DRP-5-09
May 1994

Dredging Research Technical Notes

Sediment Chemistry Profiles of Capped Dredged Sediment Deposits Taken 3 to 11 Years After Capping

Purpose

This technical note summarizes sediment chemistry profile results from coring studies of capped dredged sediment deposits. These studies document the long-term effectiveness of capping for isolating contaminated sediments from the aquatic environment and should serve to broaden the information base for making management decisions.

Background

Capping is the controlled, accurate placement of contaminated dredged material at an open-water disposal site, followed by a covering of clean isolating material. For purposes of this note, the term "contaminated" refers to material found to be unacceptable for unrestricted open-water disposal because of potential contaminant effects, while the term "clean" refers to material found to be acceptable for such disposal.

The practice of managing contaminated dredged sediments by capping is becoming more frequently considered and used as an alternative. Dredging, dewatering, and transporting contaminated sediments to nearshore or suitable upland sites can be 5 to 100 times as expensive as in-water capping (Sumeri and Romberg 1991). Despite extensive evidence that capped disposal mounds are stable, there are few data available on the long-term fate of contaminants buried by the disposal process or the nature of the cap-mound interface. This has led to questions regarding potential pathways for contaminant migration through the cap.

Guidance is available on monitoring considerations for capping (Palermo, Fredette, and Randall 1992). This note supplements the available guidance by providing examples of sediment chemistry profiles obtained from cores taken at three sites through the full cap thickness and into the underlying contaminated material.

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Additional Information

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Core Sampling and Sediment Chemistry Profiles

In the first capping trials conducted in the eastern United States in 1979 and the early 1980s, investigations of cap effectiveness focused on physical coverage of the contaminated sediments with the capping sediments and the stability of the cap. However, such surveys could not provide assurance that the sediment layers remained unmixed or that contaminants were not migrating through the caps.

Direct physical evidence of cap effectiveness through the use of long cores was first collected in the mid-1980s (SAIC 1984, Bokuniewicz 1989). The first published example of contaminant isolation below caps was presented by Truitt (1986) as part of the Seattle District's 1984 Puget Sound capping demonstration project. That study, conducted 6 months after cap placement, clearly demonstrated that the contaminants were sequestered in the deeper layers and that mixing of the layers during the placement of the capping material was minimal.

Results of sediment chemistry profiles reported in this technical note represent time frames extending up to 11 years following cap placement. These data were independently collected by the New England Division, the Seattle District (and its permit applicants), and the New York District, U.S. Army Corps of Engineers.

New England Division

Project Description

In July 1990, the Disposal Area Monitoring System (DAMOS) Program conducted a study of the Stamford-New Haven, North (STNH-N) capped disposal mound at the Central Long Island Sound disposal site located 11 km south of New Haven Harbor, Connecticut (Figure 1). This mound was created in 1979 during dredging of the Stamford and New Haven Harbors. Approximately 33,000 m^3 of clean sand from outer New Haven Harbor was used for the cap, placed over approximately 26,000 m^3 of contaminated mud from Stamford Harbor, CT.

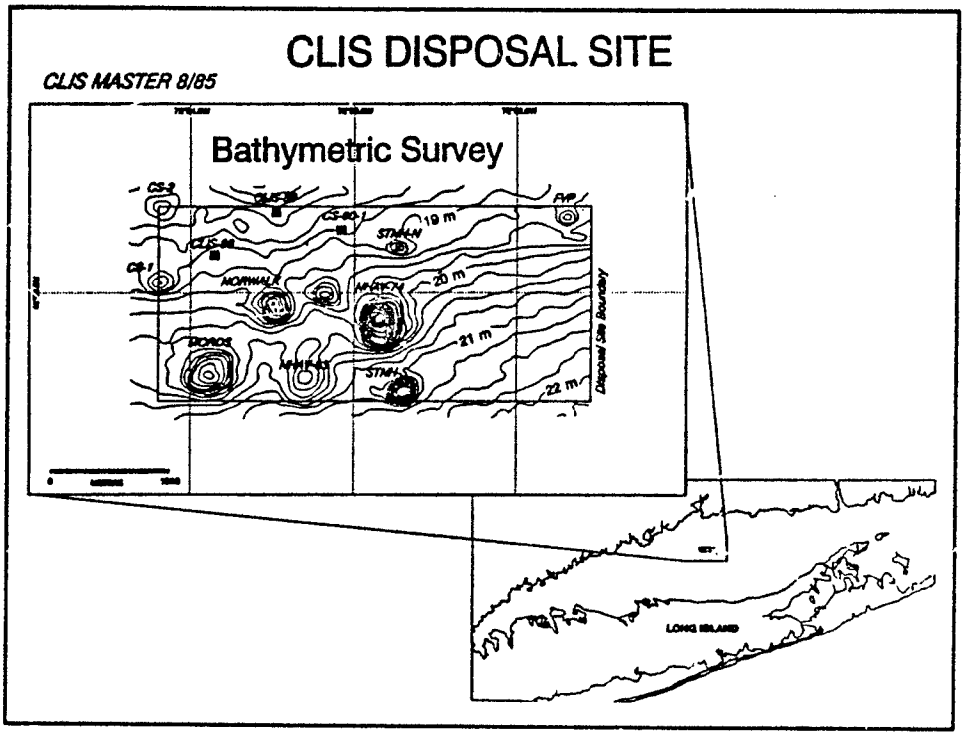

Figure 1. Location of Stamford-New Haven, North (STNH-N) capped mound at Central Long Island Sound (CLIS) disposal site

Core Sampling and Analysis

Five sediment core samples were collected from the STNH-N mound for analyses of grain size and chemical contaminants (Figure 2). All of the cores penetrated the cap into the underlying contaminated sediment. Prior to analyses, each core was divided into 20-cm-long sections. Each section was homogenized and analyzed separately for three heavy metals (cadmium, copper, zinc) and total petroleum hydrocarbons (TPH), which were known to be elevated in the contaminated Stamford sediments. Additionally, three cores were analyzed for polycyclic aromatic hydrocarbons, and one core was analyzed for polychlorinated biphenyls (PCBs) and pesticides.

Results

The five cores collected at STNH-N in July 1990, 11 years after capping, all showed distinct visual transitions from the sand cap into the contaminated mud, with the apparent zone of transition being less than 10 cm. Cap thickness ranged from 54 to 140 cm. For each of the five cores, heavy metal levels were sharply higher within the mud layer, usually by one order of magnitude or more. Results for zinc at the center station are presented in Figure 3a. The data for the other metals and core samples exhibit similar trends.

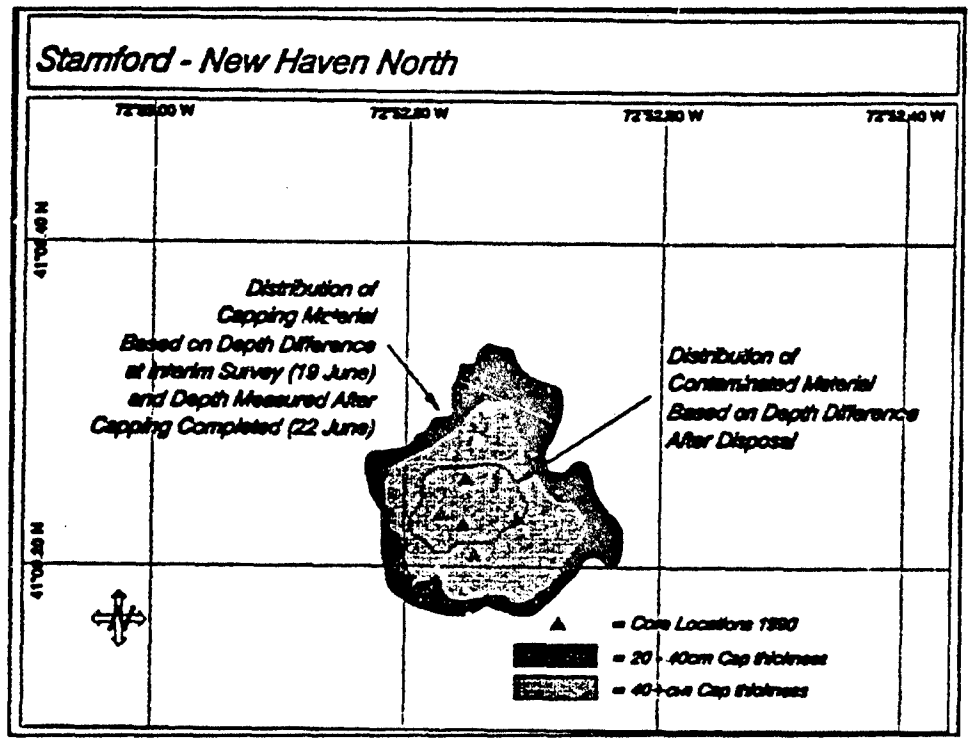

Figure 2. Location of geochemistry cores taken at STNH-N capped mound

Values within each layer generally agreed in magnitude with the predredging sampling results at the respective sources. Levels of TPH, also analyzed in all five cores, were one to two orders of magnitude higher in the mud layer in all five of the cores. Figure 3b illustrates TPH results for the center station. (Note that the TPH levels in the cap are so low (less than 10 ppm), they cannot be seen in the figure.) Results for the other organic constituents showed similar trends. Sumeri and others (1991) and Fredette and others (1992) discuss these data in more detail.

New York District

Project Description

The majority of the work and data described in this section is based on studies conducted for the New York District and reported by O'Connor and Moese (1984) and Bokuniewicz (1989).

In 1980, 390,000 m^3 of silt and clay was dredged from New York Harbor and placed at the Mud Dump Site, located approximately 11 km east of New Jersey in the New York Bight Apex in the Atlantic Ocean. The material came from six projects with elevated but variable heavy metal levels. This mound was then capped with 91,000 m^3 of clean mud, followed by 938,000 m^3 of sand (Freeland and others 1983).

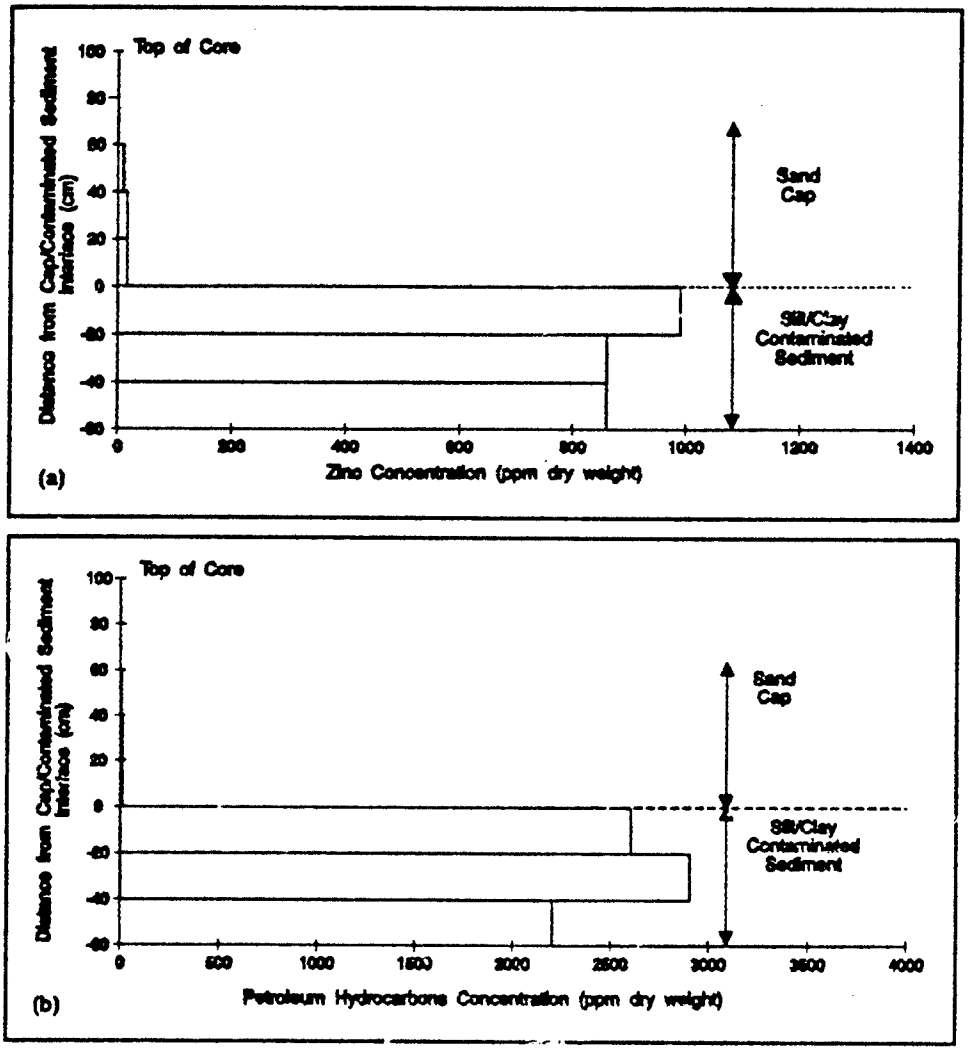

Figure 3. Concentrations of zinc (a) and TPH (b) in core sections from station center, STNH-N

Core Sampling and Analysis

Vibracore samples were taken from eight stations at the Mud Dump cap site in July 1983. All cores were analyzed to determine the thickness of the sand cap (Bokuniewicz 1989). Subsequently, the cores were subsampled at several discrete depths relative to the sand-mud interface. Each subsample was then analyzed for heavy metals (cadmium, copper, lead, and zinc), PCBs, and DDT (dichlorodiphenyltrichloroethane) and its metabolites.

Results

Bokuniewicz (1989) reported that the vibracores taken in 1983 through the capped mound (3.5 years after capping took place) showed a sand layer with an average thickness of 1.1 m and a very sharp interface between the sand and the mud. Grain size distribution in the cores showed that the sand-to-mud transition occurred over a distance of less than a few centimeters.

Metals profiles in the vibracores of capped material showed that, in general, metals concentrations in the mud just below the sand-mud interface were an order of magnitude greater than the concentrations in the upper layers of the sand cap. Figure 4a illustrates this trend for one metal (zinc) at Station 7. In all cases, the concentrations in the interface region were less than concentrations 5 to 10 cm below the interface. Also, in most cases, PCB levels below the sand cap were at least a factor or two greater than concentrations in the sand cap.

Figure 4b presents PCB data from Station 7. Results from the other stations were similar. Pesticides were detected as trace-only in the interface and deeper samples.

Seattle District

Project Description

In 1984 the Duwamish Waterway in Seattle was the initial northwest site for management of contaminated dredged material using capping (Sumeri 1984, 1989). Approximately 840 m^3 of contaminated fine-grained sediment was disposed in a borrow pit located in the West Waterway of the lower Duwamish River and capped with 3,200 m^3 of clean sand dredged from the upper Duwamish Waterway (Figure 5).

Sampling and Analysis of Sediment Samples

The project was monitored during dredging, during disposal, and after disposal (at 6, 12, and 18 months and at 5 years). Three vibracore samples were taken along the length of the project at the thickest part of the cap, as close as possible to the samples taken 18 months after capping (Figure 6). Two cores were extracted within 5 ft of the 18-month core locations and the third, within 15 ft.

Prior to analyses, the cores were subsampled at several discrete depths relative to sand-mud interface. Each subsample was then analyzed for total concentrations of copper, lead, zinc, and PCBs. These chemicals served as tracers to track potential movement of contaminants through the sand cap.

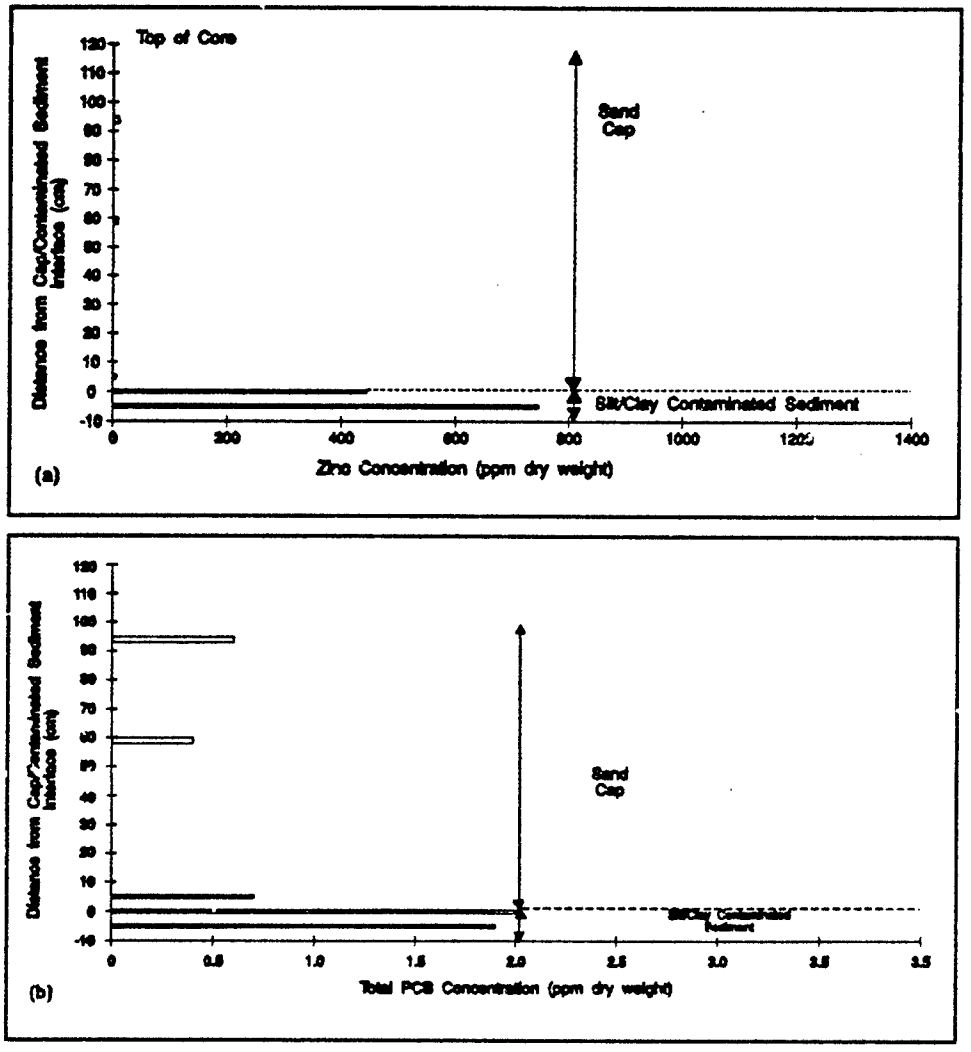

Figure 4. Zinc (a) and total PCB (b) concentrations in sections from Station 7, Mud Dump Site

Results

The post-capping 6-month, 12-month, 18-month, and 5-year sediment chemistry profiles all showed similar results. The interface between the contaminated and cap sediments was observed to be sharp and relatively unmixed in all cores. In general, the concentration of heavy metals and PCBs was at least an order of magnitude lower in the sand cap than in the contaminated sediments below. Chemistry profiles provided no indication of diffusion of contaminants into the sand cap. Figure 7 illustrates this trend for zinc and PCB 1242 from Station R, 5 years after capping.

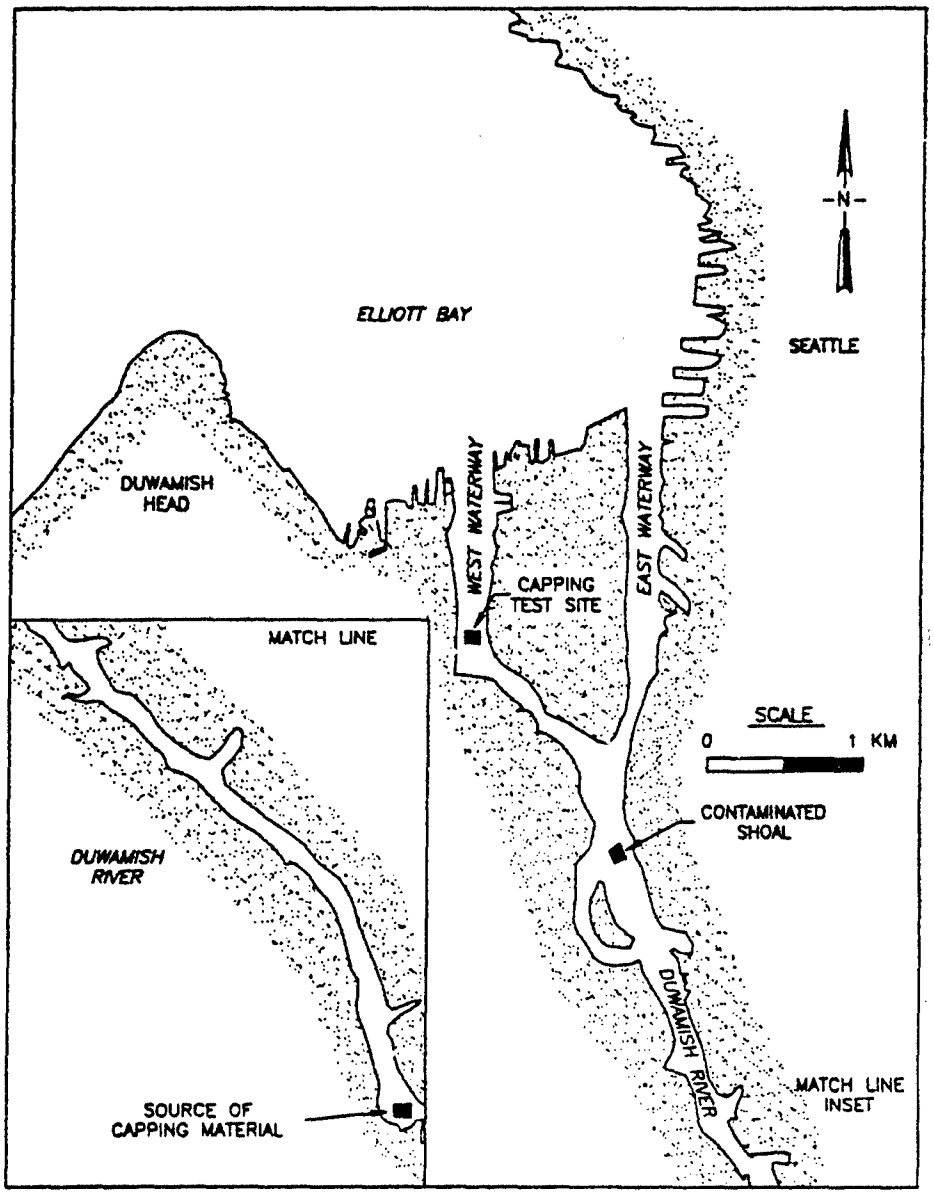

Figure 5. Duwamish capping vicinity map

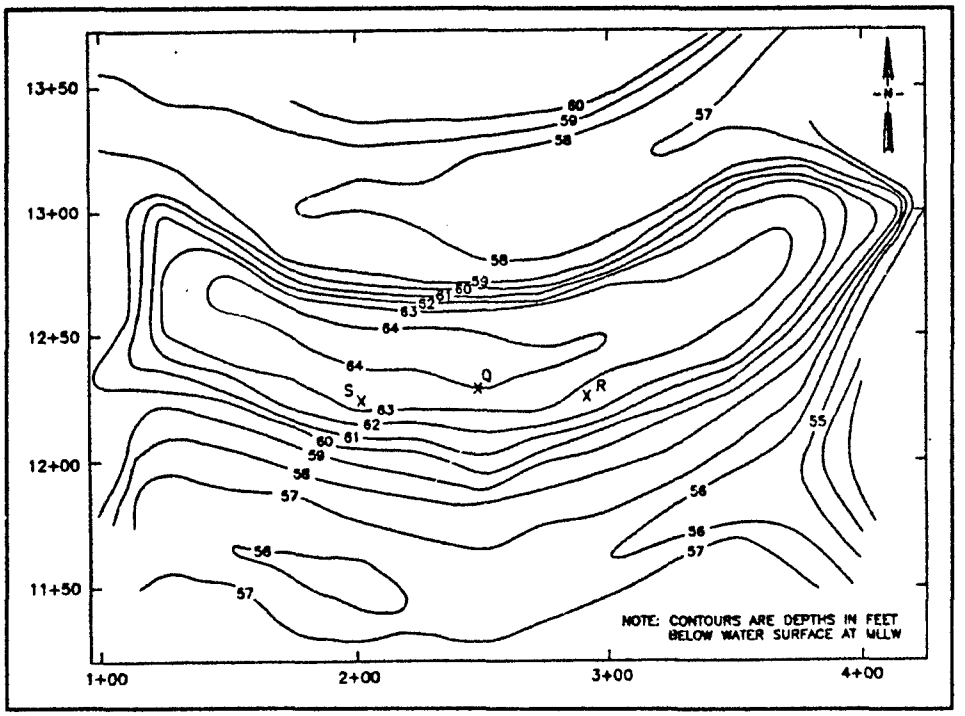

Figure 6. Location of chemistry cores (S, Q, R) of the Duwamish capping test site

Data for the other metals and stations were similar. The 18-month and 5-year sediment chemistry sand cap concentrations matched almost exactly. A more complete discussion of the results can be found in Sumeri and others (1991).

Conclusions

The field studies reported herein all provide strong evidence of the ability to place sediments in layers using surface disposal equipment and precision navigational control during disposal. Little apparent mixing was observed at the cap/contaminated interface in any of the deposits, with the transition taking place over only a few centimeters. Several instances of heterogeneity of contaminant levels in the caps were observed. The contaminant levels observed in these cases were relatively low compared to the contaminated sediments and were believed to be associated with finer material dredged along with the sand caps used in these projects. Levels of heterogeneity observed here should be expected, given the variability that is inherent in sediments both horizontally and vertically. Such heterogeneity needs to be taken into account when interpreting future coring results relative to chemical migration within caps.

Capping appears to offer a management option that will be effective for the long-term isolation of contaminated sediments from the surrounding environment. Although the breadth of experience is still relatively small,

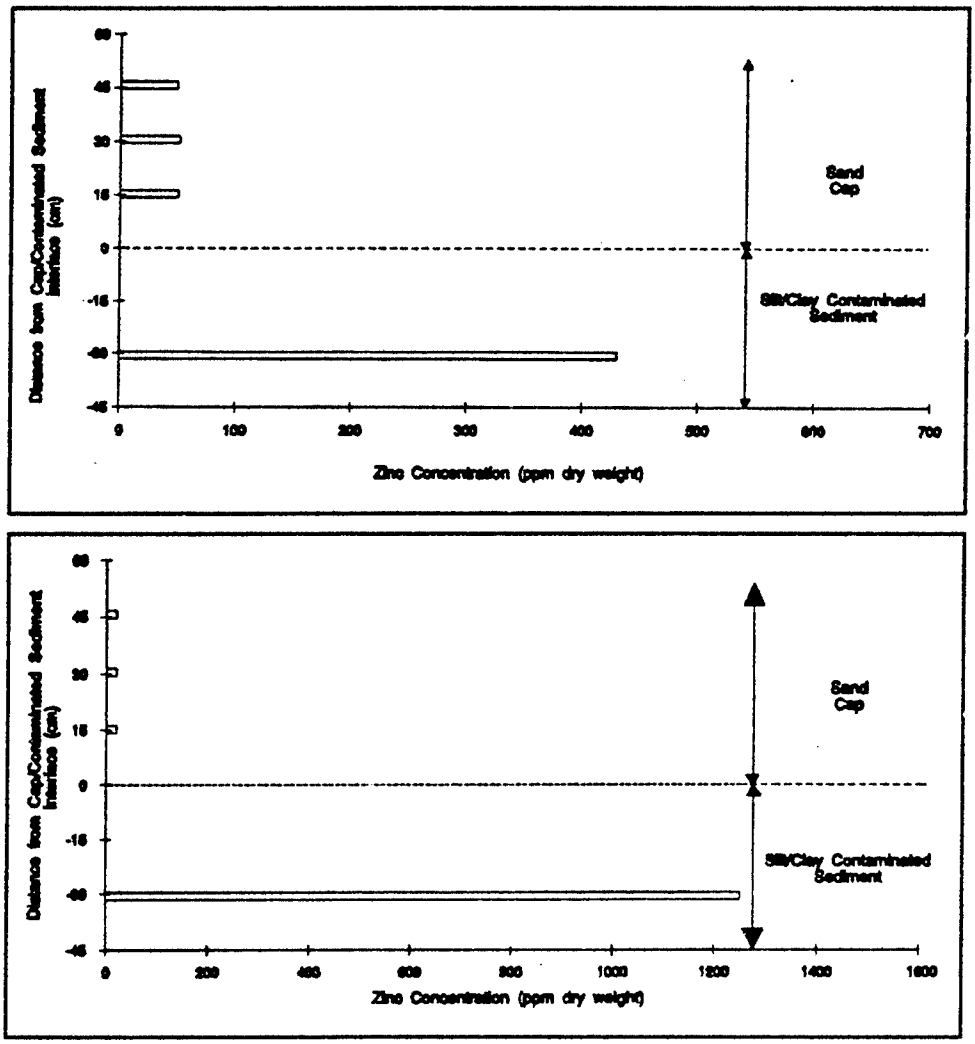

Figure 7. Zinc and PCB 1242 concentrations in core sections from Station R, Duwamish River capping site

evidence on the ability to create caps and on the effectiveness of capping is rapidly increasing as follow-up surveys of such sites continue. Many of the questions about the effectiveness of caps to contain contaminants over long time periods can now be answered with greater certainty.

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