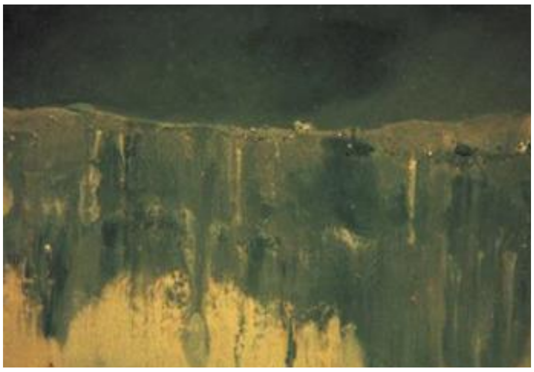
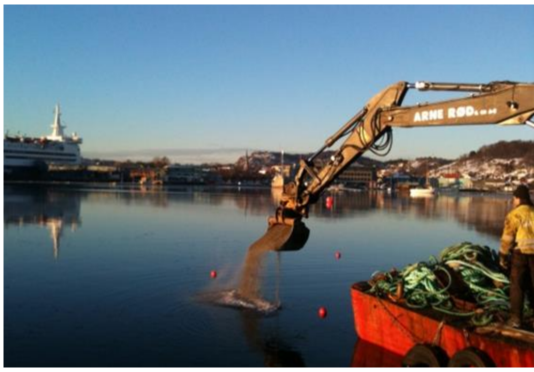
Swedish Geotechnical Institute

In-situ capping of contaminated sediments

Remedial sediment capping projects, worldwide: A preliminary overview

Joseph Jersak, Gunnel Göransson, Yvonne Ohlsson, Lennart Larsson, Peter Flyhammar, Per Lindh





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The entire SGI Publication 30 set includes the following independent parts:

SGI Publication 30-1, Huvuddokument. *In-situ* övertäckning av förorenade sediment. Metodöversikt. (In Swedish)

SGI Publication 30-1E, Main text. *In-situ* capping of contaminated sediments. Method overview.

SGI Publication 30-2E. *In-situ* capping of contaminated sediments. Contaminated sediments in Sweden: A preliminary review.

SGI Publication 30-3E. *In-situ* capping of contaminated sediments. Established *ex-situ* and *in-situ* sediment remediation technologies: A general overview.

SGI Publication 30-4E. *In-situ* capping of contaminated sediments. Remedial sediment capping projects, worldwide: A preliminary overview.

SGI Publication 30-5E. *In-situ* capping of contaminated sediments. Capping Sweden's contaminated fiberbank sediments: A unique challenge.

SGI Publication 30-6E. *In-situ* capping of contaminated sediments. An extensive, up-to-date collection of relevant technical and other international references.

SGI Publication 30-7. *In-situ* övertäckning av förorenade sediment. Övergripande sammanfattning. (In Swedish)

SGI Publication 30-7E. *In-situ* capping of contaminated sediments. Overall summary.

Fact sheet. *In-situ* capping of contaminated sediments. Method overview.

1. Introduction and approach

Presented herein is a preliminary overview of: (a) remedial sediment capping projects completed, initiated, or planned to-date, worldwide, (b) the types of capping-based remedies involved (isolation, thin-layer, conventional, and/or active), and (c) where capping, including different types, has been and is being conducted.

Since the capping overview document to which this publication is attached mainly targets a Swedish audience, sediment capping projects completed to-date in Sweden are also presented, and discussed in relatively more detail. Information is also presented herein on sediment removal (dredging) projects in Sweden. Removal projects are presented to place nationwide capping efforts into the larger context of nationwide sediment-remediation efforts in general.

Information presented herein was developed through preliminary reviews of readily available (and mostly published) information. This overview is not intended to represent an exhaustive, complete, and up-to-date summary of all remedial sediment capping projects completed, ongoing, and planned, worldwide. Such was not a goal of the capping overview project. Regardless, this summary provides a general understanding what has been and is being done in regards to capping in Sweden, Scandinavia, and worldwide.

Note, no details are provided herein for the non-Swedish capping projects listed, although a number of references are provided. Nevertheless, it is important to clarify virtually all projects listed involve capping of contaminated minerogenic (mineral-based) sediments. Global experience in capping fiberbank (cellulose-based) sediments is extremely limited, as discussed in SGI Publication 30-5E. To this author's knowledge, the very few capping projects that have been completed to-date worldwide for fiberbank (and/or fiber-rich) sediments have all been conducted in Sweden.

To underscore: This is only a preliminary overview of remedial sediment capping projects, worldwide. There is considerable merit, for a number of reasons, in conducting a follow-up review of such region- and country-specific projects that is more expansive, detailed, up-to-date and which incorporates input from multiple informed parties.

2. Sediment capping, internationally

2.1 Isolation capping

2.1.1 Conventional isolation capping

A summary listing of sediment capping projects completed, initiated, or planned worldwide up to 2005 is provided in Appendix (provided by Prof. Danny D. Reible, Texas Tech University). Based on this listing:

- Worldwide, a total of 107 projects had been completed, initiated, or planned up to 2005.
- The great majority of projects are isolation capping. Thin-layer capping projects include item #s 10, 20, 26, 62, 73, 76, and 107.

- The great majority of projects are conventional isolation capping. Active isolation capping projects include item #s 13, 28, 37, 63, and 77.
- By far the most projects (~ 75%), occurred in the U.S. This is understandable since the U.S. is where the practice of remedial sediment capping basically originated.
- 15 projects have occurred in Japan.
- A total of 13 projects have occurred in other countries (including Norway, The Netherlands, Sweden, Germany, and Belgium, as well as Hong Kong).

The project listing provided in Appendix is clearly an extensive effort. However, it is not quite complete. Furthermore, over the last 10 years or so, many more capping projects have been completed, initiated, or planned, worldwide. These additional projects also address a wide variety of sediment contaminants (organics, metals, organometallics, and/or non-aqueous phase liquids [NAPL]) which occur in an equally wide variety of aquatic environments.

Since 2005, and in the U.S. alone, a significant number of conventional isolation capping projects (both field pilot- and full remedial-scale) have been completed, initiated, or planned. A partial listing of post-2005 isolation capping projects (completed, under construction, or in design phase) is provided below (Russell, 2015; ITRC, 2014; Ebrahimi, 2015; National Grid, 2013 and other sources). Note, all but a couple of the projects listed are in the U.S., and many involve partial sediment removal prior to *in-situ* capping.

Confirmed conventional isolation capping projects:

- Baie Comeau, QC (Canada)
- LCP Chemicals Site, Brunswick, GA
- Buffalo River, NY
- Ironton Tar, OH
- Tittabawassee River, MI – SMAs 4 and 5
- San Jacinto River Waste Pits, TX – TCRA
- Tittabawassee River, MI – Reaches B and D

Could be conventional isolation capping projects. Otherwise, active isolation capping projects:

- Money Point Phase III, Elizabeth River, VA
- Esquimalt Graving Dock, BC (Canada) – Phases 1 and 2
- Eddon Boatyard, WA
- Hylebos Waterway (Commencement Bay), WA
- St. Louis River/Interlake/Duluth Tar, MN
- Campbell Shipyard, CA

2.1.2 Active isolation capping

As indicated above, many more conventional isolation capping projects have been completed, initiated, or planned to-date, worldwide, than active isolation capping projects.

Nevertheless, international interest in active isolation capping is growing. As a result, there has been a rapid increase in the number of field pilot- or full remedial-scale active isolation-capping projects (completed, initiated, or planned) over the last 10 to 15 years. The great majority of these projects occur in the U.S. and many in Norway. A partial listing of such projects is provided below (ITRC, 2014; Patmont et al., 2014; USEPA, 2013 and other sources).

Note, the projects listed below: (a) are all in the U.S., (b) are organized and listed by the type of active material used, and (c) mostly (but not exclusively) involve the use of active-capping products or technologies for delivering active materials to submerged sediment surfaces. The products/technologies used often include AquaBlok® and related products, SediMite™, and RCM™s.

Carbon-based sorbents (mostly, but not exclusively, activated carbon [AC]):

- Anacostia River, MD (project generally referenced in Appendix, item #73)
- Cottonwood Bay, Grand Prairie, TX
- Duwamish Slip 4, WA
- Onondaga Lake, NY
- Passaic River, Mile 10.9, NJ
- Puget Sound shipyard, WA
- Spokane River Upstream Dam PCB Site, WA
- Stryker Bay, SLRIDT, MN

Organoclay:

- Central Hudson Gas & Electric Corp, NY
- Cottonwood Bay, Grand Prairie, TX
- Former creosoting wood treating site, Escanaba, MI
- Gasco, Portland, OR
- Grand Calumet River, East Branch, IN
- Pine Street Barge Canal Superfund Site, VT (project generally referenced in Appendix, item #68)
- Port of Portland, OR
- Roxana Marsh, Grand Calumet River, IN
- Salem Manufactured Gas Plant, MA

Clay minerals (mostly bentonite):

- Anacostia River, MD (project generally referenced in Appendix, item #73)
- Chattanooga Creek, TN
- Galaxy/Spectron Little Elk Creek, MD
- Penobscot River, ME

Apatite (calcium phosphate minerals):

- Anacostia River, MD (project generally referenced in Appendix, item #73)
- Cottonwood Bay, Grand Prairie, TX

Additional active isolation capping projects in the U.S. are listed below (Russell, 2015). The active materials used in these projects typically include AC, organoclay or some unidentified source for total organic carbon (TOC). For most (but not all) projects, active materials were placed through water using active-capping products or technologies.

- Fox River, WI (OU1 as well as OU 2 to OU 5)
- Gloucester Harbor, MA
- Housatonic River, MA (1½ Mile Reach)
- Lower Rouge River, Old Channel, MI
- River Raisin, MI
- Silver Lake, MA
- St. Lawrence River, Alcoa East Plant, NY
- Upper Hudson River, NY

As noted in Section 2.1.1, additional active isolation capping projects could potentially be added to the above lists.

2.2 Thin-layer capping

2.2.1 Conventional thin-layer capping (including EMNR)

Relatively inert (non-active) capping materials like sediment or sand have been used in a number of conventional thin-layer capping projects. Such projects can generally be considered the same as EMNR (enhanced monitored natural recovery) projects (see SGI Publication 30-3E).

According to Merritt et al., 2009 and 2010a, several U.S. projects designated as conventional thin-layer or EMNR projects have been completed in the U.S. Target placed thicknesses for these projects ranged from 10 to 30 cm, with 15 cm most common. These projects include the following (note, all three projects are referenced in Appendix and are listed in this section for clarification):

- Wyckoff/Eagle Harbor, WA
- Ketchikan Pulp Company, AK
- Bremerton Naval Shipyard, WA

Merritt et al. further identify additional projects (all in the U.S. except one) they also consider "thin-layer capping" projects, but where placed material thicknesses were greater, on the order of 15 to 45 cm. These projects include the following (note, all projects except Saguenay Fjord and Duwamish Waterway are referenced in Appendix and are listed in this section for clarification):

- Saguenay Fjord (Quebec, Canada)
- Palos Verdes Shelf, CA
- Anacostia River, MD (portions of project involved use of active materials)
- Grasse River, NY (portions of project involved use of active materials)
- Duwamish Waterway, WA

Magar et al., 2009 also identify a couple additional EMNR projects for which placed material thicknesses were not indicated (Commencement Bay, WA and Lavaca Bay, TX).

2.2.2 Active thin-layer capping (~ *in-situ* treatment)

A significant number of active thin-layer capping projects have been completed to-date, worldwide, and interest in this remedial strategy is growing rapidly, especially over the last decade or so. Active thin-layer capping is often considered the same as (or at least placed into the same remedial category as) *in-situ* sediment treatment (see SGI Publication 30-3E).

Like trends in growth for both conventional and active isolation capping, the great majority of active thin-layer capping projects completed or planned to-date occur in the U.S. and Norway. Also, many of the projects involve the use of AC.

A partial listing of field pilot- or full remedial-scale thin-layer active capping (~ *in-situ* treatment) projects is provided below (as referenced in ITRC, 2014; Patmont et al., 2014; Ghosh et al., 2011; Cornelissen et al., 2011; USEPA, 2013 and other sources).

Note, the projects listed: (a) are all in the U.S., (b) all involve the use of carbon-based sorbents, mostly AC, and (c) mainly (but not exclusively) involve the "Method-B" approach for active-material delivery to submerged sediment surfaces (see SGI Publication 30-3E). Some projects involve the "Method A" delivery approach. For many of the Method-B projects, products or technologies were used for active material delivery.

- Aberdeen Proving Grounds, MD (multiple sub-sites and projects)
- Bailey Creek, VA
- Berry's Creek, NJ
- Bremerton Naval Shipyard, WA (multiple projects)
- Custom Plywood, WA
- Grasse River, NY
- Hunter's Point, San Francisco Bay, CA
- James River, VA
- Little Creek, VA
- Mirror Lake, DE
- South River, VA
- Tittabawassee River, MI

3. Norwegian capping projects

3.1 Introduction

Over the last decade or so, the regulatory infrastructure in Norway related to contaminated sediment characterization, risk assessment, and remediation (including published guidance in all these areas) has developed extensively. This is reflected by an impressive, yet partial, listing of sediment-related guidance documents prepared by SFT, Klif, and Miljø Directorate (see SGI Publication 30-6E).

All aspects of the contaminated sediment market in Norway have developed to a far higher level than in any other Scandinavian country. In fact, the Norwegian market is likely the second largest in the world, behind the U.S. market. The Swedish consulting community appears to recognize this (e.g. COWI, 2013).

Thus, it is not surprising a significant number of sediment capping projects (of different types) have been completed, initiated, or planned to-date in Norway. For this reason, Norwegian capping projects deserve special mention herein.

3.2 Isolation capping

3.2.1 Conventional isolation capping

In the pre-2005 summary project listing (Appendix), only two conventional isolation-capping projects were listed for Norway: project # 87 (Eitrheim Bay) and project # 109 (Sørfjorden).

In fact, a significant number of sediment capping projects, including conventional isolation-capping projects, have been completed (including prior to 2005), initiated, or planned to-date in Norway. The projects involve conventional isolation capping of contaminated sediments either *in-situ* or following removal-then-re-deposition. Most projects occur in harbor areas. A partial project listing is provided below (per COWI, 2013; Eek et al., 2013; SFT, 2006; Laugesen, 2015 and other sources).

- Bergen Harbor (multiple projects)
- Harstad Harbor
- Kristiansand Harbor (multiple projects)
- Mosjøen Harbor
- Oslo Harbor (multiple projects)
- Sandefjord Harbor
- Sunken German Submarine (Ubåt U-864)
- Tromsö Harbor
- Trondheim Harbor (multiple projects)

3.2.2 Active isolation capping

A partial listing of field pilot- or full remedial-scale active isolation-capping projects completed to-date in Norway is provided below (per Patmont et al., 2014; COWI, 2013 and other sources).

Note: (a) all involve the use of AC sorbents, (b) all involve the use of products, technologies, or methods for delivering AC to submerged sediment surfaces, namely BioBlok® or OPTICAP, and (c) some caps could be considered active “hybrids” (between isolation and thin-layer) in terms of design and/or intended functioning.

- Bergen Harbor (Kirkebukten)
- Leirvik Sveis, shipyard
- Naudodden, Farsund
- Sandefjord Harbor
- Trondheim Harbor

3.3 Thin-layer capping

3.3.1 Conventional thin-layer capping (including EMNR)

Only one project has been completed to-date in Norway that can be considered conventional thin-layer capping or EMNR. This project involved placement of a very thin sand cap (target 5 mm thick), which was included as a control plot in a field pilot-scale evaluation of different active thin-layer capping remedies in Trondheim Harbor (Cornelissen et al., 2011). The active thin-layer capping remedies evaluated involved use of AC, with or without including clay (bentonite).

3.3.2 Active thin-layer capping (~ *in-situ* treatment)

Three active thin-layer capping (~ *in-situ* treatment) projects have been completed to-date in Norway. These include projects in Trondheim Harbor (see above) and in Grenlandsfjord, both in shallow and deepwater areas (per Patmont et al., 2014; ITRC, 2014; Cornelissen et al., 2011; USEPA, 2013; NGI and NIVA, 2012; Eek et al., 2010; Schaaning and Josefsson, 2011 and other sources).

All of these projects involved: (a) use of AC, and (b) use of the Method-B approach for AC delivery (see SGI Publication 30-3E) specifically using the OPTICAP method.

4. Swedish capping projects, plus dredging projects (for comparison)

4.1 Introduction

A complete and detailed review and summary of sediment remediation projects completed to-date in Sweden would likely be very useful to numerous interested parties. However, such was not a goal of this capping overview project. Regardless, a preliminary overview of Swedish sediment remediation projects was necessary to place the capping overview into a more balanced national context.

And since the capping overview project focuses on sediment capping, emphasis was logically placed on obtaining and reviewing readily available information specifically related to completed (and planned) sediment capping projects in Sweden.

4.2 Swedish capping projects

Based on results of a review of readily available (and published) information, a preliminary summary of sediment capping projects completed to-date in Sweden is provided in Table 1.

Table 1 Preliminary summary of sediment capping projects completed to-date in Sweden.

Site or project name	Where	When	General descriptions of site, project, and cap design	References
Vanån, i Vansbro	Dalarna	1991-92	- River sediments (presumably minerogenic) contaminated by creosote (presumably NAPL). - Cap design: Basal geotextile overlain by ~ 30 cm sand. - Capped area, ~ 6,800 m^2.	Naturvårdsverket, 2003; von Post, 2005.
Lake Turiningen[1)]	Södermanland	1999 - 2000	- Fiber-rich lake sediments near stream mouth contaminated by Hg. - Cap design: Basal geotextile overlain by ~ 20 cm fine-grained sand (in some areas, ~ 20-40 cm of crushed rock for erosion protection, in addition to or instead of sand layer). - Capping area: approx. ~ 40,000 m^2.	Bergman, 2012; Nykvarns kommun, 2004; www.turingen.se.
Lake Turiningen[1)]	Södermanland	2001-02	- Soft, fiber-rich sediments in deeper parts of lake also contaminated with Hg. - Cap design: several cm of an “artificial” (aluminum-based) sediment material, derived from a placed “gel” material. - Capping area, ~ 800,000 m^2. - Note, this is considered conventional thin-layer capping.	Naturvårdsverket, 2003; Petsonk and Bergman, 2006; www.turingen.se.
Tollare	Stockholm	2008	- Fiber sediments in lake contaminated by Hg. - Cap design: Basal (and weighted) geotextile overlain by a layer of crushed stone for erosion protection. Thickness of crushed-stone layer unclear.	Valdemarsviks Kommun, 2013; Petsonk et al., 2008.
Lundbyhamnen, in Göteborg harbor	Västra Götaland	Started 2009	- Harbor sediments (presumably minerogenic) contaminated by TBT, and perhaps also other pollutants. - Involved capping of contaminated sediments that previously have been dredged but then re-deposited (somewhere else). . - Cap design: ~ 1 m sand.	Länsstyrelsen Västra Götaland, 2006; Göteborgs Stads Nyhetstidning, 2015.
Sannegårdshamnen, i Göta Älv	Västra Götaland	?	- Appears to be similar to Lundbyhamnen.	Göteborgs Stads Nyhetstidning, 2015.

Fotnot:
[1)] Both Lake Turingen projects are referenced in Appendix and are included in table for clarification.

As shown in Table 1, only a limited number of sediment capping projects have been completed or initiated to-date in Sweden. All but one are considered conventional isolation capping. The gel-cap project completed in Lake Turingen is considered to be conventional thin-layer capping, since there appears to be no active (e.g. sorptive) characteristics attributed to the artificial sediment (Bergman, 2012).

Interestingly, despite the small number of projects, they collectively represent a surprisingly broad range of aquatic environments, sediment types, contaminant types, capping strategies, capping materials, and cap designs.

In addition, at least a couple other Swedish capping projects are understood to currently be in the serious-consideration or planning stages:

- Lillesjön (Jönköping): As-contaminated minerogenic sediments (Golder, 2014).
- Södra hamnen (Skåne): PCB- and TBT-contaminated minerogenic sediments (Anchor QEA, 2015).

4.3 Swedish removal (dredging) projects

Although the focus herein is on capping, a limited preliminary review was also conducted of readily available information on sediment removal (mainly dredging) projects in Sweden. This was done for purposes of general comparison, and to place nationwide capping efforts into the larger context of nationwide sediment remediation efforts in general.

A listing of the relatively larger and more well-known remedial sediment dredging projects completed (including ongoing or planned) to-date in Sweden is provided below. Information comes from a number of readily available, published sources (Elander, 2012, 2013; Naturvårdsverket, 2003; Ekman, 2004; Göteborgs Stads Nyhetstidning, 2015):

- Järnsjön (PCBs; utsläpp från ett returpappersbruk)
- Örserumsviken (PCBs; PAHs; utsläpp från ett returpappersbruk)
- Svartsjöarna (Hg; utsläpp från ett pappersbruk)
- Skutskärs hamn (Hg; utsläpp från massaindustri, ingår i en hamnutbyggnad)
- Valdemarsviken, ongoing (Cr and Hg; utsläpp från ett garveri)
- Oskarshamn hamn, ongoing (metaller och dioxiner; utsläpp från kopparverk och batterifabrik)
- Ala Lombolo, Kiruna (Hg; utsläpp från laboratorium)
- Vanån, i Vansbro (Creosote-contaminated sediments)
- Lundbyhamnen, i Göteborg harbor (sediments contaminated by TBT, and perhaps also other pollutants).
- The Mälarprojektet, which is a navigational dredging project, but also references the presence and possible spreading of sediments contaminated by Hg; PAHs and/or TBT (Sjöfartsverket, 2013).
- Project in Gävle Harbor.

In addition to the projects listed above, references are also made in county-specific regional program summaries (see SGI Publication 30-2E) to other, perhaps smaller-scale sediment dredging projects (completed, ongoing, or planned). Many of these additional projects appear to involve sediment removal for remedial rather than navigational purposes, at least in part. Such dredging-related references are made for specific sites or areas in the following counties: Blekinge, Halland, Uppsala, and Östergötland.

4.4 Summary

It appears more remedial removal (dredging) projects have been completed (or initiated or planned) to-date in Sweden than capping projects. If this is accurate, a logical question is why.

One answer could be related to actual or predicted costs associated with Swedish experiences in implementing capping versus dredging remedies. Three of the five isolation-capping projects completed so far in Sweden incorporated the use of geotextiles (Table 1). Incorporating a geotextile in cap design increases total capping costs, often significantly. This may be giving consultants and others in Sweden the general impression capping is a relatively expensive sediment remediation technology, and perhaps one that is not economically competitive with removal technologies. If this is the perception, it is contrary to the much more widely held view that capping remedies are typically less expensive than dredging remedies (see SGI Publication 30-3E).

There could also be additional reasons for why dredging remedies seem to be more commonly considered and used in Sweden than capping remedies. These additional reasons are also based on perceptions, which may include:

- Removal (by dredging or excavation), although costly, is really the only viable, proven-effective solution for remediating contaminated sediments.
- In general, *in-situ* technologies for contaminated sediment remediation are too new and/or not yet proven-effective.
- *In-situ* capping is simply “covering up the problem”.
- Soft sediments cannot be successfully capped, or cannot be capped cost-effectively (without the use of a supporting basal geotextile, for example).
- There really isn’t any good sediment-remediation technologies available at all (dredging too expensive, and *in-situ* methods, including capping, are unproven). And because of this, most available resources instead go to soil or groundwater cleanup projects – where respective remediation technologies are, in contrast, perhaps considered more well-proven and relatively more cost-effective.

5. Capping projects in other Scandinavian countries

In addition to Norway and Sweden, contaminated sediments also occur in other Nordic countries as well, including in Denmark and Finland.

As noted by Spadaro (2011), capping – along with other *in-situ* and *ex-situ* sediment remediation technologies – is listed as being employed in Denmark and Finland. Thus, there is probably little doubt at least a few sediment capping projects, including conventional isolation capping, have been completed, initiated, and/or planned to-date in both Denmark and Finland.

An in-depth review of available information on capping projects in these other two Scandinavian countries was beyond the scope of this project. Nevertheless, it is known at least a couple capping projects have been conducted in these countries to-date:

- In Denmark: A pilot-scale conventional isolation-capping project was conducted (sometime) in the Port of Copenhagen (Rønberg et al., no date).
- In Finland: During 1998/99, a creosote-impacted, 0.5-ha area of sediment in Lake Jämsänvsi was covered by a (presumably basal) polypropylene filter geotextile overlain by 1 to 1.5 m of gravel and sand (Hyötyläinen and Oikari, 2003).

6. References

For all references cited herein, please see Publication 30-6E.

Appendix

Draft Summary of Contaminated Sediment Capping Projects, Revised 2005

The following summary table was provided (in pdf format) by Prof. Danny D. Reible, Texas Tech University.

Draft Summary of Contaminated Sediment Capping Projects
Revised 2005

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
Puget Sound/Washington										
1	Duwamish Waterway Seattle, Washington (CAD)	Heavy metals, PCBs	Existing 6-ft. deep subaqueous depression; Waterway depth 70 ft.	3 ft. design target; 2 ft. actual average after consolidation (21)	Sand (4,000 cy)	1.3 acres estimated [(a)] 0.7 acre original cap size (21)	1984	• Functionally no erosion (a small amount of cap eroded from one side to another, but was then covered by natural sedimentation) (21) • No chemical migration observed in second and third coring operations (21) • Concentrations of heavy metals and PCBs were at least an order of magnitude lower in the sand cap than in contaminated material below (22) • The 18-month and 5-yr sediment chemistry sand-cap concentrations matched almost exactly (22) • Interface between contaminated and cap sediments was sharp and relatively unmixed (22)	• First capping project (a "learning experience") in EPA Region 10 • Led by the USACE with limited involvement from EPA (21) • Key lessons learned: relationship between contaminated sediment fill volumes, CAD cell size, and rate of CAD filling (21) • Split-hull dump barge placed sand over relocated sediments in CAD cell (A) • Maximum sustained bottom currents: 0.2 ft/sec (occasional readings in the upper water column approaching 1.0 ft/sec) (23) ***- Determined to be a success with capping only in the West Waterway.*** ***- Last monitored in 2000 or 2001 (21).***	A, E, F, 21, 22, 23
2	One Tree Island Olympia, Washington (CAD)	Heavy metals, PAHs	Marina; 14.8 ft. deep	4 ft. (in order to obtain a consolidated cap of 3 ft.) (21)	Sand Clean sediment (E)	0.5 acres	1987	• Applied lesson from Duwamish: allow contaminated material to consolidate on barge and then to settle in CAD cell (1 - 2 weeks) (21) • Little prop scour; recreational divers said that cap appeared to be intact (21) • No chemical migration (A) • No erosion of cap (A)	• First permitted CAD project (21) • Maintenance dredging of a marina; top 2-3 ft. of contaminated sediments were dredged and placed in "overbuilt" (or "very deep") CAD cell in marina (21) • No ongoing monitoring required (21) • Last monitoring occurred in 1989 and showed that sediment contaminants were contained (A) ***- Still a working marina, considered a success, and still no monitoring since 1989 (21).***	A, C, E, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
3	St. Paul Waterway (Simpson Tacoma Kraft Superfund Site) Tacoma, Washington (ISC and habitat restoration)	Phenols, PAHs, dioxins, furans	Shallow, near shore sediments, 11.5 ft. deep Depth now is -20 ft. MLLW at extreme (21)	2-12 ft. 4.9-19.7 ft. actual (B, E) 3.9 ft. design (E) 3 - 13 or 14 ft. (36)	Coarse sand from Puyallup River	17 acres (11 acres of marine sediments capped; 6 acres of new intertidal habitat built along shoreline) (32)	1988	• Intensive monitoring conducted annually for 10 years (36) • Monitoring recently scaled back; cap will be checked every other year to ensure that it is still in place and that the elevation has not changed substantially; cap will be checked after any major storm or earthquake (36) • Everything is working fine; no chemical migration; cap still within specifications (A,21,36) • PRP won environmental award for habitat creation (21) • > 10 years of chemical and biological monitoring show contaminated sediments have remained confined and isolated beneath cap and cap is providing good habitat for estuarine biota (32) • St. Paul Waterway was delisted from the NPL on 10/29/96 (32)	• First designed and permitted capping project under Superfund regulatory process (21) • Some redistribution of cap materials occurred, but overall design level met (36) • C.californieus (typical deep burrowers that can cause bioturbation) found in sediments, but never at depths >1 m (3.3 ft.) (A); bioturbation would have been limited (21) ***- A storm caused some erosion in approximately 2002 and the cap was repaired. This maintenance was more for habitat restoration than cap effectiveness. Visual monitoring occurs every year. EPA prefers invasive monitoring every 10-20 years. The cap appears to be holding up well (21).*** ***- Recently completed 15 years of monitoring and closed the monitoring except for earthquake monitoring. Construction cost estimate of $5 million (10)***	A, B, C, E, 21, 32, 36 ***10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
4	Pier 51 Ferry Terminal Elliott Bay Seattle, Washington (ISC)	Mercury, heavy metals, PAHs, PCBs, PCDF	Docks at 20-25 ft. 60 to 100 ft. (at approx. 150 ft. from shore)	Docks: 4 ft. design (to achieve 3 ft. consoli-dation) (at water depths of approx. 35 ft. Rest of Site: 1.5 - 2 ft. design (to achieve 1 ft. consolidated)	Coarse sand	4 acres (2 acres with thick cap; 2 acres with thinner cap)	1989	• No chemical migration (A) • Cap within specifications (A) • Recolonization observed (A) • As recent as 1994, cap thickness remained within design specifications (A) • While benthic infauna have recolonized the cap, there is no indication of cap breach due to bioturbation (A) • For 1 or 2 years, the thinner cap was not as clean as the original cap, possibly due to mixing; the thicker cap remained clean (21) • No ongoing monitoring required (21) • Caps worked very well (21)	• Project was primarily an experiment to see if ferries would blow the cap away (hence thicker cap employed at the ferry area) (21) • During reconstruction of ferry terminal, a piling was pulled up, recontaminating the cap with creosote - cap was repaired (21) • Cap was recontaminated in top ~2cm with metals; fate and transport study demonstrated that ferry terminal was at nexus of two gyres (from north and south); this knowledge partially dictated subsequent cleanup efforts (21) ***- Ferry terminal completed some dredging and thin capping as a cap extension. Minor visual monitoring using divers since 2002 (21).***	A, E, 21
5	Denny Way CSO Elliott Bay Seattle, Washington (ISC)	Heavy metals, PAHs, PCBs	Water depth 18-50 ft.	2-3 ft.	Sand Sandy sediment from Duwamish Waterway	3 acres	1990	• 1994 cores showed recontamination in cap surface, but no migration of chemicals through cap (A) • Recontamination likely from CSO (21)	• CSO once discharged primary sewage; now discharges storm water and wastewater from some wastewater treatment plants (21) • An original project goal was to study rate of recontamination at cap surface using a mass balance approach; found not to be possible (21) ***- The CSO was cleaned out and the rate of re-contamination appears to have slowed to a stop. Monitoring continues regularly but not annually (21).***	A, B, C, E, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
6	Piers 53-55 CSO Seattle, Washington (ISC)	Heavy metals, PAHs, PCBs	Similar to those at Pier 51 (21)	1.3-2.6 ft. (A) Similar to those at Pier 51 (21)	Sand Material from Duwamish Waterway (E)	4.5 acres	1992	• No chemical migration • Cap stable, and increased by 15 cm (6 in.) of new deposition • Gyre caused sediments to erode from cap, but remaining cap seemed stable (although materials were spread around a lot) (21) • Accretion zone (21) • Difficult to discern volumes from consolidation vs. erosion (21) • Infaunal communities returned changed; much more shading after cap placement (21) ***- Erosion caused by outside influences such as currents in Elliot Bay had greater effects than the cap was designed to tolerate (21).*** ***- PCBs were detected, but they may have come from the Duwamish River (21).*** ***- Several reports recently completed in May 2004 addressing enforcement actions and standards (21).***	• Material sprayed under existing piers to form cap (21) • Pre-cap infaunal communities were destroyed in the rapid burial associated with cap construction (A) • Constituents from adjacent sediment site have been deposited in cap surface (E) • The amount of sediment accumulation was not anticipated; the ferry terminal creates a quiescent area, causing sediment dropout (21) ***- This cap could be judged a failure by previous standards, but may be considered satisfactory by new standards (21).*** ***- The capping did not function as planned, but there are benefits related to the habitat enhancement portion (21).***	A, E, 21
7	Pier 64 Seattle, Washington (ISC)	Heavy metals, PAHs, phthalates, dibenzofuran	Water depth 20-59 ft.	0.5-1.5 ft.	Sand	32.1 acres (E) 4 acres (NN)	1994	• Some loss of cap thickness in western portion; reasons unclear (erosion or consolidation/settling) • Reduction in surface chemical concentrations noted • Post capping water column monitoring showed concentrations of metals and organics to be below pre-capping concentrations (NN)	• Thin-layer capping used to enhance natural recovery and reduce resuspension of contaminants during pile driving (A) • A pier expansion project; old creosote-covered wood pilings replaced with concrete pilings, which are further spaced, allowing more light and more habitat (although still have issues with shading) (21) • Capping placed under and in front of pilings (21) ***- 5 years of monitoring showed that the cap is doing well (21)***	A, E, NN, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
8	GP Log Pond Whatcom Waterway Bellingham, Washington (ISC and beneficial habitat creation)	Mercury, phenols	Conversion of deep subtidal, shallow subtidal mudflat/debris and low intertidal riprap ; -5 ft MLLW (31)	Phase 1: 0.5 to 3 ft. Phase 2: 0 - 6 ft. Total: 0.5-10 ft. (31)	Phase 1: Coarser sand dredged material Phase 2: Finer-grained navigational dredge material (31)	5.6 acres (31)	Nov. 2000 to Feb. 2001 (31)	• No chemical migration at 3 months (A) • Cap successfully placed (A, 31) ***- Monitoring is showing that the cap is very successful (63)*** ***- In 2002, additional bathymetry was completed showing no problems (64)*** ***- 2002 core and chemical data show that mercury remains in the cap and there are no failures (64)***	• Interim Remedial Action under authority of State Model Toxics Control Act • Cap surface constructed using substrates and elevations to create beneficial use habitat • Full sediment removal was not practical because: (1) dredging with high amounts of debris would cause significant impacts to the water column, (2) dredging could have compromised integrity of containment structures (nearshore fill) for other hazardous substances, and (3) existing docks, dolphins, and shoreline structure present within or adjacent to the Log Pond would likely have been adversely impacted by a full removal action (31)	A, M, 21, 31 ***63, 64***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
9	East Eagle Harbor/Wyckoff Bainbridge Island, Washington (ISC and intertidal habitat creation)	PAHs (36)	Phase I: contaminated subtidal harbor sediments capped Phase II: contaminated nearshore sediments capped Water depths 0-45 ft. (36)	Phase I: 3 ft. (36) Phase II: 3 ft. (36)	Phase I: Clean river sediment (275,000 cy) Phase II: Upland fill (clean sand) (120,000 cy) (28) Phase III: upland fill (80,000 cy) (36)	Phase I: 54.4 acres (E) Phase II: 15 acres (36) Phase III cap on Phase II area (slightly smaller footprint) (36)	Phase I: 1993-1994 Phase II: 2000-2001 Phase III: 2001-2002	• No chemical migration • Cap erosion measured within first year of monitoring in area near heavily used Washington ferry dock • After Phase I cap placement, pools of creosote were observed at cap edges; pools likely migrated from Phase II/III area, which was not contained at the time; divers extracted the pools regularly (36) • Ongoing monitoring planned for another 10 years; then, more monitoring likely (36) • Ongoing releases from ferry parking lot and other upland sources (36) • Cap is working very well; monitoring shows that cap is staying in place and is preventing chemical migration; the agency is very happy with the cap (36) • NOAA study documented rapid and substantial increase in quality of habitat (36)	• Phase I objective: reduce immediate risk (28) • Additional remediation delayed until upland source control achieved (the fall 2000 installation of sheet pile wall) (28) • Phase II objective: extend cap from 1994 cap's approx. 2-ft. thickness contour (about 900 ft. offshore) to northern shoreline of Wyckoff facility (and to coordinate with construction of new intertidal habitat area on western portion of site) (28) • Phase III objective: place 80,000 cy clean sediment to build an intertidal area connecting Phase II area to north shoal (28) and to add more confinement material to the cap (36) • Phase III material placed in mid-February 2002 (36) • There is now a huge area that provides intertidal habitat for endangered species (36) ***- completed and works very well including the habitat (21)*** ***- enhanced natural recovery of 6.7 acres, and monitored natural recovery of 3.5 acres. Construction cost estimate is >$1.2 million (10)***	A, B, D, E, 28, 36, ***21, 10***
10	West Eagle Harbor/Wyckoff Bainbridge Island, Washington (ISC)	Mercury, PAHs	Water depth 0-45 ft.	Thin cap (0.5 ft.) over 6 acres Thick cap (3 ft.) over 0.6 acres	Quarry sand (22,600 tons for thin cap and 7,400 tons for thick cap)	6.6 acres	Partial dredge and cap 1997	• No chemical migration • Post-implementation surveys identified 16 discrete cap areas lacking in minimum thickness, so another 1,000 cy added (NN) (EPA will check this statement)	• To date, post-verification surface sediment samples have met the cleanup criteria established for the project • Ongoing monitoring • Cap has achieved its intended function and is doing well (36) ***- Cap continues to do well and there is a good habitat reconstruction (21)***	A, NN, 36 ***21***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
11	Middle Waterway Commencement Bay Nearshore/Tideflats Superfund Site (CB/NT SS) Tacoma, Washington	Mercury, PAHs, PCBs (21)	Original shoreline and mudflats; completely intertidal; high tide depths: about 13-15 ft. where capped (21)	2-3 ft. (related to habitat design) (21)	To be determined (48)	3.95 acres of thin layer cap and 0.24 acres with 3 ft. cap (per draft 8/01 document) (30) ***- capped area or 2.2 acres, natural enhanced recovery 2.2, monitored natural recovery 3.1 (10)***	Scheduled for early 2003 ***Completed in 2004 (10)***		• April 1997 Consent Order • The project just entered the "Remedial Design Phase", a significant portion of which will involve capping (21) • A few portions will be dredged because of navigation requirements (21) • Remedy includes dredging with near-shore-confined disposal, monitored natural recovery, thin-layer capping and thick capping (30) ***- It became a checkerboard of thin capping (1 foot) and thicker capping (2-3 feet) with some dredging removal, fill and small areas of capping (21)*** ***- Construction cost estimate of $14.1 million. Additional WDNR work ongoing. Dredged 107,658 cubic yards. (10)***	GG, 21, 30, 48 ***10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
12	Thea Foss Waterway CB/NT SS Tacoma, Washington	PAHs, phthalate esters, trace metals, PCBs (46), dioxins (21)	8000-ft. waterway; depth is about 15 ft. now; depth in main channel may be restored to 20-25 ft.	3 ft. for thick caps (50) possibly 0.5 to 1 ft. for thin caps	To be determined ***- CAD is underwater sheetpile and geotextile (10)***	Approx. 20 acres (46, 50) ***- Final is 30 acres (10)***	To be constructed (EPA's selected remedy) ***Completed February 2004 (21)*** ***Some cleanup ongoing (10)***	• The in-situ cap will be thick enough to contain and isolate contaminated sediments in situ from the overlying water column and habitat, and will be thick enough to resist erosion from vessel scour, wave action, or penetration by burrowing organisms (46) • 100% design expected to be complete in March 2002 (50)	• 1994 EPA Consent Decree with City of Tacoma • Project focus is not on habitat, although benefits to endangered species habitat will be considered (21); 14 acres of intertidal habitat are proposed (46) • A portion of each of the project's 8 sediment management areas (SMAs) will be thick-capped; the SMA at the head of the waterway will also employ sorbent capping to control oil seepage (46) • Enhanced natural recovery to be used at mouth of waterway (50) • Majority of sediments in navigation channel will be dredged (50) ***- Centerline of the waterway and margins dredged for the upper third of the waterway. The City of Tacoma will complete the rest which is still underway (21)*** ***- A checkerboard of removals, backfilling and thin layer capping which did not use the sorbent material described above but impervious cap instead (21)*** ***- Construction cost estimate of $73 million (10)*** ***- Monitored natural recovery of 21 acres, habitat mitigation of 13 acres. Dredged 528,500 cubic yards (10)***	21, 46, 50 ***10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
13	Olympic View Resource Area CB/NT SS Tacoma, Washington	Dioxin	Intertidal area with a small subtidal area; water depth is -15 ft. MLLW	4 ft.	Erosion protection layer over 43 in. clean sand over geotextile barrier over 6 in. TOC material	1.0 to 1.6 acres	Construction will commence in June 2002 ***Completed about 1.3 acres in February 2003 (21)***		• Approved non-time critical removal action (no ROD) • Highest dioxin concentrations in area • Site covers 12 acres, but 2.2 acres (review with EPA) will be remediated • Approximately 51,000 sq.ft. will be excavated down 1.1 ft and backfilled with clean material. The other portion (1.0 acres or 68,290 sq. ft.) will be capped (review with EPA) ***- Mostly restoration and remediation (21)*** ***- Excavated $10,500 cubic yards. Estimated cost of $3 million (10)***	10, ***21***
14	General Metals of Tacoma Hylebos Waterway CB/NT SS Tacoma, Washington (ISC) ***Other apparently separate site = Hylebos Waterway, Commencement Bay, WA (10)***	Metals, PAHs		3 ft.	Sand, gravel, geotextile liner	800 feet along shoreline under piers ***- Capped area 10.2 acres (10)***	Late 1990s	• Recent monitoring indicates that cap is functioning as designed	• Capping conducted in conjunction with repair work on dock/bulkhead structure by General Metals • Capping selected because dredging presented concerns about undermining dock structural integrity ***- Dredging only is occurring this year, 2004, plus some habitat restoration (21)*** ***- This apparent other area precision dredged 1,025,000 cubic yards. Estimated construction cost of $70 million. Cleanup ongoing (10)***	49, ***21, 10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
15	Occidental Chemical Removal Action Hylebos Waterway CB/NT SS Tacoma, Washington (trial cap)	***TCH, PCE is primary signature (21)***							• Message left with EPA Region 10 ***- Discovered that the extent of contamination is larger than anticipated, therefore under complete re-design and starting over with a design that will include capping, but because it involves solvents, a typical cap will not work. EPA wants to try something new but they do not know what yet. Extraction and dredging are expected to be significant. (21)*** ***- Dredged 36,000 cubic yards to date. Cap is under evaluation. Estimated cost to date is $10.5 million (10)***	49, ***21, 10***
16	Asarco Sediments/ Groundwater Operable Unit 06 CB/NT SS Tacoma, Washington (pilot)	Arsenic, lead, copper	Near old smelter site	30 cm and 60 cm (side by side)	Clean river sediments			• Pilot cap was very successful ***- Cap in somewhat effective, but a re-design has been added because the groundwater and tides blew out all the fines. (21)***	• Pilot study was conducted to determine if cap would remain in place and become recolonized with healthy biological communities	51, ***21***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
17	Asarco Sediments/Groundwater Operable Unit 06 CB/NT SS Tacoma, Washington (full-scale)	Arsenic, lead, copper	Near old smelter site; cap will be 0 - 60 ft. deep	3 ft.	To be determined	18 acres	To be constructed (ROD signed in July 2000) ***Completed from 2001-2002 in different segments (21)***		• Entire yacht basin will be dredged (about 20 acres) • Offshore contaminated sediments will be capped • Draft 30% design completed • Cap will integrate into armored shoreline (2/3 of armor has been placed) • Entire peninsula created by pouring arsenic-containing slag into the water, (slag is 100 feet thick in places); dredge volumes would have been too great so it was determined to isolate contaminants from benthic organisms by using a 3-foot-thick cap ***- A pilot re-design added more fines and the cap seems to be working well in the intertidal area. In deeper areas, still determining if effective but not yet failed. Spring groundwater discharge may erode the cap in places (21)***	51, ***21***
18	Lockheed Shipyard Duwamish River/Elliott Bay Seattle, Washington	Primarily arsenic, lead, mercury, zinc, copper; some PCBs and PAHs	Navigable river; major salmon route; water depth ~ 20 ft.	2 ft. minimum (ROD) 3.5 ft. currently under consideration	To be determined	Approx. 15 acre (based on 3.5 ft. cap and 85,210 cy of cap material) ***- 4 acres (10)***	Possible pier removal this winter; dredging and capping may begin in the fall or winter of 2003 ***Capping starting, to be completed end of 2004 (21)***		• A huge pier will be removed; that area will be dredged and then capped to prevent contaminant migration and to improve aquatic habitat • Area beyond current pier will be dredged but not capped • Design has not been finalized • Capping is part of remedy per ROD ***- Pier was removed but more material than planned (21)*** ***- 130,000 dredged cubic yards. Estimated cost of >$20 million. Cleanup ongoing (10)***	58, ***21, 10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
19	Todd Shipyard Duwamish River/Elliott Bay Seattle, Washington	Primarily arsenic, lead, mercury, zinc, copper, TBT; some PCBs, PAHs	Navigable river; major salmon route; very steep slopes (drops from 30 to 50 depths rapidly)	To be determined	To be determined	To be determined	Dredging and capping may begin in the fall or winter of 2003 ***Due to delays, capping started this year to be compeleted 2004-2005 (21)***		• A more involved project than Lockheed; this is still a working shipyard and site has steep slopes • Design has not been finalized • Capping is part of remedy per ROD ***- Dredged 200,000 cubic yards (10)***	58, ***21,10***
20	Puget Sound Naval Shipyard Bremerton, Washington (CAD)	PCBs, mercury (48)	Depth varies; approx. 30 ft. at CAD (48)	Approx. 1 ft. (interim cap) and approx. 3 ft. (second cap), for total of 4 ft. before consolidation (48)	CAD cap: clean dredged material from turning basin (48)	CAD: approx. 10 acres (48) ***- 25.2 acres (10)***	Dredging completed in June 2000 Final CAD cap placed in Sept. or Oct. 2001 (48) ***Finalized in 2002 (21)***	• Pit CAD sized properly (deep and wide) but experienced some "slop" (2-3 cm extending 20-50 ft. out) (21) • Key lesson learned: awareness of differences between "production" project and "environmental" project; apparently the project experienced bucket overfilling, overdredging, and underdredging, possibly causing problems with water quality (turbidity) (X) • The project went very well (48) • Monitoring plan is being developed now (48) ***- Attempted a pit cap over material placed in a hole. The hole was too small causing material to come out of the sides and re-suspend. The cap worked well except for the material around the sides. More cap material was added on the residual at the sides. (21)***	• Project involved dredging of channel and turning basin, and pier extension and reconstruction • Remedy included dredging, on-site disposal in CAD, thick and thin-layer capping, and natural recovery (29, 48) • Project unique because of significant volume of contaminated sediment (>390,000 cy), tight schedule, significant daily tidal exchange, water depth and CAD pit volume constraint (required precision dredging) (X) ***- First impressions considered the cap a failure, but now the cap is doing well after repairs. (21)*** ***- Monitoring every 1-2 years (21)*** ***- Dredged 226,000 cubic yards. Estimated cost of $11.45 million (10)***	X, 21, 29, 48 ***10***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
21	Pacific Sound Resources Seattle, Washington	PAHs, mercury, PCBs (33)	Old creosote plant located at mouth of Duwamish River; intertidal area to depths >240 ft. (33)	5 ft. in intertidal areas to -10 ft. MLLW (33) Other areas: to be determined (33)	Navigational dredged material or upland borrow intended (33)	Capping selected for 50-65 acres in remedial design (33) ***Same but this is inner circle With apron and considering slope and river mouth flow displacement, it could be 100-200 acres (21)*** ***- 58 acres (10)***	ROD signed; pre-work (e.g., pilings removal, small dredge area) likely in 2003; capping possibly in 2003 ***In construction now and expect to last through February 2005 at least (21)***	• Approximately 20 acres of cap are on an 18-21% slope (33) • Cap likely designed to require repair after a significant earthquake (33)	• Remedy is mostly capping • In navigation channel, a depression to the lone dock (at area near former plant outfall) will be dug; those spoils will be consolidated onshore (21) • A beach will be built, with 5 ft. cap to tie into shoreline structure and habitat and to sequester contamination; thinner cap (6 inches) may be used away from shore (21) ***- Dredged 10,000 cubic yards. Estimated cost of $18 million (10)***	21, 33 ***10***
California, Oregon, and other Western States										

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
22	Port of Los Angeles Shallow Water Habitat (PSWH) Los Angeles, California (CAD and habitat creation) (the "Pier 400 project") ***Also known as the Cabrillo Shallow Water Habitat (38)***	Heavy metals (esp. copper), PAHs, DDT, PCBs; a "historic soup"; large storm drain discharges to the area (38)	Bay not used for navigation; depth reduced from 40 ft. to 15 ft. to create habitat	15 ft. ***- Three parts all 15 ft. (38)***	13 ft. clean harbor material; 2 ft. clean sand (latter was habitat-driven)	94 acre CAD (FF) within 192-acre site	1995	• Project performance fine to date (27, 37, 38) • Recent discussions about possible expansion (27); expansion does include capping of any other contaminated sediments, but rather entails creation of 54 more acres of habitat (38) • No long term monitoring required (38) • 1993/94 monitoring showed that the cap was still in place (38)	• Overall effective cap was >15'. The thick cap was a result of site geometry and dredging volumes and was not required to prevent contaminant migration (FF, 38) • First CAD project in California for contaminated sediments (27) • A perimeter subaqueous berm was placed prior to placement of 5 million cy of contaminated sediments (27) • Provides habitat for endangered species (California lease tern) (27, 38) • Cap covered a designated "hot spot" (38) ***- Part 1 is the 190 acre CAD which received contaminated material and covered existing contaminated material = a true CAD. Part 2 is called the 80-acre expansion which received clean dredge material. Part 3 is 54 acres still under construction and caps contaminated sediments already in place which is a toxic hot spot (38)***	A, FF, 27, 37, 38
23	Port of Los Angeles Shallow Water Habitat (PSWH) Los Angeles, California (pilot CAD) ***There is no pilot. This is probably the 190-acre Part 1 described above in #22 (38)***	Lead, zinc, copper		12 ft. (OO)	Sand cap over 44 geotextile containers filled with contaminated sediments ***- This is the material in Part 1 described above in #22 (38)***	est. 10 acres[(b)]	Dredging from Nov. 10, 1994 to Dec. 18, 1994		• 66,000 cy contaminated maintenance dredged material from Marina del Rey and Ballona Flood Control channels were placed in geotubes	O, FF, OO, 27

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
24	Convair Lagoon San Diego Bay San Diego, California (ISC with foraging habitat creation)	PCBs	Water depth 10-18 ft. 10-acre site	2 ft. sand over 1 ft. rock	Sand over crushed rock and geogrid	5.7 acres	Oct. 1996 to mid-1998	• No chemical migration • Cap successfully placed in very shallow water • Some chemicals observed in cap • Could expect to see some chemicals in cap because of high energy environment (similar to Elliott Bay experiences) (27)	• State-ordered remediation of PCBs (27) • Ongoing monitoring for 20 to 50 years (includes diver inspection, cap coring, biological monitoring) • Designed to withstand a significant seismic event • 4 acres by shore and outfall had high localized concentrations of PCBs, so agency did not want to dredge, but instead required a cap (thin enough to preserve salt water habitat but thick enough to withstand high energy environment) • EPA wanted geotextile layer to stop burrowing shrimp; somehow, geogrid was installed instead (27) • Some disagreement on PCB action level between agencies; EPA convinced project team to cap greater area with clean sand (27)	A, E, 27

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
25	North Energy Island Borrow Pit Capping Pilot Study Long Beach Harbor, California (pilot CAD)	DDT, metals, PAHs, others (47)	Borrow pit created as result of construction of energy islands (47) Flat pit bottom, 52 to 66 ft. deep 0.5 mile offshore of Long Beach (47)	3 ft. minimum required (47) 4.9 ft. max. (47)	Clean silty sand dredged from entrance to Long Beach Harbor (47) 100,000 cy of contaminated sediment from the LA River estuary were deposited (37) in one segment of the pit that was already segmented by berms from a water line (47)	9.9 acres (47) Entire Pit: 220 acres approx. (c)	disposal in Aug. 2001 (47) cap construction completed in Dec. 2001 2-3 more years to study the pilot CAD cell (37, 47)	• Construction phase report expected in March • Pilot CAD cell to be closely studied (e.g., coring, benthic, bathymetry) over next 2-3 years • One of the biggest questions is the degree of bioturbation that will occur (37) • Fine silts in the pit bottom and clays consolidated very quickly, making it difficult to account for all material (47) • Monitoring plan is being developed now (47) ***- The one meter cap looks good after 2 years of monitoring (2002 and 2003), 3rd year coming up = 2004 after which success will be determined (37)***	• The LA Contaminated Sediments Task Force is evaluating several contaminated sediment disposal options for the region, including use of CAD cells; no judgement has been made to date and will not for at least another 2-3 years (37, 47) • USACE is performing an EIS for this 1st multi-user CAD site, which will cap up to 7 million cy of contaminated sediments with clean sediment; several engineering issues being considered (e.g., separate cells vs. layering of project sediments); several other issues being considered (contaminant limits, maximum duration of exposure) (27) • One pilot study was conducted that pertained to capping; other pilot studies were conducted that address other engineering topics (47) ***- Whether to do CAD, dredge, or treat and re-use will be decided after 3rd year of monitoring. CAD is last choice, but may run out of fill sites for the dredging option which is still the least expensive. Trying to promote treatment and re-use (37)***	P, 27, 37, 47

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
26	Palos Verdes Shelf San Pedro, California (pilot ISC)	DDT and PCBs	17-sq.mi. continental shelf and slope (34)	Cell LU: 15-45 cm Cell LD: <10 cm Cell SU: 15 cm ***Two cells at 150 feet deep and one cell at 213 feet deep (65)***	Clean sediments (two types)	135 acres (made up of three 300 x 600 m areas)	Aug. 2, 2000 to Sept. 14, 2000	Preliminary Results (Ref. H): • Disturbance of contaminated sediments was relatively localized and decreased substantially after the initial load was placed • Sediment plumes caused by capping did not pose a risk to near shore kelp beds • Spreading was less disruptive than conventional placement • There were no indications of mass sediment movement (such as mud waves or turbidity flows) as a result of capping • The pilot study went well; all indications show cap was successfully placed; monitoring continues, and indicates possible transport of contaminated sediments to cap from uncapped areas; more coring will be conducted to study this (34) ***- Post pilot cap monitoring shows the cap displaced clean sediment and pushed contaminated sediments up. There is DDT in cap surface. (65)***	• The final report for study may be issued in March, 2002 (34) • 9/28/01 Action Memorandum (Ref. I) proposes establishing institutional controls (outreach & education, monitoring and enforcement) associated with consumption of contaminated fish • EPA continues to evaluate in-situ capping and other remedies and may issue proposed alternatives by year-end, 2002 (34) ***- No capping since pilot in 2000, still studying the pilot cap. RI/FS is due out in 2006 (34)*** ***- Still monitoring but not a convincing success (65)***	G, H, I, 34 ***65***
27	McCormick and Baxter Old Mormon Slough Stockton, California	Dioxins, PAHs	Dead-end waterway; 10 ft. deep; maintenance-dredged for barge access; tidally influenced	2 ft.	Sand	8.8 acres	Construction may begin in 2002 (35) ***Now 2005 (34)***		• ROD signed 4/99 • Capping selected because site is at the end of a dead-end slough, so cap is unlikely to wash away (35)	AA, 35 ***34***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
28	McCormick and Baxter Willamette River Portland, Oregon (ISC)	Heavy metals, PAHs	15 acres of near shore sediments and soils; depths to 35 ft.	3 ft. ***- 2 feet of sand. (66)***	Sand ***- Placing concrete blocks cabled together on top of sand cap = ACB = articulated concrete block with a 6-inch profile (66)*** ***- Organoclay cap (10)***	15 acres (S) Cap may take 17 to 22 acres, depending on how thickness will vary (21) ***- actually 23 acres (66)***	Aiming for construction in 2004 (21) ***Installing cap this summer (66)***		• Long-term monitoring, OMMP, and institutional controls were also specified (A) • Cap being redesigned now (recently decided to install a piling wall around upland site to contain NAPL on site, thereby preserving treatment options in the future - waiting to see how Eagle Harbor wall performs) (21) • Habitat will be considered, particularly for juvenile salmon (21) ***- 2 areas of organic clay placement to control NAPL (creosote) seeps covering less than 1 acre. (66)*** ***- Estimated cost of $9 million (10)***	A, E, S, 21 ***66, 10***
29	Ross Island Lagoon/ Port of Portland Portland Oregon (CAD)	Metals, TBT, PAHs, PCBs (41); some COCs more prevalent in certain cells (57)	lagoon; no significant current (57); first CAD cell depth: ~80 ft.; other CAD cell depths: 0-30 ft. (57)	1 ft. (41) 1 ft. minimum for Cells 1-4; 2 to 10+ ft. for Cell 5 (61) Some discussion in late 1990s about increasing cap thickness; details not provided (57)	Fine-grained material derived from on-site sand and gravel washing and processing operations (39) Material from Ross Island rock crushing settling pond (61)	8.4 acres[(d)]	Dredging from 1992 to 1998 Cell 5 was first to be constructed	• OR DEQ accepted a Dec. 2000 study showing that contaminated sediments from Port facilities in capped disposal areas do not pose a threat to human health or the environment (40) • CAD cells are working well; model developed from data predicts no exceedances of any water quality criteria in the next 500 years (57) • A barge tipped over in 1998; the spilled material was covered with a 1-ft cap; a portion of the Cell 5 cap was breached and repaired in 1998 (57, 61)	• In five Port dredging events from 1992 to 1998, ~160,000 cy of dredged material were transported to the lagoon for permitted confined disposal; RIS&G accepted, placed and capped the in-water containment cells (39) • 4 cells accepted material from navigational dredging; 1 cell accepted material from the Port of Portland's Pencil Pitch spill (57) • Some discussion about lowering dike between two islands; current hydrology study is studying possible effects on cap integrity (57)	D, T, 39, 40, 41, 57, 61

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
30	Inlet Basin Soda Lake, Wyoming (case study)	PAHs, benzene, metals, NAPL	Natural playa basin, 2-12 ft. deep; recharges each year by runoff and dries later in the year (H)	1.5 ft.	Native sand	5.6 acres	Before June 15, 2000 and Aug. 31, 2000	• After 3 months, the upper 2 feet of cap contained no organic contaminants in excess of screening levels • Short-term effects from cap placement were minimal • Long-term integrity also evaluated	• The Draft Final Remedy Decision dated Oct. 29. 2001 does not propose capping, but instead proposes excavation • The WY DEQ concluded that the best alternative would be to excavate the sludge and place it in a lined corrective action management unit. Capping was not implemented. (17) ***- The cap is not performing because after the pilot study the cap was allowed to dry up. The decision was driven by a question of long term effectiveness and not leaving wastes behind for future generations. The WYDEQ wants the contaminants out of the environment. The inlet basin has been in the drying process. Excavations are expected to go full scale this fall and hope to finish by Spring 2005. (17)***	H, L, 17
Great Lakes										
31	Upper River section Sheboygan River, Wisconsin (pilot)	PCBs	9 hotspots totaling 1,200 sq. yds.	1 ft. of coarse material and upper geotextile over lower geotextile fabric	Armored stone composite	0.25 acre	1989-1990	• No monitoring data • Cap appears to be intact with significant silting-over and thus additional stabilization • Undetermined cap effectiveness • Some erosion of fine-grained material	• Composite armored cap required because of location in high-energy river environment. Gabions placed at corners for anchoring. Additional course material placed in voids and gaps. • A 1990 bench-scale armoring study by Enseco, Inc. indicated that capping had a significant effect on reducing PCB concentration measured in exposed aquatic organisms (E).	A, E, D

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
32	Areas C and D Manistique, Michigan	PCBs		2.7 ft.	Composite	17 acres	Planned, but not implemented (site remediation was dredging)	• Project not built	• Composite cap over a 17-acre site includes armoring and geotextiles	A
33	Manistique Capping Project Michigan (ISC)	PCBs	Shoal in river with depths of 10-15 ft.	40-mil (0.1 ft.)	HDPE	0.6 acre	1993	• Physical inspection of temporary cap approximately 1 year after installation showed cap to be physically intact with most anchors in place	• A 240 ft. by 100 ft. HDPE temporary cap was anchored by 38 2-ton concrete blocks placed around the perimeter of the cap • This temporary cap was installed to prevent erosion of contaminated sediments within a river hotspot with elevated surface concentrations	A, B
34	Hamilton Harbor Ontario, Canada (ISC demonstration)	PAHs, metals, nutrients	Lacustrine waterbody	1.6 ft.	Clean sand	2.5 acres	1995	• Significant reductions in the flux of site contaminants were observed after capping (D)	• Capping selected because of impracticality of dredging and upland disposal due to large sediment volumes (E)	A, B, D, E
35	Madison Metropolitan Sewerage District Lagoons Madison, Wisconsin	PCB (greater than 50 mg/kg)	2 sludge lagoons in wetlands 141-acre site	1 ft.	Geotextile and lightweight soils			• Planned in ROD	• According to the ROD (dated March 31, 1997), the final site remedy includes the segregation and in-situ containment of sludge with PCBs > 50 mg/kg. The soil will be seeded.	E
36	Oxbow Lake near Rib River Wausau, Wisconsin (ISC) (“Snow Cap” project)	Lead	Shallow, 4-acre oxbow lake at former battery reclaiming site; important breeding habitat for small fish		4-layer composite cap (geotextile and sand blanket, w/ 2nd layer of geotextile and rock “islands”); then snow		Winter, 1997, to take advantage of snow and ice	• Data from 5 locations during Mar. 1999 found current lead concentrations in the water column to be at background or non-detect levels • Benthic organism populations noted in shallow water; vegetation becoming established on the new substrate	• This new method cost significantly less than “conventional (and environmentally invasive) sediment dredging in terms of both funding and time resources” • The technique offers the advantage of providing a safe habitat for existing fish populations • The approach costs one-third the cost to remove sediments	V

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
37	Ottawa River Toledo, Ohio (ISC Demonstration)	PCBs	0.2 mile stretch; estuary with low flows; 8 ft. deep	0.33 to 0.66 ft.	AquaBlok™ (clay-mineral aggregate), with or without geotextile	2.5 acres	1999	• Monitoring results limited (E) • Ohio EPA completed a benthic community study before AquaBlok™ application and found the site to be sterile; there are plans to conduct a follow-up study in 2001, but improvements may not be seen because of ongoing contamination from a nearby Superfund site (45)	• The goal of the demonstration was to assess application methods, not necessarily provide permanent remediation (45) • The Ottawa River has a 100-year flow velocity of 4.8 ft/sec for approx. 1 hour. Flume tests of similar AquaBlok ™ compositions withstood water velocities of 6 ft/sec for 50 hours with an approximate 10% loss. (45)	E, 45
38	Triangle Pond Tommy Thompson Park Downsview, Ontario	Lead, iron, oil & grease	Man-made water body in park	1.6-9.8 ft. design 6.6-13.1 ft. actual	Clean sand and fill	2 acres	1999			C, O, U
New England/New York										
39	Stamford-New Haven-N New Haven, Connecticut (Central Long Island Sound (CLIS) area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) Up to 7-10 ft. (F)	Sand		1978 ***1979 (67)***	• No chemical migration • 11 years of monitoring show this to be one of the most stable mounds ***- Do not see any visual problems with 2004 bathemetry and cores recently collected. ACOE is currently working up the core data. (67)***	• Cores collected in 1990 • Contaminated sediment from Stamford Harbor was capped with slightly less contaminated material from New Haven Harbor (FF)	A, F, FF ***67***
40	Stamford-New Haven-S New Haven, Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~70 ft. deep	1.6 ft. (A) Up to 13 ft. (F)	Silt		1978 ***1979 (67)***	• No chemical migration • 11 years of monitoring show this to be one of the most stable mounds	• Cores collected in 1990 • Contaminated sediment from Stamford Harbor was capped with slightly less contaminated material from New Haven Harbor (FF) ***- Continued bathemetry in 2002 for North and South and oters and nothing unusual noticed (67)***	A, F, FF ***67***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
41	New York Mud Dump Disposal Site (a.k.a. "New York Bight" or "Long Island Bight")	Metals in silt and clay dredged from 6 projects in NY Harbor (E)	Flat bottom 80-90 ft. deep (F)	3-4 ft. avg. 5-9 ft. max.(F)	Mud (120,300 cy) Sand (1,200,700 cy) (E)		1980	• No chemical migration ***Monitored in 2002 and it looks fine. (72)***	• Cores taken in 1993 (3.5 years later) showed cap integrity over relocated sediments in 80 ft. of water (A) • Simultaneous with the Mud Dump Site closure, the site and vicinity will be redesignated as the Historic Area Remediation Site (HARS) • A portion of HARS will be remediated, with approximately 1 m of capped clean dredged material (E) ***- This site is now considered part of the HARS and called the "former mud dump site". (72)***	A, E, W ***72***
42	New York Mud Dump Capping Project New York, New York (CAD)	Trace dioxin	Open water sediment disposal site (500,000 cy)	3.2 ft.	Clean sand		1993-1994	• Long-term monitoring being conducted • Engineering of cap construction considered a success ***Monitored in 2002 and it looks fine. (72)***	***- This site is now considered part of the HARS and called the "former mud dump site". (72)***	D *72*
43	Historic Area Remediation Site (HARS) (former Mud Dump region)	PAHs, PCBs, DDT, dioxin, metals	HARS is 15 sq. nautical miles; water depths: 40 - 138 ft.	3.2 ft.	Relatively clean dredged sediments	9.0 square nautical miles (7638 acres)	To be constructed ***Started in 1997, larger area started in 1998 (72)***	***Monitored in 2002 and it looks fine. (72)***	Required under proposed rule in 40 CFR 228 ***- Controversial because dredge material was used as cap material. Clean material to be added, which will continue for 10 years with the goal to cover with at least 1.0 meter of clean sand over the entire HARS area (72)***	LL, MM ***72***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
44	Mill-Quinnipiac River (MQR) Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) 6-10 ft. avg. (F) 4.9 ft. as of 8/91 (PP) 9.8 ft. as of 9/93 (RR, SS)	Silt	10.7[e]	1981-1982 1982-1983 1993-1994 (SS)	• Due to slow, retrograde recolonization rates, cores were collected in 1991 - showed presence of PAHs in the cap (PP) • One year later, benthic improvements were noted (QQ) • In Sept. 1993, more cap material was placed. July 1994 monitoring showed that the mound height had increased by another 1.5 m, the diameter had not changed, and recolonization rates met or exceeded the targeted rates (RR) • Small to moderate pockets of consolidation near the apex and SW flank were noted (SS)	• PAHs were not included in the protocols in 1982 when the first cap was placed. (PAHs were included in the protocol starting in 1989). ***- A 2x1 nautical mile site all received bathemetry in 2002 which continues regularly but less than annually. There does not appear to be any problems. More material was added in the last 5-7 years (67)***	A, F, PP, QQ, RR, SS ***67***
45	Norwalk, Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) up to 6-7 ft. (F)	Silt		1981	• No problems	• Routine monitoring ***- 2002 bathemetry survey (67)***	A, F ***67***
46	Central Long Island Sound Disposal Site (CLIS) Long Island, New York	PCBs metals, oil & grease	Multiple sediment disposal mounds	20 -41 cm (A) 0.5 - 3 ft. typical (PP, QQ, RR, SS)	Course sand and shell fragments ***- varies in material and grain size (67)***	Varies ***- cap area growing (67)***	1979-1983 (A) Continued well into the 1990s (SS) and probably still active ***- still active in 2004 (67)***	• Some cores show uniform structure with low-level chemicals and others show no chemical migration • Some slumping noted (A) • As of 1996, no evidence of particle re-suspension or cap erosion; stable benthic communities over the majority of stations sampled; effects of seasonal hypoxia recognized at other stations (SS)	• Extensive coring study at multiple mounds showed cap stable at many locations • Poor recolonization in many areas • Most cap elevation changes due to consolidation, not erosion • Early 1990 coring results indicate that the cap layers continue to isolate contaminants from water column (B) ***- 2002 bathemetry (67)***	A, E, PP, QQ, RR, SS ***67***
47	Cap Site 1 Connecticut (CLIS area)	Metals, PAHs	Generally flat ~60 ft. deep	1.6 ft.	Silt		1983	• No chemical migration	• Cores collected in 1990 ***- CLIS Area had bathemetry survey 2002 and 2003 (67)***	A, F ***67***
48	Cap Site 2 Connecticut (CLIS area)	Metals, PAHs	Generally flat ~56 ft. deep	1.6 ft. (A) 0.6-4.5 ft. (F)	Sand		1983	• Required additional cap • One of the more successful mounds	• Cores collected in 1990 ***- CLIS Area had bathemetry survey 2002 and 2003 (67)***	A, F, FF ***67***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
49	Experimental Mud Dam New York (CAD)	Metals, PAHs		3.3 ft.	Sand		1983	• No chemical migration; minor cap erosion (FF)	• Cores collected in 1990 ***- Truly experimental and not considered a site. Likely now part of the HARS listed above (#'s 41-43) (72)***	A, FF ***72***
50	New Haven Harbor New Haven, Connecticut NHAV 93 (CLIS area)	Metals, PAHs	Generally flat 60 ft. deep; part of a large-scale CAD project	1.6 ft. (A) 1.6 - 3.2 ft. (TT)	Silt	50.0 acres (UDM deposit itself) and 70 - 124 acres (total mound) (estimated from Ref. TT)	1993-1994	• No chemical migration (A) • July 1994 monitoring noted no major topographic changes and maintenance of minimum required thickness of 0.5 m (average thickness was 0.75 m along margins of the UDM deposit, and 1.25 m at center (RR) • Target recolonization rates were met or exceeded in most areas, except for three; Sept. 1994 tests demonstrated that cap supplementation was not required (RR) • Aug. 1995-Sept. 1995 monitoring showed moderate amounts of consolidation (0.25 m over most of cap, and 0.5 m near center); 1996 monitoring noted 0.25 to 0.75 m of consolidation over majority of mound with little change in size or shape, and that benthic community continued to recover (SS)	• From 1984 to 1992, contaminated sediments were disposed in 7 separate mounds that were located to form a ring (UU) • In 1993, sediments from New Haven Harbor and five private marinas were placed in the middle of the ring and later capped. Significant consolidation was noted before capping took place(TT) • Capping was completed by Mar. 1994 (RR) ***- CLIS Area had bathemetry survey 2002 and 2003 (67)*** ***- Sediment profiles around 2000 showed the top 15-20 centimeters recovering biologically based on visual observations of soil (67)***	A, FF, RR, SS, TT, UU ***67***
51	CLIS 94 Mound CLIS Area			1.6 to 3.2 ft.	Dredged material	43 acres[(f)]	Jan. 1995 to May 1995 (UU)	• Sept. 1995 monitoring showed good benthic recovery despite added stress of seasonal hypoxia and recent impact of disposal (UU) • July 1996 monitoring showed continued benthic recovery, higher dissolved oxygen and several pockets of consolidation at apex (0.25 to 0.5 m) (SS)	• This mound forms the beginning of the second placement ring which will eventually become a CAD • This mound completely envelopes the CS-90-1 mound (UU) ***- This CLIS Area had bathemetry survey 2002 and 2004 (67)***	SS, UU ***67***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
52	CLIS 95 Mound CLIS Area		Small, capped, dredged disposal mound	5.2 ft. (estimated from volume and area) (SS)	Dredged material	7.8 acres[(g)]	Sept. 1, 1995 (SS) ***- And 1996 (67)***	• Rapid recolonization of sediments observed (SS)	• Slightly irregular shape, due to bottom slope and distribution of capping material (SS) • The CDM:UDM ratio is 3.1:1.0 (SS) ***- More cap material added in 1996 (67)***	SS ***67***
53	Port Newark/Elizabeth Project New York	Metals, PAHs, low levels of dioxin (FF)		5.3 ft. 1 m design(FF)	Sand	198[(b)]	1993	• No chemical migration ***- 2002 Monitoring shows the cap to be at the same thickness with no problems. (72)***	• Extensive coring study	A, FF ***72***
54	52 Smaller Projects New England	Metals, PAHs		1.6 ft.	Silt		1980-1995	• No chemical migration	• Routine monitoring ***- capping ongoing in 2004 (67)***	A ***67***
55	New London Disposal Site, Thames River, Connecticut		49 ft. deep	Irregular, 10 to 70 cm	Clean sediment		1988-1989			C, FF
56	S-90-1 Harbor Village/Branford River (CLIS area)		Generally flat 60 ft. deep	Incomplete coverage; several distinct cap mounds 0.6 to 2 ft. thick			1989-1990			FF
57	Massachusetts Bay Disposal Site Massachusetts (Demonstration) ***- Demonstration of capping (67)***		90 miles deep; 22 naut. mi ENE from Boston ***- 90 meters not miles (67)***		Clean sediment		***1998-2000 (67)***		***- Demonstration showed that capping can be accomplished at this depth (67)***	C ***67***
58	Portland Disposal Site Yarmouth, Maine	Metals, PAHs	177 ft. and deeper		Fine-grained dredged sediment & sandy material		Oct. 1991 to June 1992	• Sediment chemistry data showed that the cap effectively isolates contaminants	***- Irregular monitoring. The last monitoringmay have occurred in 1997 (67)***	VV ***67***
59	Portland Disposal Site Yarmouth, Maine (Demonstration Project)	Metals, PAHs	Deep water ocean disposal site; 210 ft. deep	1.6 ft. 0.7 ft. (WW)			***1995-1997 (67)***	• Project showed that dredged material may be effectively placed, capped, and monitored at deep water disposal sites (WW)	• "A tightly controlled, closely monitored deep-water demonstration capping project in which clean sediment was capped with 20 cm of clean sediment" (WW)	II, WW

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
60	General Motors Superfund Site St. Lawrence River Massena, New York	PCBs	11-acre near shore site; depth of river at cap no deeper than 4 ft. (XX)	1.5 ft.	Sand, gravel and armor stone	1.7 acre	1995	• In 1999, armored cap appeared intact with minimal disturbance; no routine maintenance required; however, additional armor material added in 1998 to restore minor nearshore areas (D) • The cap is working very well, based on yearly inspections. In the first year, minor repairs were required (more fill rock) (XX)	• Capping used where repeated dredging failed • As of 1996, cap has maintained its integrity as a whole. Direct comparison of pre-remediation fish data with post-remediation data is complicated by uncertainties about collection locations for the pre-remediation fish. There are data anomalies. (Z) • Water velocities in the River range from 2.75 to 4.42 ft/sec (D) • Cap consisted of sand, activated carbon and gravel (24)	B, E, Z, XX, 24
61	Reynolds Metals Co. Massena, New York	PCBs, PAHs, lead, other organics, other metals (60)					Nov. 2001 (59)		• Message left with EPA Region 2 • ROD abstract states that untreated sediment and treated residuals will be disposed onsite in the Black Mud Pond and that the Pond will be capped	59, 60
62	ALCOA Grasse River Massena, New York (Pilot study)	PCBs	Backwater to St. Lawrence River; approx. 20 ft. deep; study covered 750 ft. section (26)		Test materials: • 1:1 sand/topsoil mixture • granulated bentonite (clay) material • AquaBlok ™ (these 3 test materials were used alone or in combination) (26)	Approx. 7.5 to 8 acres (25)	July 9, 2001 to Oct. 19, 2001	• Extensive monitoring conducted prior to, throughout, and after the capping pilot study work(26) • The study concluded that a cap to cover the PCB-containing sediments can be successfully constructed in the Lower Grasse River (26) • Optimal results achieved with a 1:1 sand/topsoil cap applied via a clamshell attached to a barge-mounted crane (26) • Little apparent short-term impacts noted during pilot project; negligible water quality impacts; monitoring will continue in 2002 (26) • Capping will be carried into the Feasibility Study, both singly, and in combination with other remedies (25)	• Capping is one of the cleanup alternatives being evaluated for remediation of contaminated sediments in the Lower Grasse River • The study was conducted to better understand how different capping materials could be installed on the river bottom using various placement techniques (26) • Capping was performed in two phases: initial "Test Cell " to test potential materials and placement techniques; real-time results from the Test Cells were evaluated and select capping techniques and materials were then used in larger "Pilot Cells" (26) • Steep side slopes were a particular concern (25)	15, 25, 26

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
63	Marathon Battery Superfund Site East Foundry Cove Marsh Cold Spring, New York (cap and habitat restoration)	Cadmium, nickel, cobalt	Shallow estuarine	1-2 ft. cover soil (11)	BentoMat (1 in. Bentonite clay between 2 layers of geotextiles, material expands when wet); 1 -2 ft. of clean fill on top (11)	12 acres (11)	April 1995 (AA)	• Increases in sediment Cd concentrations probably due to cyclic flooding of marsh during high tide (D) • Several problems experienced (e.g., replanting difficulties due to ice (in first year, bad ice flow destroyed cattails), geese (which eat the young shoots), tidal velocities that prevent seed settling) (11) • Snow fences and other measures implemented (11)	• Highest contamination levels in East Foundry Cove Marsh near the plant's former outfall: 171,000, 156,000 and 6,700 mg/kg for Cd, Ni, and Co, respectively (12) • Mean Cd concentration: 27,799 ppm (D) • Sediments were excavated (average post-excavation concentration was approx. 25 ppm for Cd, with no sample exceeding 100 ppm cleanup goal) • The area was subsequently capped to isolate residual Cd from hydrologic and biologic processes, and to restore habitat (11, 13)	D, AA, 11, 12, 13
64	Rhode Island Sound ***a.k.a. Brenton Reef Disposal Site (67)***		108-115 ft. deep; <0.5 ft/s bottom currents	Irregular, with some bald spots <17.4 ft.	Compacted silts and sand		***Late 1960s (67)***		***- One of the first capping sites (67)***	C ***67***
65	Boston Harbor Navigation Improvement Project Massachusetts (CAD)	Multiple	Mystic River: 40 ft. MLLW Chelsea Creek: 38 ft. MLLW 8+ ft. tide (8)	3 ft. for each CAD cell (8)	Clean sand from Cape Cod Canal	2.4 acres [h]	1997: 1 CAD Cell at Conley Terminal 1998-2000: 7 CAD cells in Mystic River, including one "Super Cell" 2000-2001: 1 CAD cell in Chelsea Creek (8)	• Key lesson learned: allow the contaminated materials to consolidate for several months or more before capping (CC) • Longest consolidation period was 200 days (8) • Other lessons learned: how far cells could be filled before causing "slop out" (8) • Corps originally planned to have 60 shallow cells, no deeper than 20 ft. each, but modified plan to have fewer, deeper cells (some as deep as 80 feet) (8)	• 40 to 60 ft. deep pits dug to contain contaminated sediments • The Conley Terminal CAD cell was a test case and Boston's first capping project • Because benthic community returned without cap, that CAD cell was not capped • Lessons learned from that site were applied to subsequent CAD cells (8) • Chelsea Creek CAD cell still has 50,000 cy capacity to be filled, so will probably remain uncapped for 5 years • A vessel passage study was conducted to ensure that the deepest and most powerful ships in channel would not pull silt out-CAD cells performed quite well in tests (8) ***- Bathemetry survey in 2004, and prior monitoring was completed (67)***	J, T, CC, HH, JJ, 8 ***67***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
66	Upper Acushnet River Estuary/ New Bedford Harbor Massachusetts (pilot CAD)	PCBs, heavy metals	Estuary; pilot test site was small cove north of Coggeshall St. Bridge; depth ranged from 0.0 to 0.5 ft. (MLW)	2 ft.	Clean sediment produced during pilot study	CAD cell measured 180 ft. by 140 ft. (25,200 sq. ft., 0.6 acre)	Jan. 1989 to Feb. 1989	• Analysis of six sediment cores taken on June 22, 1989, revealed elevated levels of PCBs in the surface layers of sediment, indicating that capping efforts were unsuccessful. The results pointed out the need for a high degree of control on the positioning and movement of the discharge point within the CAD cell. The position of the diffuser within 2 feet of the contaminated sediment layer may have resulted in a mixing of sediments. A deeper CAD cell would allow the diffuser to be separated from the contaminated sediment layer while still remaining within the confines of the cell.	• The pilot study evaluated three types of hydraulic pipeline dredges, and two types of disposal methods (CADs and CDFs) • The bottom elevation of the CAD cell was approx. -6 ft. MLW; Within the 180 ft. by 140 ft. cross section, a 50 ft. by 50 ft. section had bottom elevation of -8 ft. MLW • Suspended sediment and contaminant levels were elevated in the vicinity of the CAD cell compared to background conditions and other phases of the study (a silt curtain was not in use during monitoring) • A statistically significant increase in contaminant levels was not detected at the Coggeshall Street Bridge ***- Dredging started in 2004. Now concentrating on dredging and not capping. ROD is specifying dredging < 1 million cubic yards for off-site disposal. 3 CDFs are still being considered. If there are CDFs, they will be along the shoreline and include capping operations. (68)***	7 ***68***
67	Providence River and Harbor Maintenance Dredging (CAD)	Various (6)	Channel depth 35 to 43 ft. now (6)	Target thickness 1 ft. minimum; 3 ft. desired (6)	Suitable sediments from lower in the channel (6)	308 acres (6)	Possibly Nov. 2002 or spring or summer 2003 (6) ***Project in final stages of construction, should be completed in 2 months (67)***		• Five CAD cells currently designed for the Upper River to contain 1.2 million cy of dredged material (subject to change) • EPA is "on-board" with the project • EPA comments of 10/01 pertaining to dilution and mixing zone water quality requirements (Ref. K) have been addressed; final Water Quality Certification is pending ***- Dredging since 2003 (67)***	K, 6 ***67***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
68	Pine Street Barge Canal Burlington, Vermont (ISC)	PAHs, metals, VOCs	Northern end (turning basin) depth is 8-10 ft.; Southern end depth is 2-3 ft.; possibly 2 ft. higher in spring (5)	Possible thickness is 1.5 to 2 ft. if sand is used; if geotextile is also used, thickness may be less (5) ***- 1.5 to 2 ft. regardless in final installation (69)***	Sand/silt, with or without geotextile (5) ***- Also included Geogrid (69)***	5-6 acres of affected canal sediments and 2-3 acres of wetlands ***- Final=3-8 acres wetland 4 acres subaqueous (69)***	To be constructed; may be complete in 2003 (5) ***Completed July 2004 (69)***	• ROD specifies a cap (5) ***- NAPL leaking on one edge surfaced along the canal cap edge that was controlled by extending cap beyond canal edges. The NAPL that leaked was vacuumed off the cap. (69)***	• Original remedial action required dredging; local opposition, then public consensus, led to development of in-situ capping remedy ***- Cap design included a geotextile under everything and a geogrid in the basin and canal. No geogrid in the wetlands (69)***	E, T, 5 ***69***
69	Housatonic River, Upper 1/2 Mile General Electric Site Pittsfield, Massachusetts	PCBs	Water depth typically 3-4 ft. (can range from 2-10 ft.) (YY); average flow 105 cfs (AA)	1 ft. silty sand; 1 ft. armor stone (62)	Multi-layer river cap: geotextile, silty sand with >0.5 % TOC, geotextile, GeoGrid, armor stone (62)	possibly 2-3 acres, based on drawings in Work Plan (62)	*Completed September 2002(70)*	***- Performing well based on ongoing monitoring (70)***	• Purpose of cap/armor is to provide a chemical and physical barrier between the residual PCBs (after removal of contaminated sediment) and the overlying water (62) • A 12-inch thick silty sand layer with a 0.5% TOC concentration is proposed for the majority of the area; in certain areas, a 6-inch thick silty sand layer will be installed where 1.5 ft. sediment removals is proposed; an 18-inch thick silty sand layer will be used in one area where deeper excavation is proposed (62) ***- Mechanical excavation of 2 feet from bank and 3 feet bank soils that was replaced with 2 feet of cap. Visual monitoring in 2003 and 2004. Cores planed after 5 years = 2007. (70)***	Y, AA, YY ***70***

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
70	Messer Street Gas Plant Winnipesaukee River Laconia, NH	PAHs	Depth at underground phone cables 10-15 ft.	1 ft.	Course gravel, similar to on-site conditions	<0.1 acre	2000-2001	• Project went well • Too early to identify any issues • Monitoring will be conducted where free product was removed and sediment excavated ***- Annual visual monitoring from diving shows that the cap is holding up very well and considered a success (71)***	• Overall design relied more on excavation than capping ("stabilization") • Stabilization was used primarily in one area where buried telephone cables cross the river • Stabilization specifically not used if free product was present, area was subject to scour, or depth was less than 10 ft. • Other isolated portions of the 18 separate remediation areas may have used stabilization	4 ***71***
71	Rahway River Linden, New Jersey	DDT, metals	RCRA Corrective Action at industrial facility		Nonwoven geotextile, native sediment, sand filter material, second geotextile layer, rip rap armor	0.5 acre		• Cap construction is complete and has received final closure approval	• Message left with the NJDEP	E
Other Domestic Projects										
72	Lower Mobile Bay Alabama (ISC) pilot		Open ocean thin layer disposal	1 ft. maximum	Silt maintenance dredged material	<10 acres	1988	• Pre-, during, and post-project monitoring was conducted by the Mobile District (of US ACE), WES, and EPA • Motile and non-motile organism impacts and recolonization and water quality were monitored • Minimal impacts resulted, and organism levels were at pre-project levels in 6 months • Project considered a success (16)	• Energy sources: long wind fetch across Mobile Bay and surface wave energies from boats and natural conditions (16)	W, 16

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
73	Anacostia Watershed Prince George's County, Maryland (pilot)	PCBs, PAHs, pesticides, metals	15-20 ft. depths; near shore site with heavy propeller wash			10,000 sq.ft.	To be constructed (design should start this summer)	• Full commitment made to conduct pilot study	• Because there are a number of contaminated sediment sites on the Anacostia River, the entire watershed will be addressed in its entirety, with stakeholder input • Final remedy anticipated to be reactive cap	14
74	Koppers Superfund Site Charleston, South Carolina (ISC)	PAHs, pentachoro-phenol, trace dioxin, lead, arsenic	Ashley River; intertidal system; 1,500 ft. reach; cap mostly in intertidal zone; under 6 ft. of water at high tide (18)	1.5 ft. minimum	Geotextile and minimum of 18 in. sand (18)	3 acres (18)	Dec. 2001 (18)	***- Monitoring every 6 months shows that the southern portion is being eroded slowly away from the tide action, but this is viewed as a minor issue and repair will occur with rip rap. All else is working and vegetating well on its on (18)***	• Originally, only sediments in the Barge Canal were to be capped, and enhanced natural sedimentation was to be used in the Ashley River • Due to public concern with sheet piles surrounding property access, and agency's desire to avoid delays, EPA decided to cap the Ashley River • Approx. 2 ft. of sediment has already naturally deposited on the Barge Canal, but EPA will continue to evaluate the remedy for the Barge Canal (18) • Sediments in the Barge Canal are "marginally toxic" (AA)	AA, 18
75	Calhoun Park/Aquarium Charleston, South Carolina	PAHs (former coal gas manufactu-ring plant)	Cooper River intertidal area; portion above water line at low tide; a portion continually submerged (19)	3 ft.	Clean sand	0.5 - 0.75 acre, estimated (19)	1996	• Sand cap an interim measure, not a formal remedy • Some scouring and mounding noted • Very dynamic environment (19) ***- Monitoring shows that some maintenance is needed but do not know how much yet (18)***	• An aquarium was proposed to be built on the site. To avoid resuspension of PAHs during construction of 300 pilings, 3 ft. of clean sand was first laid (without geotextile) (18) • Ecological risk assessment warrants further evaluation of formal remedy, although aquarium and National Park Service boat dock present physical constraints (19) ***- Still discussing addition of more capping but none added yet since construction (18)***	18, 19

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
76	Ward Cove Ketchikan, Alaska (thin-layer capping)	Ammonia, sulfide, and 4-methylphenol (AA) (generated in place from existing contami-nation)	Deep estuary, 1 mi. long & 0.5 mi wide; water depth at proposed capping areas: -10 to -110 ft. MLLW (AA) Very soft organic sediments; 80-acre AOC (X)	0.5 - 1 ft. 0.5 -0.75 ft. (X)	Clean sand from upland borrow source (10)	27 acres (10)	Feb. 2001	• All sediment targeted for capping was covered by a thin-layer cap (10) • The project went very smoothly; the AOC will be sampled every third July or until remedial objectives are achieved (1) • Contractor had to verify that cap was properly placed (10) • First monitoring event will take place in 2004 (chemical monitoring and bioassays will be conducted) (10) • Lessons learned: (1) possible to place uniform cap on soft sediments with clamshell, (2) use a trial and error approach, (3) success when a close owner/contractor/regulator working relationship is in place to allow field modifications to meet clean-up objectives (X)	• Originally, 21 acres were going to be covered by a thin cap and 5 ft. of mounding would be used on another 6 acres. The mound capping was not required since thin-layer caps could be supported by the sediment. • Natural recovery was used where capping was infeasible, on 53 acres of the site (10) • The thin layer cap provides a clean substrate for recolonization of the benthic community (10) ***- Strength test said that the soft sediments could not hold the sand cap, and the 6-12 inches of sand would fall though, but visual inspection shows the sand to be in place. July 2004 sampling of sediment chemistry, bioassay, and fauna. The monitoring report is expected to be final in Decemeber 2004 (10)***	X, AA, 1, 10
77	Eagle River Flats Fort Richardson Army Base Anchorage, Alaska (pilot and follow-up study)	White phosphorus	Estuarine salt marsh next to former army firing range	3 to 4 inch layer (42)	Hydrated AquaBlok™	1.2 acre (1994 study)	1993 (pilot) 1994 (definitive study)	• The AquaBlok™ immediately and significantly reduced the mortality of the duck test population (42) • After one year, the treated area became revegetated and supported benthic life (42) • After four years of exposure to extreme temperature and tidal influences, the treated area remains capped (42) • Data collected to date indicates that AquaBlok™ shows promise for reducing waterfowl mortality from white phosphorous poisoning (43)	• High waterfowl mortality was observed in early 1980s and traced to ingestion of white phosphorus-impacted sediments • 1993 pilot study indicated that the system could reduce mortality of foraging waterfowl (43) • Definitive study conducted in 1994 to evaluate the longevity of the system and measure its effects on waterfowl foraging behavior and mortality (43)	42, 43

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
78	Eagle River Flats Fort Richardson Army Base Anchorage, Alaska (full-scale)	White phosphorus	Estuarine salt marsh next to former army firing range						• Preferred remediation method in Oct. 1998 ROD is to temporarily drain ponds to allow the pond sediments to dry out and allow white phosphorous to sublimate and oxidize over a five year period, and then cap and fill area with AquaBlok™ where white phosphorous exposure remains a concern (44) • AquaBlok™ would only be applied to small, deep portions of pond bottoms and would not significantly change overall pond depths or feeding habitat (44)	44
79	Nome, Alaska (CAD)		Harbor depth 20 ft.	4 ft.		1 acre			• Small project similar to One Tree Island, in which contaminated surface layer was dug up and deposited in CAD cell. • Approx. 35,000 cy of material placed in CAD cell	21
80	ALCOA (Point Comfort)/Lavaca Bay Site Point Comfort, Texas (thin layer capping)	Mercury	Tidal-estuarine; always underwater; water depth approx. 6-8 ft.	0.5 ft. ***- 1.0 foot (20***	Hoping to find a new clay material; possible use of dredge spoils from federally maintained channel	50 acres estimated	ROD signed in Dec. 2001; construction may start in Dec. 2002 ***- Now June 2005, still working on Consent Decree (20)***		• Remedy will include dredging, capping, and natural recovery • Thin layer cap will be used to accelerate natural sedimentation • Final design not complete • Modeling of Category 5 hurricane indicated wet deposition, not exposure of deeper sediment ***- In January 2002, 200,000 cubic yards of dreding which is now complete. nThe final design is also complete (20)***	20
81	Homestead Air Force Base Outfall Canal (OU-11) Florida	PAHs, metals (2)	Canal approx. 40-50 ft. wide, 1 mile long and 10 ft. deep (2)	Possibly 2 ft. (2)	Possible: concrete-injected fabric, under geotextile mat, under clean sediment for plant growth (2)		In the Proposed Plan stage of Superfund (2)	• The capping remedy has been approved by the Air Force, EPA, the State and Durham County (3)	• Extensive storm water conveyance system of canals and swales transports the contaminants to the Canal • Canal discharges storm water to Biscayne National Park, hence the urgency to address the sediments which appear to have damaged flora and fauna adjacent to the mouth of Outfall Canal (2)	2, 3
International Projects										

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
82	Rotterdam Harbor Netherlands (CAD)	Oils	Water depth 16 - 39 ft. (A)	2-3 ft.	Silt/Clay sediments	Est. minimum of 16.3 acres(i)	1984	• No available monitoring data	• Groundwater pollution was a potential concern so site was lined with clay prior to sediment disposal and capping	A, F, FF
83	Amsterdam Netherlands (CAD)		Harbor basins; multiple CADs							KK
84	Ijmuiden (Averijhaven) Netherlands (CAD)		Tidal waters at entrance to the North Sea; 1 CAD							KK
85	Ijmuiden (Amerikahaven) Netherlands (CAD)		Non-tidal waters in main port area; 1 CAD							KK
86	Julianakanaal Netherlands (CAD)		Shipping channel						• Deep pits in this channel were used for disposal of contaminated sediments from the River Maas	KK
87	Eitrheim Bay Norway	Metals	Water depth up to 10 m		Geotextile and gabions	100,000 m^2				B
88	Kihama Inner Lake Japan (ISC)	Nutrients	3 sites	5 and 20 cm	Fine sand	3,700 m^2				B, C
89	Akanoi Bay Japan	Nutrients	3.9 ft. deep; 2 sites	20 cm	Fine sand	20,000 m^2				B, C
90	Hiroshima Bay Japan (ISC)		Water depth 70 ft.	5.3 ft.	Sand with shell		1983	• No available data		A
91	Hiroshima Bay-Phase 1 Japan			50 cm	Sand	19,200 m^2	1979			B
92	Hiroshima Bay-Phase 2 Japan			30 cm	Sand	44,160 m^3	1980			B
93	Lake Biwa Japan			20 cm	Sand	22,000 m^2				B
94	Matsushima Bay Japan		Included dredging	30 cm	Sand	675 m^2				B
95	Minami-ko Japan			20 cm	Sand					C
96	Uranouchi Bay Japan		20-60 ft. deep	15-20 cm	Sand	17,400 m^2				B

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
97	Suonada Bay Japan		3-16 ft. deep	30-50 cm	Sand	15,900 m^2	1986-1987			B
98	Mikawa Bay Japan			40-100 cm	Sand	14,100 m^2				B
99	Tsuda Bay Japan		33-49 ft. deep	50 cm	Sand	418,000 m^2	1991-1993			B
100	Gokasho Bay Japan			20 cm	Sand	106,900 m^2				B
101	Uwajima Bay Japan			20 cm	Sand	46,800 m^2				B
102	Minimata Site Japan	Mercury		2.8 m	Geotextile sheets, two types of sand					B
103	Belgium (CAD)									T

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
104	East Sha Chau Contaminated Mud Pits Hong Kong (CAD)	Varied domestic and industrial pollutants, particularly metallic radicals (copper and chromium)		3 m minimum	Pits I-III: Initial placement: ~1m sand, then ~2m clean capping mud One year later after pit infill settling: another 1-2m clean mud to bring cap back to level of surrounding seabed (55) Pit IV: 6m - 8m	Pits I-III: 570 acres[j] Pit IV: 500 acres[j]	Pits I-III: Dec. 1992 to Dec. 1997 Pit IV: beginning in Dec. 1997	• Independent reviews of results indicate absence of adverse and/or cumulative impacts, including risks to public health and ecology, and conclude that the disposal program has effectively isolated contaminants from the marine environment (55) • The Environmental Impact Assessment study for CMP-IV determined that even though the pit would have larger surface area than previous CMPs, unacceptable environmental impacts would be unlikely as long as the maximum backfill level is limited to -14m PD. While a cap of 3m would be resistant to erosion under extreme storm events, there is space above the 3m cap for placement of about 5 m of additional clean material giving a final cap thickness of 6-8m (55) • Usefulness of sand cap layer as part of CMP-IV was re-assessed and determined to be unnecessary because the mud cap layers will be placed by hydraulic methods and because costs don't appear to be warranted - earlier caps always a revealed a distinct boundary between clean and contaminated mud (55)	• Pits designed to maximize capacity while minimizing affected seabed area (55) • Dec. 1992 to Dec. 1997: three pits used [CMP I, CMP IIa-d, and CMP IIIa-d] - these pits were dredged to base of the soft marine deposits, normally about 15 m below seabed (55) • Design process evaluated effects of storm-induced shear stress during a seasonal typhoon for uncapped pits and completed cap; possibility of remobilization and loss of contaminated sediment was very low if filled depth was limited to 9m below sea level; geophysical surveys showed maximum natural scour to be ~1m, so 3m cap thickness used (55) • Design cap also precludes burrowing organisms and anchors of shallow draft ships from breaching the cap (55) • After Dec. 1997: CMP-IV used; these were exhausted marine sand borrow pits with estimated volume of 30 Mm^3 expected (55) • Capacity in the 4th pit will be exhausted in late 2007 (56) or 2003 at least (55) • New CAD sites are being considered (BB, 56) • 22 Mm^3 disposed of from Dec. 1992 to approx. Jan. 2001 (BB); 40 Mm^3 expected by 2003 (55)	T, BB, 55, 56
105	Lake Schwelvollert Trebnitz, Germany (ISC)	Phenols, ammonium, PAHs	Former open mining pit; 89 ft. deep max.; 9 hectares							DD, EE
106	Sweden (ISC)									T

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Constructed	Performance	Comments	References
107	Lake Turingen Sweden (pilot ISC)	Mercury	197 acre lake, with maximum depth of 10 m	3 cm gel (Vattenresurs AB process)	Proprietary gel material ("artificial sediment")					52
108	Lake Turingen Sweden (full scale)	Mercury (from paper mill releases from 1946-1966)	197 acre lake, with maximum depth of 10 m (52)	Phase 1: cap - not specified Phase 2 cap: 5 cm (~2 in.) (52)	Phase 1 cap: geotextile and "suitable clean technological material" (53) Phase 2 cap: proprietary gel material ("artificial sediment") (52)	Phase 1 cap: not specified Phase 2 cap: 198 acres (52)	Phase 2 cap: to be completed in late autumn 2002 (52)		• Phase 1: dredge sediments from the final reaches of River Turingen channel and section of Lake Turingen just outside of mouth of river; "clean" several shallow areas of the lake near river mouth; spoils to be redeposited underwater in the southern part of the lake; cap non-dredged areas of the lake near the river mouth (53) • Phase 2: cap the "remaining accumulation in the lake bottoms with artificial gel" (53) • Vattenresurs AB in Sweden patented the Phase 2 capping method (52) • Raceway testing shows Phase 2 cap can manage current of 0.3 m/s (52)	52, 53
109	Sørfjorden Site Norway	Zinc, lead (54) (Concentra-tions of metals in sediment exceeded 10% zinc and 0.9% lead) (54)	Small bay near zinc factory; water depth < 33 ft.	30-60 cm (B) 30 cm sand over permeable membrane (54)	Nonwoven geomembrane and woven polyester geotextile and sand (B)	17.3 acres (54)		• Capping was selected because of fears of gross contamination during dredging and lack of safe areas to deposit spoils; the industrial waste in bay is a very significant source of pollution; the contaminated material at the shoreline is exposed to tides and waves and is continually eroded and resuspended; during stormy weather the entire bay has been colored red (54)	• The cap will be used in combination with a piled wall near shore (54) • The sandy layer on top of the membrane is meant to protect the membrane, to adsorb some of the contaminants that are transported through the membrane, and to arrange for recolonization of organisms; the membrane will prevent bioturbation into the contaminated sediments and erosion of the sediments during stormy weather (54)	B, 54

NOTES

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C. Abbreviations:

AOC	Area of Concern
CAD	Confined Aquatic Disposal
CB/NT SS	Commencement Bay Nearshore/Tideflats Superfund Site
Cd	Cadmium
CDF	Confined Disposal Facility
CDM	Capping Dredged Material
cfs	Cubic Feet Per Second
CLIS	Central Long Island Sound
CMP	Contaminated Mud Pit
COC	Chemical of Concern
CSO	Combined Sewer Overflow
cy	Cubic Yards
DDT	Dichloro-diphenol-trichloroethane
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
HDPE	High Density Polyethylene
ISC	In-Situ Capping
MLW	Mean Low Water
MLLW	Mean Lower Low Water
NAPL	Non-Aqueous-Phase Liquid
NPL	National Priorities List
NUAD	Not Suitable for Unconfined Aquatic Disposal
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDF	Polychlorinated Dibenzofuran
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
TBT	Tributyl Tin
TOC	Total Organic Carbon
UDM	Unacceptably Contaminated Dredged Material
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound
WES	Waterways Experiment Station (USACE)

D. Footnotes:

(a) Estimated by dividing the 0.6 m thickness into the 3100 m3 volume (Ref. E). According to J. Malek (Ref. 21), the initial cap area was approximately 0.7 acres. Because too much material was placed in too small a hole, too quickly, there was "slopping out", so the actual cap feathered out to an area of approx. 1.3 acres.
(b) Estimated from diagram provided at http://www.wes.army.mil/el/dots/doer/pdf/trdoer1.pdf (Ref. FF). B. Ross (EPA Region 9) believes that the calculated area could be correct for the LA project.
(c) Estimated from diagram provided at http://www.wes.army.mil/el/dots/pdfs/drv1n2_3.pdf (Ref. P). Approx. 0.25 by 1.4 miles
(d) Estimated from diagram provided at http://www.epa.gov/tio/tsp/download/palermo-jointsession.pdf (Ref. T)
(e) Estimated by dividing the 1.5 m thickness (Ref. PP) into the volume of capping sediments, 65,000 cu m (Ref. RR)
(f) Estimated based on mound diameter of 470 meters (Ref. UU)
(g) Estimated based on mound diameter of 200 meters (Ref. SS)
(h) Estimated based on diagram provided (Ref. 9) for the Mystic River CAD cells
(i) Estimated from one (out of three) pit dimensions of 550 by 120 meters (Ref. EE)
(j) Estimated based on diagram provided (Ref. 55) for the East Sha Chau mud pits

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