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Why Confined Aquatic Disposal Cells Often Make Sense

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ABSTRACT

Confined aquatic disposal (CAD) cells are increasingly becoming the selected option for the management of unacceptably contaminated sediments. CAD cells are selected as the preferred alternative because this approach provides an acceptable compromise when cost, logistics, regulatory acceptance, environmental risk, and perception of various alternatives are considered. This preference for CAD cells often occurs even when other alternatives with similar risk reduction and less cost, such as an open water capping alternative, are considered as options. This paradox is largely a result of subjective factors that affect regulatory acceptance such as public perceptions.

Keywords: Confined aquatic disposal   Contaminated sediment   Environmental risk   Capping

Special Section

INTRODUCTION

Confined aquatic disposal (CAD) cells are constructed to reduce the risk from unacceptably contaminated sediments (UCSs) by storing them in a depression in the bottom of an aquatic system (Figure 1). Confined aquatic disposal cells may be constructed from (1) naturally occurring bottom depressions; (2) sites from previous mining operations, such as beach nourishment borrow sites; or (3) new dredging operations created expressly for the containment structure. Confined aquatic disposal cells can reduce the risk from UCSs by confining the sediments to a smaller footprint, increasing contaminant diffusion times, removing UCSs farther from physical processes that can result in transport, and providing a means to effectively cap the sediments. All of these factors can contribute to the reduction or elimination of exposure pathways and the reduction of contaminant transfer rates, which results in a reduction in risk to human health and the environment.

Confined aquatic disposal cells are being selected as the alternative of choice by a growing number of navigation dredging and sediment remediation projects such as harbors in Boston, Massachusetts, USA; Providence, Rhode Island, USA; and Los Angeles, California, USA (USACE, MPA 1995; USACE 2001, 2002; Alfageme et al. 2002; Moore et al. 2002), and the Puget Sound Naval Shipyard, Bremerton, Washington, USA; St. Louis River–Duluth Tar Site, Duluth, Minnesota, USA (USEPA 2000; MPCA 2004); and Hong Kong airport (Whiteside et al. 1996; Shaw et al. 1998) sediment clean-up projects. Selection of the CAD cell alternative is often made from a suite of alternatives that includes open water placement, followed by capping, enhanced natural recovery, diked confined disposal facilities, upland placement, treatment, and no action. This article discusses some of the factors that have lead to the increasing popularity of the CAD cell alternative as well as some of the disadvantages that need to be considered before its implementation.

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REGULATORY FACTORS

A primary consideration for any alternative that is being evaluated by a project proponent is whether the alternative will be acceptable to the relevant permitting agencies. Usually permitting for aquatic sediment disposal involves seeking approval under the Clean Water Act (CWA) or the Marine Protection, Research, and Sanctuaries Act and reviews by the US Army Corps of Engineers, US Environmental Protection Agency (USEPA), and relevant state environmental agencies. Local approvals may also be necessary from conservation commissions, boards of health, or other relevant agencies. Various federal, state, nongovernmental organizations, and the public are also involved during project review.

Proposed locations for CAD cells are often near the dredging location in inland waters regulated by the CWA (e.g., within the confines of rivers, harbors, estuaries, and bays), whereas open water capping alternatives often involve consideration of deeper-water, offshore sites regulated by the Marine Protection, Research, and Sanctuaries Act (ocean waters within and beyond the territorial sea). When this situation arises, the current USEPA policy that capping is not an acceptable management method under the Marine Protection, Research, and Sanctuaries Act favors the selection of the CAD cell alternative.

Other regulatory factors that favor selection of CAD cells over other alternatives include consideration of adjacency issues and transportation effects. Confined aquatic disposal cells are often proposed close to the area where the UCS are currently lying and thus the area may already be ecologically impaired. As a result, no new area is affected by creation of the CAD cell, and the UCS sediments are kept close to their source and handled "on site." Under the CWA regulations, adjacency, in addition to the limitation of impacting new areas, can be an important decision factor favoring CAD cell use. For many environmental remediation projects, on site alternatives

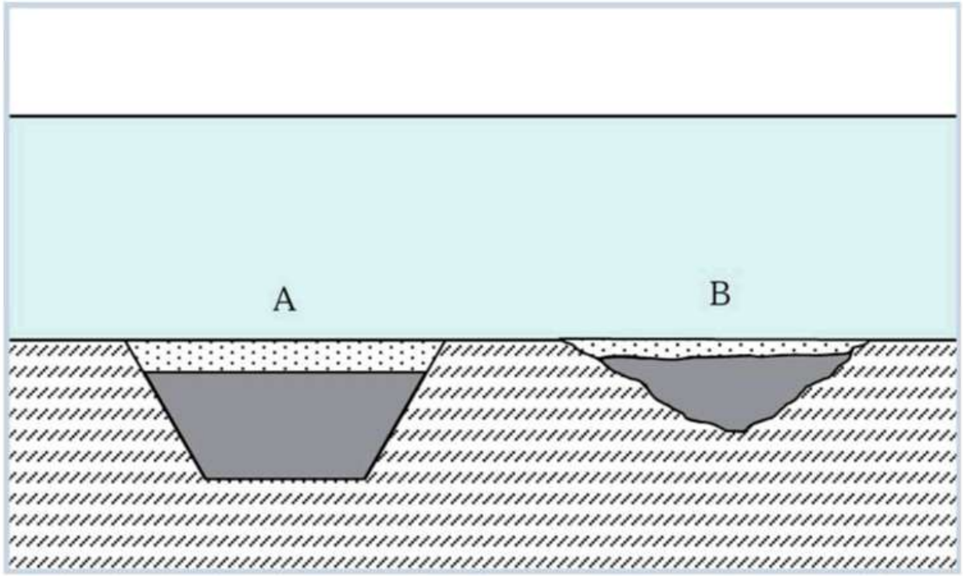

Figure 1. Schematic confined aquatic disposal (CAD) cells. **(A)** Cell dredged to meet specific project needs. **(B)** Cell using existing bottom depression or old borrow pit.

receive preferential consideration under both federal and state remediation legislation.

The CAD cell alternative results in fewer transportation effects than do most other alternatives because of relatively shorter transport distances and the use of barges. Consequently, fossil fuel use is lessened, as are the concomitant air quality effects, in comparison to either longer transport routes or the use of truck transport. Direct human exposure to truck-related traffic accidents and heavy truck use damage to roadways are also avoided.

PERCEPTION

Perception is a factor of enormous importance when a permitting agency weighs the public interest aspects of a project relative to other balancing criteria. Public acceptance is oftentimes contrary to alternative rankings based on objective technical comparisons of alternatives. In many instances in which decisions are made on controversial projects, the public acceptance factors, as well as concomitant political pressure, carry much greater weight than does any other factor.

Even when CAD cells offer no technical advantages, my observation has been that the general public has greater comfort with the CAD cell concept; other alternatives that may be similar or better technically, such as open water capping, often do not result in the same level of comfort. In my view, people are comfortable with the concept of boxes, bowls, and containers, and CAD cells generally fall into that category for most of the general public. CAD cells provide a feature with clearly defined limits, which can result in a certain degree of psychological comfort, and they also can appear to provide greater protection from major natural events such as waves, storms, and floods. Technical analysis may show that other alternatives can equal or exceed protection from such natural events, but the public does not always find those arguments convincing enough to overcome established perceptions.

COST

The CAD cell alternative, although often more expensive than are open water alternatives, is usually within the lower range of alternative costs (USACE 2001). As a consequence, project proponents often accept the CAD cell option as economically feasible.

In cases in which the proposed CAD cell utilizes an existing bottom depression, the cost of the CAD cell alternative may be similar to or less than open water disposal with capping. When a CAD cell must be dredged to accommodate the UCS, the disposal costs are usually 2 to 3 times that of open water capping options. However, other alternatives are usually 5 to 100 times the cost of open water options, unless sufficient economies of scale exist owing to large project size. Thus, although the cost differential between open water capping and CAD cells can be substantial, project proponents have often found that the added cost is acceptable when balanced with public acceptance, regulatory acceptance, and expediency.

ENVIRONMENTAL AND HUMAN HEALTH RISK

Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives (Kane-Driscoll et al. 2002). Relative to upland disposal, there is less rehandling of material and fewer contaminant transfer pathways: upland disposal can result in greater dermal contact, volatile emissions, and groundwater pathways. Upland disposal also increases risks of highway accidents, which can lead to injury and death. Compared with many other environmental and human health risk predictions used to evaluate dredging projects (trophic transfer rates, fish species residence time at disposal sites), highway accident risks can be quantified with little uncertainty by use of existing accident rate statistics.

In comparison to the no-action alternative, CAD cells, even when uncapped, result in a reduced surface area for contaminant release and less potential for direct contact by humans and biological resources, resulting in lower risks. Certainly the potential for diffusion of contaminants out of a CAD cell or for groundwater transport need to be evaluated, although these pathways are likely to be very slow (initial exit times measured in decades or centuries) and of low magnitude (for analysis of cap transport rates, see Murray et al. 1994).

LOGISTICS

CAD cells can usually be constructed by using readily available, conventional construction equipment with a minimum of transport and rehandling. Mechanical dredging equipment, especially clamshell bucket dredges, are most readily compatible with CAD cell construction. In regions where clamshell dredges are less commonly available, however, the challenges of creating a CAD cell with hydraulic equipment can severely limit design options. These include the inability to create steep CAD wall side slopes and the inability to dredge much deeper than 20 m (T.J. Fredette, personal observation on a proposed project for the Port of Santos, Brazil).

Transport distances from the UCS dredging site to the CAD cell may also be relatively short, leading to less transport conflicts in comparison to either longer haul distances for offshore sites or highway traffic effects for upland options. In addition, the sites often proposed for CAD cells have less land-use conflicts than do nearshore or offshore diked facilities and upland locations. Real estate costs, rehandling facility requirements, containment structure construction, abutter/neighbor conflicts, and transport route logistics are usually not necessary or are less problematic for CAD cell alternatives.

CHALLENGES OF USING CAD CELLS

The use of CAD cells does present some unique challenges for consideration before they are selected for use. For example, when the proposed site of a CAD cell is within a navigation channel, the uses of the channel and the future plans to deepen the channel must be part of the evaluation and design. In such instances, the future channel depths may require limiting the elevation to which the CAD cell is filled or possibly may require the future relocation of some of the CAD cell sediments. Also, in locations where tugs may need to apply extreme power to maneuver ships over the CAD cell, the need for protective armoring should be evaluated.

The CAD cell selection can also be drastically limited by subsurface geological conditions, especially the depth to bedrock. In addition, when the width of the area in which the CAD cell is proposed is narrow, such as in a channel, the necessary side slopes for wall stability may limit the effective depth to which a CAD cell can be constructed. Evaluation of the effect of CAD cell excavation on aquifers or the transport of contaminants from groundwater flow also may be relevant in certain situations.

Construction issues associated with CAD cells include evaluating effects to existing infrastructure, planning for sufficient storage volume, surging of material outside the CAD cell during filling, and applying a cap. Planning of CAD cells in both the Boston and Providence harbors required consideration of effects to the structural integrity of nearby piers and seawalls so that geotechnical failure would not damage these facilities (USACE, MPA 1995; USACE 2001).

The CAD cell design should provide volume contingency, although planning for bulking of the material may be unnecessary. Sizing a CAD cell to closely match the dredging volume creates a risk that the cell will be filled before the dredging is completed. This can occur when the dredging volume was underestimated because of survey inaccuracies or when additional sediment was deposited into the area after the volume survey was completed. The capacity of the cell can also be affected when water is added to the sediment during the dredging process (bulking), creating a greater volume than initially expected. However, depending on the length of time over which a CAD cell is filled, the 1st material placed into the CAD cell may become compressed relative to its dredging area in situ volume, which may compensate for any bulking that occurs in material added to the cell later in the process. However, because the estimate of the volume to be dredged is imprecise, providing additional volume capacity (contingency) in the CAD cell is prudent.

Surging of sediments beyond the limits of the CAD cell has been documented (Germano 2003) and may require the modification of placement procedures as the cell approaches its fill capacity. Alternatively, surge loss could be handled by clean-up dredging around the CAD cell once the main portion of the project is complete or by the application of a cap over the lost material.

Although not likely, the potential effect to aquifers or the potential for groundwater flow to transport contaminants should be considered. Usually, the sediments being placed into the CAD cell will be fine grained with relatively low permeability. In that event, groundwater flow is likely to be diverted around the cell rather than through it.

Over the long term, the number of locations at which CAD cells can be constructed in a particular harbor or region may have limitations that will restrict the ability to use this alternative once the available sites are taken. For this reason, CAD cells may represent only an intermediate-term solution and should be used only for sediments that have clearly been shown to be in need of special management.

CONFINED AQUATIC DISPOSAL CELL SUCCESS

The CAD cells have been used successfully at several locations around the world, including Hong Kong; Los Angeles, California, USA; Bremerton, Washington, USA; Newark, New Jersey, USA; Boston; Hyannis, Massachusetts, USA; and Providence, Rhode Island, USA. We have seen both successful and less-than-fully successful (mixing of cap and UCS instead of covering) placement of caps on CAD cells, which has demonstrated the need to plan for sufficient consolidation of the sediment to be capped (Myre et al. 1998; Fredette et al. 1999, 2000, 2002). Nonetheless, even when CAD cells are uncapped, the contained sediments will almost always be farther removed from the physical forces that result in transport to other areas compared with the initial, no-action situation. Because the top surface of a CAD cell will almost always be below the surrounding bottom, physical forces will affect the surrounding bottom before affecting the sediments in the CAD cell. Thus, when the surrounding bottom is being resuspended, the CAD cell will likely act as a sediment receptor. It is difficult to envision a plausible scenario in which substantial erosion from a CAD cell is likely. Risk reduction through smaller footprints of the sediment exposed to the water column and reduced or eliminated exposure and transport pathways with less mass transport are also beneficial.

CONCLUSION

The CAD cell alternative is likely to be chosen for a rapidly increasing number of projects that must manage UCSs. This trend will result from this alternative best meeting the nexus of regulatory acceptance, public perception, cost, risk reduction, and feasibility.

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