Making Site-Specific Assessments

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I am a physical oceanographer working on the problems of coastal sediment transport. I will addres the issue of site assessment, which is covered in Chapter 4 of the NRC report. I realize that talking about site assessment problems and criteria is a bit like carrying coals to Newcastle, because the majority of this audience may know as much, or more, about it than I do. However, it is important for you to get at least one person's perspective on the committee's bias with regard to site assessment, particularly given that this topic is a bit outside the charge to the committee, which initially was technologically oriented and looking for the technical "fix."

Very early in the committee's deliberations, we realized that we needed to spread our wings a bit and look at the larger picture, beginning with the fundamental issue of the site itself. Some of you may be well-advised over the course of this symposium to question what we mean by "contaminated." For the moment, we assume it means that, based on some criteria, someone said, "That stuff is contaminated." We believe that effective management of a site containing contaminated sediment begins with a reasoned, detailed, and systematic assessment of site characteristics.

An assay seeks to define the extent and character of the contamination, including probable sources, sinks, potential mobility, and ultimate bioavailability, which, after all, is what we are particularly interested in. Beyond their obvious technical and scientific utility, such data serve as a basis for determining the governing regulatory framework, identifying who the stakeholders are and their particular interests, and defining the optimal management protocols and remediation procedures. It is the foundation upon which all else should be built.

It is our experience, and I think it was more or less unanimous among the committee members, that quality site assessments are seldom done. It was also the impression of the committee that quality site assessments *can* be done; it is not beyond the state of the art. Central to the evaluation, however, is a fundamental understanding of the factors governing contaminant transport and availability. You have to know something about the system with which you are working.

Given the affinity of the majority of the contaminants of concern for fine-grained sediments, the transport often involves displacement of cohesive materials. The displacements are governed by a variety of interactions among local and regional, meteorological, hydrodynamic, biological, geological, geochemical, and perhaps even geopolitical factors. The interactions typically result in a transport system characterized by a high degree of spatial and temporal variability. Therein lies the rub. A high degree of spatial and temporal variability establishes some very particular constraints on the adequacy of sampling and survey protocols. How do you specify what is there, given the state of the art? Don Hayes, the next speaker, will talk about this issue in terms of the technologies available to dredge, or clean up in place, the contaminants of concern.

Taking a look at the various transport systems, for example, it should not be surprising that the factors governing transport on the California continental shelf and affecting the displacement of contaminants off Los Angeles differ substantially from the factors affecting transport at an Upper Hudson River site. The latter is a moderate-energy riverine environment impounded by a variety of dams and locks above Troy, heading down into the tidal river below Albany to Poughkeepsie and, beyond that, the estuary down to New York City, including the Port of New York and New Jersey.

The effects and characteristics of the system are compounded by significant variations in the sedimentary characteristic of the area. For example, a high-organic deposit of fine-grained materials, mixed sawdust, sands, and silts, interlaced with lathe debris from the historical lathing operation in the Upper Hudson, makes for an interesting deposit in terms of friability, transportability, and contaminant availability. Such a deposit could be found in a shoreside dump.

Contrast that system with a coastal environment, such as an inlet on Long Island Sound contaminated by a variety of constituents, mostly metals and sewage-related materials, with sediments characterized predominately by sands and dynamics affected by the inlet. Contrast that with a system such as the estuary of the Acushnet River, Upper New Bedford Harbor, an area of relatively low energy in terms of winds and waves but affected by significant tides and stream flows and the recipient of an historical discharge of polychlorinated biphenyls (PCBs).

Another example would be tidal flats, where the degree of aeration and exposure, or potential for volatilization, is very different from that of the California continental shelf or Upper Hudson. Contrast this with some of the Gulf Coast petrochemical areas receiving yet another variety of contaminants discharged into yet another set of different environments, with energy-grade lines running nearly horizontal [i.e., the channel slope changes by only 1 ft in 40 mi (0.3 m in 64.4 km) in an area with relatively low tidal energy, in fairly confined embayments such as a bayou, but receiving bursts, or very flashy discharges, of rainfall runoff.

Therefore, to assess what is going on from a temporal standpoint, you might put out a variety of instruments and leave them for some period of time. There are relatively few long time-series observations available to us in many of the environments of concern. If you put out a bottom-monitor array of instruments, you might be interested in looking at suspended material concentrations. In observing the velocity record, you might be interested in the current speed, time variations, characteristic M2 tide (i.e., semi-diurnal lunar component of the astronomical tide), characteristic spring/neap cycle (i.e., monthly variations in tidal range), and a number of aperiodic events. The systems we work with tend to be affected by an ambient velocity field perturbed aperiodically by the passage of moderate-to-high-energy storm events.

We hear a lot about storm events, and in some areas they are sufficient to cause mass failure of the deposit and orders-of-magnitude changes in material transport. However, that effect has to be scaled against the slow, persistent cycling of significant concentrations of material over each tidal cycle. In some areas (e.g., Long Island Sound), that slow, persistent cycling is as significant in terms of mass flux as are many of the storm events. The particular time scale of interest depends on the chemical time scales of concern, processing times, or biological uptake and processing times.

A plot may show the inherent nonlinearity of many of the relevant processes. The characteristics of the response of sediments vary significantly as a function of antecedent conditions, such as, in one case, the wind stress field. If you get the right wind, then you get a particularly energetic wave field. Alternatively, if you have a number of wind stress events, you might expect the first event after a quiescent period to be more effective in terms of stirring up materials than one that comes later. The third one may not be as effective in terms of the resuspension of materials. In other words, a variety of nonlinearities, as well as a variety of time scales, are inherent in the process.

Beyond the time scale, we might be interested in the spatial scales. A change in structure over relatively small spatial scales has profound implications in terms of the mobility of the material. It varies as a function of sediment type and, to some extent, the history of working of the sediment, the textural characteristics, which can vary significantly in space.

The committee kept coming back to the need for site-specific assessments, not only because of the variations from a spatial standpoint due to hydrodynamics, meteorology, and the rest, but also because of the characteristics and structure of the sediment column. The spatial variability, of course, can be complicated by perturbations. We also could have interfacial photographs that would give clear evidence of burrowing infauna and reworking of the sediments, and that burrowing and reworking would have a characteristic seasonal variability. Therefore, we may have some spatial and seasonal variations as well as variations due to local sediment characteristics.

Mapping of these characteristics on a larger scale is facilitated by the use of acoustic techniques. Not all of us have the patience, time, and money to go out and bounce an interfacial camera all over Long Island Sound or up and down the East Coast, but you can significantly cut the survey time if you use acoustic techniques, which we will hear more about in a later session. A low-frequency seismic profile over a dump site gives you some feeling for the effects of deposited material on the sediments and sediment structure. It also may show several acoustically opaque regions where you begin to lose the strata because of the presence of gas in the deposits. Another consideration is the production of methane and what it means in terms of the structure, fabric, texture, and transport of the materials as well as the irrigation and migration of contaminants in the sediment column. These effects can vary significantly in space and time.

Although we are dealing with moderately high content and often fine-grained sediments, which might appear to be easily eroded, the materials are, for the most part, relatively stable. The materials have a certain amount of consistency, coherence, and stability. One should not assume that, because we are dealing with fine-grained deposits, these materials are easy to move around. The mobility also can be affected significantly by burrowing infauna, which may be macro- or megafauna.

With this background as a bias, recognizing the inherent spatial and temporal variability in the system, the committee argued for the application of a systematic approach to site assessment. We argued that the best method is a tiered approach, and we provided you, in Chapter 4, with a "strawman" outline. By no means is it intended as the "do all and end all"; rather, it is intended to point to a couple of things that the committee felt were important, beginning with a review of historical data. The review of historical data on a site is often overlooked. None of us has the time to visit the library anymore; we hardly have time to use the World Wide Web. As result, we often go out and reinvent the wheel. Sometimes we get away with it, but often this approach slows down the project and increases costs.

An example provided in the NRC report is Marathon Battery. The fact that they were dealing with an archeological site was overlooked when they were working out their disposal options. As a result, they had to go back to the drawing board to work out a way to deal with an old gun emplacement. Another example is the reference to the Boston Harbor study and the discussion of the utility and value of historical data as a preface to newly acquired data. Many historical data not only will satisfy present-day quality assurance and quality control (QA/QC) criteria, but also will withstand wild-point editing and consistency checks and serve as a perfectly adequate basis for surveys intended to satisfy today's QA/QC criteria.

When you search for such data, a variety of files (e.g., federal, state, local, historic district) are often a fount of information. I never fail to be amazed at the amount of water quality data available for New York Harbor. If you can spend the time searching for data (which may not be put together quite the way you expect), the data can provide a good starting point. Hence, it is important to look at the historical data.

The next item to be addressed is whether contaminants are present. If not, then there is no problem. If they are present, then there is a need to decide if a full site assessment is worth the time and effort. It becomes necessary to gather data, do a literature review, and conduct an evaluation of site dynamics to see what is needed and note obvious data deficiencies. The primary emphasis is on the degree to which the contaminants may be available and may have significant effects on the ecosystem and public health.

If there are obvious data deficiencies (e.g., no bathymetry for the area, no good sediment map), then it becomes necessary to conduct initial field surveys to fill in the gaps. For example, you go to Lake Onondaga and look for accurate, high-resolution bathymetry, and even though the area has been studied extensively because of a variety of historical contaminants, you are hard-pressed to find the data. The surficial sediment maps are gross characterizations of what is out there. It is hard to believe this after probably 20 or 30 years of study, but it very well could be the case.

When you are through with the initial field surveys, you will have fundamental information. The initial field surveys tell you there is a problem; for example, there may be PCBs, dioxins, and metals of concern in the navigation channel that need to be dredged. It may be necessary, or useful, to push the current state of the art. This is where the need arises to conduct detailed field surveys. It was the committee's impression that techniques are available to provide us with the highest-resolution distribution of contaminants. We may not have the money to do it, but the techniques are available.

You may question some of the speakers at this symposium about capabilities to push the state of the art to provide high-resolution "surgical dredging," or dredging that will allow you take off a layer of material that may be just 1 or 2 cm in vertical extent. With the global positioning system (GPS) and differential GPS, we probably can get down to centimeter scales in the horizontal. You may hear arguments that we also can provide vertical dredging tolerances of centimeters. Coring techniques are possible, but as I hope I have made clear, the spatial variability does not favor the use of a just few cores to characterize a large area. You probably have to combine some amount of coring with higher-resolution acoustic techniques; however, it can be done and the argument may be that—even given the costs—it is warranted and should be done.

In summary, remembering that the systems we deal with are affected by significant spatial and temporal variability, an understanding of site history, existing conditions, and dynamics is needed for the design and implementation of a successful management plan. The process of site assessment is complex because of the variability, but it is possible—although it may be expensive—to obtain the information necessary to make informed decisions. There always will be some uncertainty, and you must determine what level of uncertainty is acceptable. If one waits until all uncertainty has been eliminated, then no decision ever will be made.

We believe that data gathering must focus on specific needs. (As a scientist, this causes me great pain.) Data gathering is not an end in itself; it must be process oriented. If someone is going to gather data, then someone else must ask why, because everything is rooted in a fundamental understanding. The manager must have a fundamental understanding of the dynamics affecting the transport and availability of the contaminants of concern, and all the sampling is dictated by that requirement.

Good site assessment results in minimum-cost projects that meet clean-up objectives and allow the implementation of optimal remediation schemes. It is the foundation for all of the work we do. The committee felt it was a very important part of the process.