 1) the materials are known to interact, as with dioxin congeners, or 2) if the methods are applied to mixtures that do not have the same mechanism/mode of action. Putzrath observed that a more accurate analysis of the risk posed by exposure to mixtures of chemicals can be estimated from existing data, for example, by using models that allow interactions among chemicals.

The author noted that conventional human health risk assessments do not provide estimates of risk (defined as likelihood of harm, given exposure). They are, instead, screening methods, useful for identifying exposures that pose no or negligible risk. Because of assumptions built into the procedures, they cannot practically be used for risk estimation. If

necessary, risk estimates could be made, although for most contaminants doing so would not be easy. In addition, the investment (in management resources, mainly) needed to gain acceptance of the first true risk-based assessment would be considerable. Fortunately, it seems that for essentially all navigation dredging projects, use of screening assessments to select management options should give results acceptable to the public and the Corps.

Integrative Methods

Three speakers, John Stansbury (University of Nebraska - Omaha), Spyros Pavlou (URS Consultants, Seattle), and John Wakeman (Corps of Engineers, Seattle District) described different computerized decision-analytic methods for integrating costs/risks and benefits. Stansbury's work was sponsored by the Corps.[5] Pavlou focused on the use of a computer-based comparison in a deliberation over dredging at the U.S. Navy base in Bremerton, WA. He found that the ability to test different management scenarios in real time helped illustratethe consequences of different assumptions and choices to parties interested in the project.[6] Wakeman demonstrated recent, commercially available software capable of facilitating the kinds of displays Pavlou found useful.

Krupnick suggested that it was useful to view the cost/risk/benefit analyses under discussion here as proceeding in two phases. Risk analyses are done to identify management options that will comply with relevant laws and regulations. Other cost/benefit analyses then inform the selection of options from among those that comply. Based on subsequent discussion, this paradigm for decisions should probably be modified: conventional risk assessment can be used as a screen to identify management options that will not comply with the relevant regulations, and thus can be eliminated. Because most of these regulations include some ambiguity and thus room for weighing real costs and benefits of different options, deliberations often need to include indicators of health or ecological risk. For instance, Pavlou noted that one

---

[5] J. Stansbury, I. Bogardi, and E. Z. Stakhiv, 1999. "Risk-cost optimization under uncertainty for dredged material disposal. *J. Water Resources Planning and Management* 125: 342-351.

[6] S. P. Pavlou and J. S. Stansbury, 1998. "Risk-cost trade off considerations for contaminant sediment disposal." *Hum. Ecol. Risk Assessment* 4: 991-1002.

criterion in the Bremerton harbor decision was a PCB sediment concentration target (or standard) equal to the background concentration in Puget Sound adopted by the state of Washington. Initial risk-screening analysis suggested that to be accepted, dredging would have to reduce concentrations to below the background. Analysts were able to show that the management option ultimately adopted would, over a period of a few years, reduce several "hot spots" in the vicinity to this target level, and this led to acceptance of the project.

Cura noted that a key problem in integrating assessment is finding acceptable means to weigh and thus value different kinds of risks. Putzrath repeated an aphorism to illustrate this dilemma: "How many whales is your grandmother worth?" Krupnick suggested that if human health were taken into account primarily by screening out unacceptably risky management options, then all other costs and benefits can be monetized. (In fact, the value of human health can also be monetized, and Krupnick summarized some of his recent research on the subject. He also acknowledged that doing so will remain controversial in some contexts.)

With this one caveat, it seems that using computer-based benefit-cost comparisons of the kind described by Pavlou and Wakeman can be very useful means to help inform deliberations over dredged material management options.

A well-known expert in risk communication, Dr. David McCallum of Focus Group, joined the group for a time, and shared some of his experiences with improving communications among people managing projects similar to those at issue in this workshop. He and colleagues have worked with EPA Superfund and U.S. Army site managers at various times, having been called in to help with cleanups of contaminated sites that had become controversial. He emphasized two things. First, project managers must come to understand the concerns of all involved stakeholders. (Managers may not be able to resolve all such stakeholders' issues, but , often, stakeholders' first concern is that they be heard.) Second, whenever different governmental agencies have some authority in a project, clear lines of communication must exist in order to forestall their working at cross purposes. Of course, this is especially true when these several agencies are also communicating to the public. Then they need to take pains to say the same things.

Dr. McCallum also emphasized the utility to project managers of the results of understanding the values and interests of involved publics, something usually obtained through the standard methods of opinion research.

Observations

1. ***An unsustainable drain exists on senior management and technical resources available for dealing with "problem" navigation dredging projects. It occurs primarily because significantly contaminated sediments are not usually encountered in navigation channels (a few harbors excepted), and thus few project managers learn how to manage them effectively. Both methodologic and cultural/management barriers stand in the way of diminishing this drain. One principal problem seems to be getting project managers to call for help sooner rather than later. Another situation causing resource drains is "out of process" decisions.***

This workshop was focused on identifying methods that may help the Corps attain its goals of reducing costs of navigation dredging and improving consistency of decisionmaking across Corps districts. From the discussions it became apparent that the barriers to attaining those goals are as much cultural as methodologic. Infusing methodologic technology into the district offices may help reduce costs, but for the goals to be achieved, cultural and organizational issues must also be addressed.

The decision-analytic process for dredging projects was described as consisting of a normal phase and, sometimes, an expanded phase. In the normal process, the chemical, physical, topographic, and other characteristics of the sediments and initial-candidate management sites are identified and described; these data are then used to develop a cost-benefit assessment of the project, which serves as the basis for a decision to proceed, to modify the initial project plan, or to postpone dredging. This process works well for the great majority (more than80%) of projects.

However, occasionally a decision will go awry, frequently, according to workshop participants, because of unexpected findings during physical and chemical analysis of sediments

to be dredged, such as discovery that the sediments are contaminated. (Note that this point was made as an aside, and other causes were not identified.) In these cases, extensive chemical, biological, and risk analyses are required—as, usually, are extended negotiations with various interested parties.

Because these extended-analysis projects tend to be lengthy and demanding, as well as uncommon, few project managers have the opportunity to develop the knowledge and skills needed to freelance a successful decision-analytic process. Thus "problem" projects tend to demand more senior management and technical resources than the Corps can really afford.

In addition, very rarely, yet often enough to exacerbate resource demands, a "problem" project will occur in a locale and manner that prompt politicians to step into the decision process, usually to the detriment of all the directly affected parties. Participants call these "out of process" decisions.

2. ***For normal projects, the decision analytic process and associated methods used by the Corps serves project managers very well. Further, the Corps' economic and risk analysis practices are generally satisfactory, and the technical staff can adequately assess risks and benefits associated with both normal and contaminated-sediment projects.***

For the normal and some "problem" decisions, the results of these analyses provide the information needed for decisionmaking. For most "problem" and all the "out of process" decisions, however, the normal analyses are not adequate to the task of informing decisionmakers and those affected by or interested in the outcomes. (This observation is almost a tautology: project managers discover they have a problem, and then discover that they need some unusual kind of analysis!) Further, in general, the methods of both economic and risk analysis used by the Corps are sound and technically sophisticated. However, economic methods that are used do not allow analyses to take into account certain kinds of benefits (and costs) that may be relevant in some cases. And the methods available for human health assessment are limited to showing compliance, or lack of it, with federal laws and regulations. Methods for ecological risk assessment are state-of-the art, capable of supplying all the information needed for decisions.

3. The Corps' navigation dredging program seems to lack adequate understanding of nonmarket costs and benefits that may accrue from different methods of managing dredged materials, although the techniques for estimating these costs and benefits are well known to Corps economists. The Corps does not attempt to estimate non-use benefits; nevertheless, the navigation dredging program may benefit from understanding the non-use values associated with its materials management options.

At present, the Corps develops at least an adequate understanding of the market values of costs and benefits associated with dredging projects. There have long existed Corps policies and practices directed at assuring this understanding. Further, the Corps has decided that it will not use estimates of nonmarket, non-use values in its project-level cost-benefit analyses. However, the trend of dredged-materials management practices seems to be toward identifying placement solutions that result in improvement of habitats or improved access to specific habitats. For example, creating varied topography on the ocean body increases habitat for some species, as does creation of tidal flats or sandbars. While these may provide market-value benefits (such as increased commercial fish catch), they almost always provide nonmarket benefits in the form of improved sport fishing, bird watching, etc. Methods exist to estimate the value of these nonmarket benefits; the Corps may benefit from knowing at least their general magnitude. The values may or may not be large compared to the value of maintaining shipping channels, but they may be big enough to tip certain project valuations. In any case, it would be worthwhile doing some baseline studies to understand something of these values.

Discussions also brought out indications that the Corps may underestimate non-use values associated with habitat creation and restoration. The project to restore Poplar Island in Chesapeake Bay was cited as one, perhaps extreme, example. The cost of restoring this eroded island is twice that of another management option for the dredged materials. However, the decision to restore the island was a political one, and did not follow usual decisionmaking processes. The benefits perceived by political actors in the process were at least equal to the extra cost. Yet since these benefits are primarily regional rather than national, this extra expense represents a misallocation of national resources; other dredging projects will be delayed as a result.

The Corps has evolved a rough sense of the magnitude of non-use benefits, primarily from experience with what various ports are willing to invest in cost-sharing projects, etc. The non-use value inferred for the Poplar Island project from its extra cost is large. It seems likely that it would be useful to the Corps to know if this value is an aberration, a consequence of particular politicians' political power, or if the general public places such a high value on creation of this kind of habitat.

4. The approach used for risk assessment is excellent. However, health risk assessment methods have limitations, and confusion exists regarding appropriate standards for contaminants in sediments, especially regarding consumption of fish and seafood that may be or become contaminated from dredged materials. The Corps does lack systematic methods for assessing and characterizing accident risks.

The analytic process used in contaminated-sediment decisions typically occurs in two steps. Usually in the first, management options that result in unacceptably large risks to human health are eliminated. Acceptability is judged by reference to the Clean Water Act and other relevant federal and local regulations; the results of these assessments can be used to show that the feasible materials management options will comply with those laws. In the second, and if no "safe" options can be identified in the first, ecologic risks and other costs and benefits associated with the various management options are evaluated.

The general framework developed by Menzie-Cura Associates provides an excellent roadmap for conducting the assessments needed to assure compliance. This framework remains adequate and appropriate for those decisions in which demonstrating compliance is not straightforward, such as when state laws with "narrative" standards are in force. In such cases, the issue of compliance becomes part of a deliberation or negotiation involving interested and affected parties beyond the regulatory agencies normally involved in materials management decisions. In these situations, the methods used for ecological risk assessment provide the information needed and useful to those involved in the deliberations.

However, the methods for human health assessment may or may not be adequate. If deliberations can be satisfied by demonstrating that human health risks are negligible, present

methods suffice. Yet if it were to become necessary to estimate true risks to human health from different dredged material management options, the resources needed to do so are not generally available. (Risks to habitats and other biota can be estimated.) Except in a very small number of cases (the "dioxins" may be one), neither the data nor the necessary science exists, and professional practices are just beginning to be developed.

Note that in the Bremerton Navy Yard case that Pavlou described, one of the parameters negotiated was a surrogate indicator of human/environmental risk: the concentration of PCBs in sediments remaining after completion. What was accepted as the background concentration in Puget Sound was taken as a target to be met, in this case by natural attenuation over several years.

There were hints that other environmental "standards" play or have played similar roles in other dredging projects. Similar use of such indicators is common in Superfund remedy selection negotiations, probably the rule more than the exception. Costs and other values are weighed against standard cleanup levels; larger concentrations are accepted more often than not. These negotiations are almost never informed by estimates of the risks to human health posed by different cleanup levels. Parties to the negotiations tacitly assume that there exists enough "windage" in the standards that deviation from them will pose no significant risk in almost all cases.

(As Putzrath noted, the toxicity values estimated by regulatory agencies are often regarded as "certain" and rarely challenged in risk assessments involving numerous chemicals, even though the exposure parameters in risk estimates are often challenged. Yet the quality of these toxicity values can be as variable as the quality of exposure parameters.)

Confusion over how to use information on contaminant levels in fish and shellfish in decisionmaking arises in part from the disjointed jurisdiction over fish and seafood. FDA is responsible for regulating commercial catches (both fresh and salt water) nationwide, while individual states are responsible for regulating this aspect of noncommercial fishing. These several agencies do not always use common approaches or standards. Although many contaminants may be found in sediments to be dredged, a few (fewer than 10) seem to dominate the "problem" projects. These few are commonly found in other media, as well, and advisories

and/or standards for total consumption are available for most of them. It was not clear from the discussion if this confusion is sometimes a serious hindrance to decisionmaking, or just a nuisance. If it is a hindrance, the Corps may benefit from a harmonized approach to identifying appropriate standards

It was not clear from discussions how deliberations over what concentrations of chemicals constitute "contamination" for purposes of ocean dumping treat these kinds of "risk" standards; it may be that they are absolute thresholds – that is, concentrations smaller than some number imply that the sediment is not "contaminated" for ocean-dumping purposes. If so, EPA's standard numbers for this purpose—RfD, RfC, and "slope factor" values that appear in the IRIS compilation—are vulnerable to challenge in court, since they have several times been ruled as not legally binding for regulatory purposes.

On the other hand, these numbers can be viewed and used as though they are related to human (and ecological) risks, but not directly proportional nor even a simple function of them. Instead, they represent, in the judgment of government officials, an acceptable risk-benefit balance; that is, small enough to pose little risk to humans or wildlife in, for example, Puget Sound, but not so small that costs are driven to an unacceptable level. In fact, EPA's RfD and other such numbers are derived using procedures that explicitly include this kind of risk-benefit balancing. Used in this way, they are both appropriate and legal.

The Corps manages occupational accident risks among its employees using standard approaches; we can assume that, in general, those risks are considered in the cost-benefit accounting process because they show up as increased wages (risk premium) paid to the workers. (It was not clear if contractors' employees' occupational risks are overseen by the Corps.) However, there are occasions in which substantially increased risk may be posed to dredging workers, or possibly to those who may indirectly be affected (for example, by highway accidents if dredged materials are transported by truck); it may be important to highlight these unusual risks in deliberations over materials management decisions. The Corps has not brought in methods to make such estimates, although these methods are not difficult to learn and there are analysis contractors who can perform them.

5. The Corps may lack the necessary methods for characterizing and presenting consequences of different options.

One impetus for the Workshop was a perception that the Corps' methods and practices for risk/cost/benefit characterization may need improvement. In particular, analysts and some senior managers feel the need for methods that provide nontechnical people an understanding of the real differences among decision alternatives. Some participants also expressed a hope that improved and consistent characterization methods might help address the problem of inconsistencies among different Corps districts.

The discussion did not address this issue squarely; rather, it centered on ways that have been tried to solve particular problems, such as the one in New York harbor. Several innovative characterization methods were described, some of them technologically quite capable. Yet the absence of a focused discussion on the shortcomings of present practices limits the utility and reliability of observations that can be made here; it isn't clear that a real problem exists.

Part of the perceived difficulty arises from the belief that risks to human health and the environment need to be compared with other costs and benefits. However, that is not necessarily the case. Discussion brought out several instances of successful deliberations, including some that brought in the general public, in which surrogate measures for human or ecological risk were perfectly satisfactory. In particular, when human health risks can be considered negligible, something that existing methods can demonstrate, this issue can be dropped out of deliberations.

This suggests that what may be wanted, in fact, is a different framework for conceptualizing decision processes than now exists. It seems that now, once a hitch arises, project managers continue through the normal decision process, assuming that a normal cost-benefit analysis will suffice for a decision. This analysis may be expanded by more detailed ecologic and human health risk assessments, but the basic decision process remains the same. But if this process fails, if a satisfactory decision cannot be reached by involving only the normal participants, project managers have no paradigm for a different kind of process. (Here it is assumed that the "normal participants" include the state and federal regulators who are usually involved in project decisions.) In particular, if results of risk assessments are assumed to be

required for expanded cost-benefit analyses, emotional response to findings of "risk" can throw a monkey-wrench into the proceedings.

A modified decision process could minimize this problem, potentially speeding decisions and reducing costs by shortening deliberations. Project managers could break the decision on managing dredged materials into two steps. The first would consist of screening-level ecologic and human health assessments of all the management options under consideration, with the intent of identifying options that cannot be considered safe; these would be eliminated. The second would then consist of a normal cost-benefit analysis of the remaining options. In effect, the project manager would begin any deliberations with other parties by asserting that all the options under consideration meet accepted criteria for human health and environmental safety (obviously, the Corps would need to describe and justify those criteria).

If a risk assessment screen eliminates all the financially-viable management options, the project manager requires help. Now, a much more elaborate set of cost, benefit, and risk analyses are required. The discussions did not provide information on how project managers behave in such situations, the kinds of help available, or other relevant aspects of the Corps' culture, so no useful observations on possible ways of offering such help can be given here. It would be quite feasible for the Corps to review past "problem" decisions, with an eye to understanding what may usefully facilitate project managers' asking for and receiving help in these situations.

6. Among management/cultural issues to consider, different levels of performance among districts burdened with highly-visible "problem" projects may suggest a need for altering what is expected of senior management. The "stovepipe" organizational ethos of the Corps seems to inhibit the ability of project managers to learn how to deal with surprises.

Participants contrasted the ability of certain districts (such as Boston and Norfolk) to achieve agreement on solutions for dredged materials management, with others (for example, New York), where intractable problems seem to be the rule. It was not clear to what extent this difference can be attributed to New York peculiarities versus differences in managements, but

there seemed to be basis for an inference that the talents and skills of district management can be important to keeping "problem" projects from escalating into "out of process" decisions.

Project managers' abilities to learn how to manage surprises is hampered by their relative lack of numbers and opportunities to practice handling such surprises. It is further hampered by the Corps' quasi-military organization which gets a high degree of accountability, on the project level, in return for little interchange across organizational lines. Both these situations are said to be widely recognized and resistant to change.

Recommended Directions

1. Develop a new project management framework for "problem" projects, especially when public involvement occurs.

It was observed that the Corps has available to it most of the risk and cost-benefit analysis methods and technologies needed to make satisfactory dredged-materials management decisions. The primary cause of unacceptable decision costs appears to be project managers' reliance on a decision-analysis framework that is optimal for ordinary decisions but fails when serious problems arise. Because hard-to-change features of the Corps' culture and situation makes it difficult for project managers to learn how to cope on their own, reducing these decision costs requires these managers to develop their central technical support groups, as well as a new decision framework for the managers to use. This new framework will require first a thorough analysis of the more common reasons why problems occur, and then a set of instructions (behaviors) for coping with these problems. These instructions should include recommendations on how soon to bring in technical assistance from outside the districts (and divisions), when to consult with different regulatory authorities, etc., as well as appropriate tools for risk and benefit analyses. Once the instructions and tools have been developed, tested, and found to be useful, project managers will need to be trained in their use.

2. Increase the Corps' knowledge of stakeholders (the public and others) and their values, both local and national.

Problem decisions become much more difficult than they need to be when project managers and their senior managers have to make assumptions about what regulators, local and

regional environmental leaders, the public, and locally important politicians want, know, and value. Gaining the necessary knowledge will always be an ongoing process; senior Corps managers need to continue to invest in getting to know those with whom they will have to work when problems arise. Learning what the public wants and values, however, usually requires more than interpersonal interactions. The Corps should consider commissioning studies of public attitudes and values that are relevant to dredged materials management decisions. Baseline studies of national/regional values are necessary; consideration should be given to supplementing these locally, where warranted.

3. Continue to upgrade project managers' skills (including cultivating relations with stakeholders).

The Corps now offers continual training for project managers. The Corps may want to consider enhancing this training by teaching managers to build working relationships with members of the public (and their self-appointed representatives). Once a new framework for "problem" decisionmaking is developed, training on it should be added to the program; in the meantime, there may be utility in adding elements of risk analysis, if this subject is not already covered, as preparation for learning how to handle problems if they arise.

4. Evaluate methodologic needs and identify ways to fill them, particularly:

- ***risk-cost tradeoff for internal planning,***
- ***communications plans, methods, tools, and***
- ***food safety standards for noncommercial fish and shellfish.***

The Corps now uses methods for economic and risk analysis that generally meet its needs; further investment in methodologic development should focus on meeting specific needs. The Corps should investigate if three kinds of methods would add value, and invest in their development only if they are found to be useful.

One of these methods is computer-based procedures for displaying the tradeoffs among costs, risks, and benefits for different materials-management options in real cases. Programs that facilitate such comparisons are commercially available; the Corps may want to evaluate them systematically, to see if recommending use of one or another, and training District staff in their use, makes sense.

A second possible need is for approaches to communicating with stakeholders and the public. Examples would be developing prototype communications plans, acquainting District staff with effective communications methods and tools, and so on.

Third, as noted, the lack of accepted standards for what constitutes tolerable concentrations of common contaminants in fish and shellfish may pose a significant ongoing difficulty for project managers. Or it may just be an occasional irritant. If this situation causes enough difficulty to warrant resolving it, the Corps will want to engage with FDA and key state agencies to develop a method for identifying situation-specific tolerances. These would preferably be based on the tolerable weekly intake recommendations of the Joint WHO-FAO Expert Committee on Food Additives.

5. Evaluate utility to the Corps of:

- ***adjusting requirements (job) of senior management positions in navigation dredging; and***
- ***long-term forward planning for foreseeable materials management problems***

Because some Corps districts appear to do a better job of learning local stakeholders' wants and values than others, senior management's knowledge and skills in this area may differ significantly. In the private sector, formally making the development of key relationships a part of managers' jobs (and their performance reviews) fosters the development of such relationships. It may be that some generally comparable incentives can be devised to help the process of learning about others.

The Corps, like most federal government agencies, engages in forward planning. It may be worth evaluating the extent to which the planning process includes consideration of long-term needs for dredged materials management solutions, and if actions to address such needs are taken.

6. Develop plans for working with USDA and EPA over the long term to reduce sediment inputs to navigable streams.

In the long term, the best solution to managing dredged materials is not to dredge sediments in the first place. Obviously, this statement represents an unattainable ideal. However, reducing sediment loads to navigable waters would have significant benefits beyond

reducing costs of dredging. USDA and others have already begun to address the problem of erosion of farmlands; EPA and many state agencies share concerns about the unsolved problems of "non point-source pollution." A search for innovative ways in which the Corps could work with these other agencies to reduce sediment loads could benefit the Corps' public image, and reduce navigation-management costs as well. (The ERDC is developing a new research program on Regional Sediment Management that may be a vehicle for these interactions.)

7. Consider reviewing the appropriateness of judging value of navigation dredging projects only by a differential in direct "use" benefits.

Focusing evaluation of benefits only on those who may directly gain from completion of some project may distort priorities at the margin, especially when complications occur while finding appropriate management solutions for dredged materials. The Corps' stated policy for choosing management alternatives—to select the least-costly, practicable, and environmentally acceptable alternative—considers factors and values besides direct cost. It may make sense for the benefits side of the equation to include other factors and values also, if only to give project managers a better ability to judge tradeoffs that must be made.

8. Build communication and public participation efforts into all projects that deal with contaminated sediments, matching the level of effort to the issues involved.

Dredging projects involve multiple state and federal angencies which sometimes act as though they house competing interests. Effrective sharing of information among the principals and effective resolution of differences are essential to have efficient managment of projects. This kind of situation is not unique: for instance, similar kinds of conflicts arise in Superfund projects. Good relations among principals has been found to be a hallmark of efficiently-run Superfund projects. The characteristics of the individuals involved influence this process. However, effective written communications plans and joint training of team members make a difference.

Good intra-project communication becomes even more important when additional stakeholders – such as state governments and local interest groups – are added to the mix. Now

the messages from various project participants must be *clear* and, to the extent possible, *consistent.*

Identifying the stakeholders and their interests, and listening to them are key components of effective communication.

All of this suggests that the Corps would benefit from a standard procedure for communications to the involved stakeholders, for all projects, but especially for those which have the potential to develop controversy. The standard procedure should include a stakeholders' communication assessment (which can be quite simple, depending on circumstances). However, as a basis for such a standard procedure, the Corps may want to conduct a systematic review of selected projects, including interviews with key people. Results from focus-group interviews could also be useful. The resulting procedure can be prospectively evaluated and refined as necessary.

Appendix I

Workshop: Advancingthe State of the Art of Analyzing Risks and Benefits of Dredged Material Management

AGENDA

31 October — morning:

a) Purpose and objectives — Todd Bridges

b) Legal/regulatory context, how decisions get made, etc— Joe Wilson

c) How risks and benefits are now analyzed — Robert Engler

d) Risk & benefit analysis practices from a District Office perspective — John Wakeman

31 October — afternoon

e) Environmental costs and benefits (non-market, use and non-use) — Alan Krupnick

f) Evaluating risks to biota — Jerry Cura

g) Discussion — Todd Bridges & Jim Wilson

1 November — morning

h) Estimating accident risks — Brent Finley

i) Evaluating human health risks, especially from mixtures — Resha Putzrath

j) Discussion — Todd Bridges & Jim Wilson

1 November — afternoon

k) Comparing different kinds of risks — presentations by Randy Bruins, John Stansbury, Spyros Pavlou; comments by Alan Krupnick and Jerry Cura

l) Discussion: — Todd Bridges & Jim Wilson

2 November — morning

m) Discussion: possible directions — Jim Wilson

Adjourn at 10 a.m.

Appendix II

Workshop Participants

Beiring, Elizabeth, J.D., Ph.D., Ocean Dumping Team Leader, U.S. EPA (4504F), EPA West, 1200 Pennsylvania Avenue, NW (Room 7115E and Mail Code 4504T), Washington, DC 20460, Phone: 202-566-1270, Fax: 202-566-1546, e-mail: beiring.elizabeth@epa.gov

Bridges, Todd, Ph.D., Research Biologist, U.S. Army Corps of Engineers, U.S. Army Engineer Research and Development Center, Waterways Experiment Station, EP-R, 3909 Halls Ferry Rd., Vicksburg, MS 39180-6199, ofc 601-634-3626, fax 601-634-3713, e-mail: Todd.S.Bridges@erdc.usace.army.mil

Bruins, Randall J.F., Ph.D., Environmental Scientist, National Center for Environmental Assessment, U.S. EPA, MS-190, 26 W. Martin Luther King Dr., Cincinnati, OH 45268, ph (513) 569-7581, fax (513) 569-7916, e-mail: Bruins.Randy@epamail.epa.gov

Cura, Jerome J., Ph.D., LSP, Principal, Menzie-Cura & Associates, Inc., 1 Courthouse Lane, Suite 2, Chelmsford, MA 01824, phone: (978)453-4300, Fax (978)453-7260 email: jcura@menziecura.com

Engler, Robert M., Ph.D., U.S. Army Corps of Engineers, U.S. Army Engineer Research and Development Center, Waterways Experiment Station CEERD-EM-D, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, 601-634-3624, Fax 6016343528, e-mail: Robert.M.Engler@erdc.usace.army.mil

Finley, Brent, Exponent, Inc., 631 First Street, Suite 200, Santa Rosa, CA 95404, 707-535-0492, e-mail: bfinley@exponent.com

Francingues, Jr., Norman R. Research Civil Engineer (Retired), Environmental Effects of Dredging Programs, Environmental Laboratory, U.S. Army Engineer Research and Development Center ATTN: CEERD-EM-D, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, e-mail: stormin@canufly.net

Krupnick, Alan J., Ph.D., Senior Fellow and Director, Quality of the Environment Division, Resources for the Future, 1616 P St. N.W., Washington, D.C. 20036, 202-328-5107, Fax: 202-939-3460, e-mail: Krupnick@rff.org

McCallum, David B., Ph.D., Focus Group, Box 356, Tilgham Island, MD, 21671, TEL 410-886-2141, FAX 410-886-2216, e-mail : focusgroup@friend.ly.net

McNair, Jr., E. Clark, U.S. Army Corps of Engineers, 303 Pinehurst St., Vicksburg, MS 39180, TEL: 601-634-0102, FAX: 601-634-1587, e-mail: Clarkmc@canufly.net

Pavlou, Spyros P., Ph.D., URS Corporation, Information Technology Systems & Risk Management, Century Square, 1501 4th Ave., Suite 1400, Seattle, WA 98101-1616, Phone: (206) 438-2268, Fax: (206) 438-2699, e-mail: spyros_pavlou@urscorp.com

Putzrath, Resha, Ph.D., DABT, Principal, Georgetown Risk Group, 3223 N Street, NW, Washington, DC 20007, Phone: 202-342-2110, Fax: 202-337-8103, e-mail: rmputzrath@mindspring.com

Redford, David, Chief, Marine Pollution Control Branch, U.S. Environmental Protection Agency, U.S. EPA, EPA West, 1200 Pennsylvania Avenue, NW (Room 7115E and Mail Code 4504T), Washington D.C., 20460, ph (202) 566-1288, fax (202)566-1546, e-mail: redford.david@epa.gov

Stansbury, John, Ph.D., PE, Associate Professor, Civil Engineering, University of Nebraska 205C PKI, 1110 South 67th Street, Omaha, NE 68182, Phone: 402-554-3896, Fax: 402-554-3288, e-mail: jstansbu@unomaha.edu

Wakeman, John S., Ph. D., Senior Scientist, U.S. Army Corps of Engineers, Seattle District CENWS-EC-TB-ET, POB 3755, Seattle, Washington 98124-3755, ph (206) 764.3430, fax 206.764.3706, e-mail: john.s.wakeman@usace.army.mil

Wilson, James D., Ph.D., Resources for the Future, 10021 Springwood Drive, St. Louis, MO 63124, ph (202) 328-5099; (314) 569-2615, fax: (314) 569-2904 e-mail: wilson@rff.org

Wilson, Joseph R., Environmental Policy Writer, U.S. Army Corps of Engineers, Directorate of Civil Works, Operations Division , Dredging and Navigation Branch , 441 G Street, NW, Washington, DC 20314, ph (202)761-4649 , fax 202-761-1685, e-mail: joseph.r.wilson@usace.army.mil