PDHonline Course C176 (3 PDH)

Guidelines for Hazardous and Toxic Waste Collection and Removal

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CHAPTER 3

CONTROL AND CONTAINMENT TECHNOLOGIES

3-1. Definition. Control and containment technologies are those remedial systems that are used primarily for management of contaminants onsite and to prevent excursions to the air or ground water.

3-2. Applicability. Control and containment remedial techniques are usually undertaken where the volume of waste or hazard associated with the waste makes it impractical or impossible to dispose of the contamination offsite to a secure landfill site or to treat the waste or contaminated material onsite. In some cases, portions of waste materials have been removed, but the residual contamination in soil and ground water must be contained onsite. Remedial techniques generally are used for onsite containment with processes such as flushing of an aquifer or natural biological degradation accounting for the actual destruction of contaminants. Site control and containment remedial techniques are often implemented along with treatment systems to minimize the volume of material requiring treatment. For example. if leachate seeps from the site it must be treated, and control of run-on and percolation through the site can reduce the volume of water that must be collected and treated.

3-3. Techniques.

a. Waste Collection and Removal. The first step in remediation is usually the collection and removal of waste materials, including wastes, soils, sediments, liquids, and sludges.

b. Contaminated Ground Water Plume Management. Often it is necessary to control contaminant movement in the subsurface by intercepting or controlling leachate and ground water around and under a site.

c. Surface Water Controls. Control and containment technologies usually involve managing the movement of contaminants in and out of the controlled area. Many common construction processes used in managing ground water and surface water are often employed. Leachate control involves containment and collection of water contaminated by contact with hazardous wastes. Control of leachate will involve the use of subsurface drains and liners.

d. Gas Control. Gases and volatile compounds must be controlled at many hazardous waste sites both to allow access to the area and to prevent wider dispersion of contaminants.

Section I. Waste Collection and Removal

3-4. Drum Handling.

a. Background.

(1) The disposal of drums containing wastes in landfills and at abandoned storage facilities has been common practice in the United States.

Many of the problems with uncontrolled disposal sites can, in part, be linked to improper drum disposal. In addition to contributing to ground-water, soil, air, and surface-water contamination, several explosions and fires, resulting from incompatible wastes can be attributed to leaking drums.

(2) Since each disposal site is different, selection and implementation of equipment, and methods for handling drum-related problems, must be independently determined. The primary factors that influence the selection of equipment or methods include worker safety, site-specific variables affecting performance, environmental protection, and costs. All sites should include the construction of earthen dikes and installation of synthetic liners in the drum-handling area to minimize seepage and run-off of spilled materials, and the use of real-time, air-monitoring equipment during all phases of site activity.

(3) The organization of a typical drum cleanup site is shown in Figure 3-1.

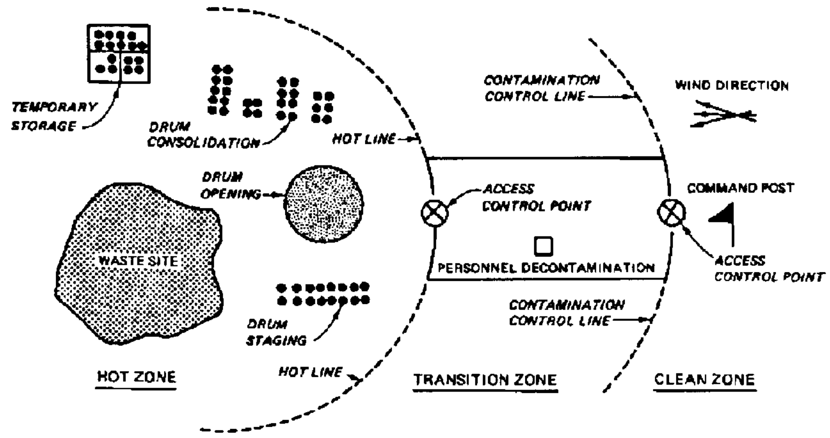

Figure 3-1. Organization of the Waste Site Cleanup Area

b. Drum-Handling Activities.

(1) Site-specific variables. The safety of drum handling is greatly affected by site-specific conditions, including accessibility of the site, drum integrity, surface topography and drainage, number of drums, depth of burial, and the type of wastes present.

(2) Detecting and locating drums. Typically, drums at an abandoned site will be detected through the use of historic and background data on the site, aerial photography, geophysical surveying, and sampling. Background data and aerial photography records which will show changes in the site over time, such as filling in of trenches and mounding of earth, should be available onsite during the construction phase of the remedial action to

determine if the drum location is as predicted. Geophysical survey methods are highly dependent upon site-specific characteristics. Magnetometry is usually the most useful survey method for locating buried drums. Metal detectors, ground penetrating radar, and electromagnetics are also used to detect buried drums with varying success. Regardless of the geophysical method used to determine the location of buried drums, the results must be verified by sampling.

(3) Environmental protection. Four basic techniques for environmental protection which should be practiced at all sites are: (a) measures to prevent contaminant releases, such as overpacking or pumping the contents of leaking drums; (b) actions which mitigate or contain releases once they have occurred, such as perimeter dikes, (c) avoidance of uncontrolled mixing of incompatible wastes by handling only one drum at a time during excavation, and (d) isolating drum-opening operation from staging and working areas. Some of the preventive measures and mitigating actions for minimizing contaminant releases during drum-handling activities are summarized in Table 3-1.

(4) Determining drum integrity. The excavation and handling of damaged drums can result in spills and reactions which may jeopardize worker safety and public health. Generally a drum is inspected visually to check the drum surface for corrosion, leaks, swelling, and missing bungs. Worker safety should be stressed during this inspection since it requires close contact with the drum. Any drum that is critically swollen should not be approached. Swollen drums should be isolated behind a barrier and the pressure released remotely. Nondestructive testing methods to determine drum integrity have been found to have serious drawbacks and limitations. Most of these methods such as ultrasonics or eddy currents require that the drum surface be relatively clean and free from chipped paint and floating debris. Buried drums are usually not in condition to be safely and easily cleaned.

(5) Container opening, sampling, and compatibility. Each container on a site may have to be opened, sampled, and analyzed prior to disposal.

(a) Container opening and sampling should be conducted in an isolated area to minimize the potential of explosions and fires should the drum rupture or the contents spill. Drum-opening tools include hand tools (nonsparking hand tools, bung wrenches, and deheaders) and remotely operated plungers, debungers, and backhoe-attached spikes. EPA*s National Enforcement Investigations Center (NEIC) has developed two remotely controlled drumopening devices. Procedures for drum opening and sampling are outlined in Appendix XIV of the Chemical Manufacturers Association, Inc. (CMA), report "A Hazardous Waste Site Management Plan.

(b) Compatibility testing is required prior to bulking, storing, or shipping many of the containers. Compatibility testing should be rapid, using onsite procedures for assessing waste reactivity, solubility, presence of oxidizer, water content, acidity, etc. A compatibility testing procedure is also outlined in Appendix XV of the CMA report.

(6) Drum consolidation and recontainerization.

Table 3-1. Measures for Minimizing Contaminant Releases during Drum Handling

Potential environmental problem	Preventive measures
Ground-water contamination	Improve site drainage around the drum-handling area and minimize run-on and run-off by constructing a system of dikes and trenches.
	Where ground water is an important drinking water source; it may be necessary to hydrologically isolate the work area using well-point dewatering.
	Use liners to prevent leaching of spilled material into ground water during drum handling, drum opening, recontainerization, and decontamination.
	Use sorbents or vacuum equipment to clean up spills promptly.
	Locate a temporary storage area on highest ground area available; install an impervious liner in the storage area and a dike around the perimeter of the area; utilize a sump pump to promptly remove spills and rainwater from storage area for proper handling.
Surface-water contamination	Construct dikes around the drum-handling and storage areas.
	Construct a holding pond downslope of the site to contain contaminated run-off.
	Use sorbents or vacuum equipment to promptly clean up spills.
	Design the dikes for temporary storage area to contain a minimum of 10 percent of total waste volume; ensure that holding capacity of storage area is not exceeded by utilizing a sump pump to promptly remove spills and rainwater.
Air pollution	Avoid uncontrolled mixing of incompatible wastes by (1) handling only one drum at a time during excavation, (2) isolating drum-opening operation from staging and working areas, (3) pumping or overpacking leaking drums, and (4) conducting compatibility tests on all drums.

(Continued)

Table 3-1. (Concluded)

Potential environmental problem	Preventive measures
Air pollution (Cont.)	Promptly reseal drums following sampling.
	Any drum which is leaking or prone to rupture or leaking, promptly overpack or transfer the contents to a new drum.
	Utilize vacuum units which are equipped with vapor scrubbers.
	Where incompatible wastes are intentionally mixed (i.e., acids and bases for neutralization) in a "compatibility chamber" or tank, releases of vapors can be minimized by covering the tank with plastic liner.
Fire protection	Use nonsparking hand tools, drum-opening tools, and explosion-proof pumps when handling flammable, explosive, or unknown waste.
	Avoid uncontrolled mixing of incompatible waste by (1) handling only one drum at a time, (2) pumping or overpacking drums with poor integrity, (3) isolating drum opening, and (4) conducting compatibility testing of all drums.
	Use sand or foams to suppress small fires before they spread.
	Avoid storage of explosives or reactive wastes in the vicinity of buildings.
	In a confined area, reduce concentration of explosives by venting to the atmosphere.
	Cover drums which are known to be water-reactive.

(a) A proposed drum consolidation protocol that can be used as a guide in assessing drum consolidation requirements was also prepared by the CMA. The protocol is based on grouping the waste into categories that are compatible based on limited testing rather than doing individual analyses of the contents of each drum prior to disposal. This approach would be best suited to a manufacturing facility where the products or wastes types are limited and the objective is to consolidate many samples into a relatively small number of waste streams for bulk disposal. In the case where a disposal method is based on concentrations of a particular waste constituent (e.g., concentration of PCBs), care must be taken not to consolidate containers into bulk streams that would substantially alter the method for disposal, subsequently increasing the costs for the remedial action.

(b) In the case where consolidation is not feasible, based on incompatibility of wastes or costs, drums can be overpacked, contents transferred to new drums, or contents solidified to facilitate handling.

(7) Storage and shipping. Temporary onsite storage of drums may be part of the remedial action prior to ultimate disposal. Requirements for storage of hazardous wastes over 90 days are regulated under the RCRA. RCRA-permitted facilities for drum storage for over 90 days require:

(a) Use of dikes or berms to enclose the storage area and to segregate incompatible waste types.

(b) Installation of a base or liner that is impermeable to spills.

(c) Sizing of each storage area (containing compatible wastes) so that it is adequate to contain at least 10 percent of the total waste volume in event of a spill.

(d) Design of the storage area so that drums are not in contact with rainwater or spills for more than one hour.

(e) Weekly inspections.

(8) Technical standards. The technical standards for these requirements are found in 40 CFR Parts 264-265. Manifesting and shipping of the hazardous wastes are covered by DOT regulations found in 49 CFR 171-177, 40 CFR 263, and other applicable Federal, state, and local laws and regulations. A RCRA storage permit will be required for onsite storage of hazardous waste held over 90 days.

3-5. Storage. Storage is the holding of a waste for a temporary period of time, at the end of which the waste is treated, disposed of, or stored elsewhere.

a. Applicability.

(1) Storage systems have general applicability to all types of waste streams as a mechanism for accumulating and holding waste on a temporary basis. Storage should be considered viable only in cases where the

accumulation of waste prior to treatment or disposal results in a cost reduction or makes some treatment process or disposal method more feasible. Examples include accumulation of waste until a sufficient volume is obtained for bulk shipment or bulk treatment, thus decreasing costs. Under the RCRA regulations, a generator may accumulate hazardous waste onsite without a permit for a period of up to 90 days as long as certain conditions are met as specified in CFR Title 40, Part 262, Subpart C, Section 262.34.

(2) Different storage techniques are capable of handling wastes in solid, semisolid, and liquid forms. Problems associated with the applicability of storage techniques to various wastes generally occur with regard to storage of hazardous waste. The RCRA regulations pertaining to storage facilities under Part 264 address two particular problem wastes, ignitable or reactive wastes and incompatible wastes. Special requirements for each storage technique are detailed in the regulations for these wastes.

(3) Wastes that emit or produce toxic fumes should not be stored in a manner which allows for the emission of fumes except possibly in emergency situations.

b. Methods. Storage methods include waste piles, surface impoundments, containers, and tanks.

(1) Waste piles. Waste piles are small noncontainerized accumulations of a single solid dry nonflowing waste. They may be maintained in buildings or outside on concrete or other pads. Waste pile storage is suitable for semisolid and solid hazardous wastes such as mine tailings or unexploded ordnance wastes. The siting criteria for waste piles are less stringent than those for landfills or surface impoundments. Waste piles should be located in a hydrogeologic setting that offers both sufficient vertical separation of wastes from uppermost ground water and low permeability soils providing the hydraulic separation. The design elements required by the regulations for waste piles include liner, leachate collection and removal, run-on and run-off control, and wind dispersal control.

(a) Liners selected for a waste pile must be compatible with the waste material and be able to contain the waste until closure. Considerable flexibility is permitted in the choice of liners for short-term storage of wastes. A liner may be constructed of clay, synthetic materials, or admixes. Table 3-2 summarizes liner types, characteristics, and compatibilities. If a waste pile is going to be used for an extended period of time, a double liner with a leachate collection system may be required. Figure 3-2 illustrates waste pile details and a double liner system. If the waste pile contains particulate matter, wind dispersal controls are required by the regulations.

(b) The principal closure requirement for a waste pile is removal or decontamination of all waste and waste residue and all system components (liners), subsoils, structures, and equipment which have been contaminated by contact with the waste. However, if contamination of the subsoils is so extensive as to preclude complete removal or decontamination, the closure and postclosure requirements applying to landfills must be observed. Ensuring

Table 3-2. Summary of Liner Types

Liner material	Characteristics	Range of costs[1]	Advantages	Disadvantages
Soils				
Compacted clay soils	Compacted mixture of onsite soils to a permeability of 10^{-7} cm/sec	L	High cation exchange capacity; resistant to many types of leachate	Organic or inorganic acids or bases may solubilize portions of clay structure
Soil bentonite	Compacted mixture of onsite soil, water, and bentonite	L	High cation exchange capacity; resistant to many types of leachate	Organic or inorganic acids or bases may solubilize portions of clay structure
Admixes				
Asphalt concrete	Mixtures of asphalt cement and high-quality mineral aggregate	M	Resistant to water and effects of weather extremes; stable on side slopes; resistant to acids, bases, and inorganic salts	Not resistant to organic solvents; partially or wholly soluble in hydrocarbons; does not have good resistance to inorganic chemicals; high gas permeability
Asphalt membrane	Core layer of blown asphalt blended with mineral fillers and reinforcing fibers	M	Flexible enough to conform to irregularities in subgrade; resistant to acids, bases, and inorganic salts	Ages rapidly in hot climates; not resistant to organic solvents, particularly hydrocarbons
Soil asphalt	Compacted mixture of asphalt, water, and selected in-place soils	L	Resistant to acids, bases, and salts	Not resistant to organic solvents, particularly hydrocarbons
Soil cement	Compacted mixture of portland cement, water, and selected in-place soils	L	Good weathering in wet-dry/freeze-thaw cycles; can resist moderate amount of alkali, organics, and inorganic salts	Degraded by highly acidic environments
Polymeric membranes				
Butyl rubber	Copolymer of isobutylene with small amounts of isoprene	M	Low gas and water vapor permeability; thermal stability; only slightly affected by oxygenated solvents and other polar liquids	Highly swollen by hydrocarbon solvents and petroleum oils difficult to seam and repair
Chlorinated polyethylene	Produced by chemical reaction between chlorine and high-density polyethylene	M	Good tensile strength and elongation strength; resistant to many inorganics	Will swell in presence of aromatic hydrocarbons and oils

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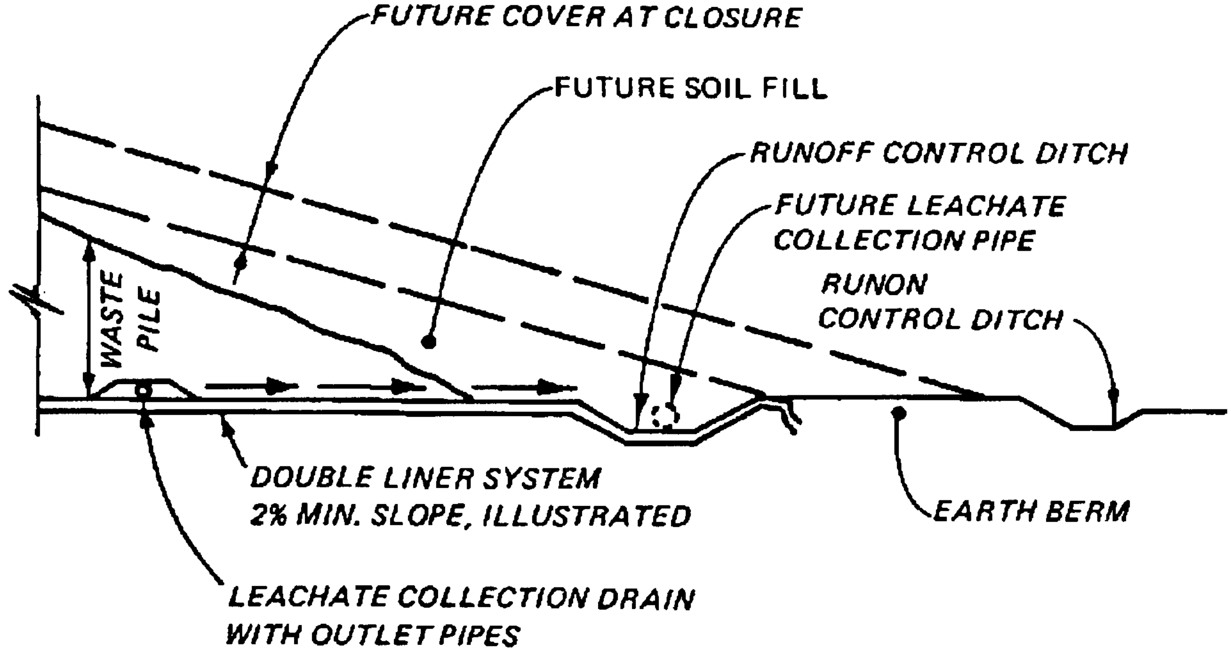
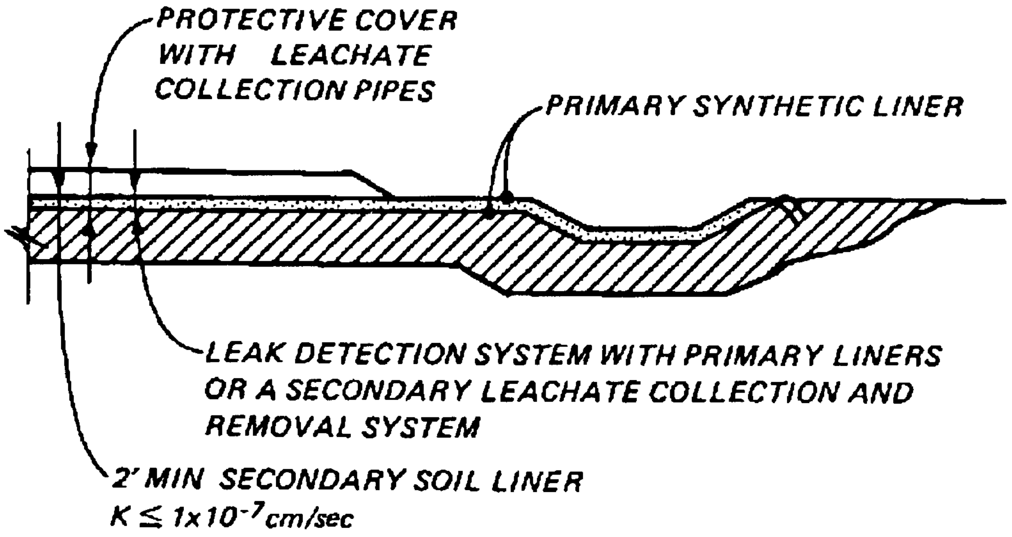
[1] L - \$1.12 to \$4.78 per square meter (\$1 to \$4 installed costs per square yard) in 1981 dollars; M - \$4.78 to \$9.57 /m^2 (\$4 to \$8 per square yard); H - \$9.57 to \$14.35 /m^2 (\$8 to \$12 per square yard). (Source: "Comparative Evaluation of Incinerators and Landfills," prepared for the Chemical Manufacturers Association, by Engineering Science, McLean, VA, May 1982).

Table 3-2. (Concluded)

Liner material	Characteristics	Range of costs[1]	Advantages	Disadvantages
Polymeric membranes (Cont.)				
Chlorosulfonate polyethylene	Family of polymers prepared by reacting polyethylene with chlorine and sulfur dioxide	H	Good resistance to ozone, heat, acids, and alkalis	Tends to harden on aging; low tensile strength; tendency to shrink from exposure to sunlight; poor resistance to oil
Elasticized polyolefins	Blend of rubbery and crystalline polyolefins	L	Low density; highly resistant to weathering, alkalis, and acids	Difficulties with low temperatures and oils
Epichlorohydrin rubbers	Saturated high molecular weight, aliphatic polyethers with chloromethyl side chains	M	Good tensile and tear strength; thermal stability; low rate of gas and vapor permeability; resistant to ozone and weathering; resistant to hydrocarbons, solvents, fuels, and oils	None reported
Ethylene propylene rubber	Family of terpolymers of ethylene, propylene, and nonconjugated hydrocarbon	M	Resistant to dilute concentrations of acids, alkalis, silicates, phosphates, and brine; tolerates extreme temperatures; flexible at low temperatures; excellent resistance to weather and ultraviolet exposure	Not recommended for petroleum solvents of halogenated solvents
Neoprene	Synthetic rubber based on chloroprene	H	Resistant to oils, weathering, ozone, and ultraviolet radiation; resistant to puncture, abrasion, and mechanical damage	None reported
Polyethylene	Thermoplastic polymer based on ethylene	L	Superior resistance to oils, solvents, and permeation by water vapor and gases	Not recommended for exposure to weathering and ultraviolet light conditions
Polyvinyl chloride	Produced in roll form in various widths and thicknesses; polymerization of vinyl chloride monomer	L	Good resistance to inorganics; good tensile, elongation, puncture, and abrasion resistant properties; wide ranges of physical properties	Attacked by many organics, including hydrocarbons, solvents, and oils; not recommended for exposure to weathering and ultraviolet light conditions
Thermoplastic elastomers	Relatively new class of polymeric materials ranging from highly polar to nonpolar	M	Excellent oil, fuel, and water resistance with high tensile strength and excellent resistance to weathering and ozone	None reported



TYPICAL WASTE PILE DETAILS



DOUBLE LINER SYSTEM

Figure 3-2. Base Liner Details for Waste Piles adequate containment of waste should be an important consideration in initial design of a waste pile.

(2) Surface impoundments. Surface impoundments include any facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area. They may be formed primarily of earthen materials or man-made materials, and designed to hold an accumulation of liquid wastes or wastes containing free liquids. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons. Surface impoundments are used for the storage, evaporation, and treatment of bulk aqueous wastes.

(a) Mixing of wastes is inherent in a surface impoundment. Incompatible wastes should not be placed in the same impoundment. The potential dangers from the mixing of incompatible wastes include extreme heat, fire, explosion, violent reaction, production of toxic mists, fumes, dusts, or gases. Some examples of potentially incompatible wastes are presented in Table 3-3.

(b) Surface impoundments should be located in a hydrogeologic setting that limits vertical and horizontal hydraulic continuity with ground water. The hydraulic head formed in the impoundment provides for a high potential for liquid seepage and subsurface migration. As with waste piles, surface impoundments may require the use of liners, leachate collection and removal, and runon and runoff controls. An example detailing base liners for surface impoundments is shown in Figure 3-3.

(c) Surface impoundments must be inspected during their operating life. These inspections should include monitoring to ensure that liquids do not rise into the freeboard (prevention of overtopping), inspecting containment berms for signs of leakage or erosion, and periodic sampling of the impounded wastes for selected chemical parameters.

(3) Removal methods.

(a) Removal methods for settled residues and contaminated soil include removal of the sediment as a slurry by hydraulic dredging, excavation of the sediments with a jet of high-pressure water or air, vacuum transport of powdery sediments, excavation of hard solidified sediments by either dragline, front-end loader, or bulldozer.

(b) The major operation at an impoundment involves the "removal" of the liquid waste. Table 3-4 summarizes liquid waste removal methodologies.

(c) In addition to the requirement of a single liner with ground-water monitoring wells or a double liner with a leak detection system, other design elements include prevention of overtopping the sides of the impoundment and construction specifications that ensure the structural integrity of the dikes.

(d) Closure options include the removal or decontamination of all wastes, waste residues, system components, subsoils, structures, and equipment or the removal of the liquid waste and solidification of the remaining waste.

Table 3-3. Examples of Potentially Incompatible Wastes

Group A chemicals	Mixed with	Group B chemicals	May have	Potential consequence
1-A Acetylene sludge Alkaline caustic liquids Alkaline cleaner Alkaline corrosive liquids Alkaline corrosive battery fluid Caustic wastewater Lime sludge and other corrosive alkalies Lime wastewater Lime and water Spent caustic		1-B Acid sludge Acid and water Battery acid Chemical cleaners Electrolyte, acid Etching acid liquid or solvent Pickling liquor and other corrosive acids Spent acid Spent mixed acid Spent sulfuric acid		Heat generation; violent reaction
2-A Aluminum Beryllium Calcium Lithium Magnesium Potassium Sodium Zinc powder Other reactive metals and metal hydrides		2-B Any waste in Group 1-A or 1-B		Fire or explosion; generation of flammable hydrogen gas
3-A Alcohols Water		3-B Any concentrated waste in Group 1-A or 1-B Calcium Lithium Metal hydrides Potassium SO_2, Cl_2, $SOCl_2$, PCl_3, CH_3, $SiCl_3$ Other water-reactive waste		Fire, explosion, or heat generation; generation of flammable or toxic gases
4-A Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other reactive organic compounds and solvents		4-B Concentrated Group 1-A or 1-B wastes Group 2-A wastes		Fire, explosion, or violent reaction
5-A Spent cyanide and sulfide solutions		5-B Group 1-B wastes		Generation of toxic hydrogen cyanide or hydrogen sulfide gas

(Continued)

Table 3-3. (Concluded)

Group A chemicals	Mixed with	Group B chemicals	May have	Potential consequence
6-A		6-B		
Chlorates Chlorine Chlorites Chromatic acid Hypochlorites Nitrates Nitric acid, fuming Perchlorates Permanganates Peroxides Other strong oxidizers		Acetic acid and other organic acids Concentrated mineral acids Group 2-A wastes Group 4-A wastes Other flammable and combustible wastes		Fire, explosion, or violent reaction

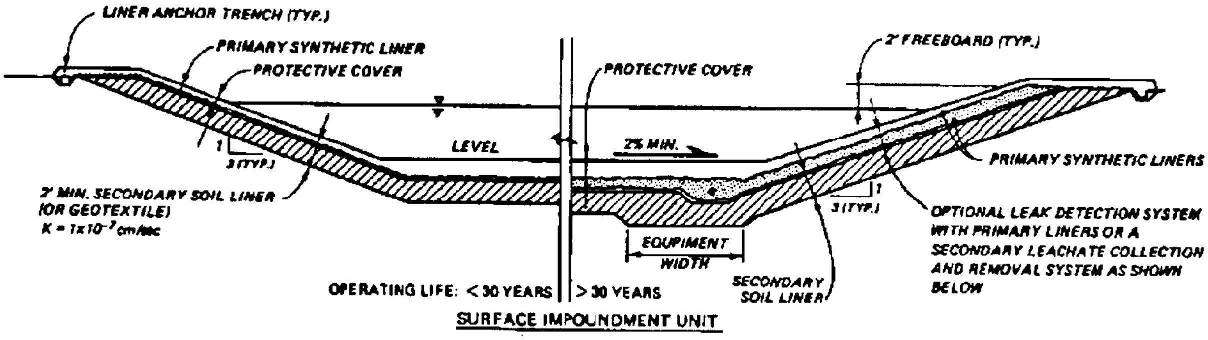


Figure 3-3. Base Liner Details for Surface Impoundments

Solidification also requires the placement of a final cover and ground-water monitoring to ensure that stabilization and capping operations were successful.

(4) Tanks. Tanks are stationary devices designed to contain an accumulation of hazardous waste and are constructed primarily of nonearthen materials (e.g. , wood, concrete, steel, plastic) which provide structural support. Tanks should be designed to be strong enough to ensure against collapse or rupture. Closed tanks should be vented or have some means to control the pressure. Tanks should be compatible or have a liner that is compatible with the stored waste. Incompatible wastes should not be stored in the same tank.

c. Summary of Current Regulations. References to EPA advisories and regulations for hazardous waste storage, treatment, or disposal are listed below.

Containment Method	Regulations
Landfills, surface impoundments, waste piles, and land treatment units	Federal Register, Vol 47, No. 143
Containers and tanks	Federal Register, Vol 46, Page 2867
Standards for waste containers	40 CFR Part 264, Subpart I, Sections 264.170-264.178; and Subpart J, Sections 264.190-264.199
Standards for surface impoundments	40 CFR Part 264, Subpart K
Standards for waste piles	40 CFR Part 264, Subpart L and Subpart F

Table 3-4.Liquid Waste Removal Methods for Surface Impoundments

Method	Description
Decanting	Liquids within or ponded on the surface of the impoundment can be removed by gravity flow or pumping to a treatment facility if there is not a large percentage of settleable solids.
Pumping and settling	Liquids or slurries composed of suspended or partially suspended solids can be removed by pumping into a lined settling pond and then decanting. Sludges are disposed in a dry state, and either returned to the impoundment or disposed in another contained site.
Solar drying	Liquids are removed by evaporation; sludges remaining after evaporation are left in the impoundment or disposed in another contained site. Note that volatile organics should not be handled in this manner.
Chemical neutralization	Aqueous waste with low levels of hazardous constituents frequently lends itself to chemical neutralization and subsequent normal discharge under NPDES permit requirements
Infiltration	Certain aqueous waste can be handled by infiltration through soil, provided that the hazardous substances are removed by either soil attenuation or underdrain collection of the solute. Collected solutes are usually treated.
Process reuse	Some aqueous waste can be recycled in the manufacturing process a number of times until the contaminants are at a level requiring disposal by one of the methods previously mentioned. Reuse does not dispose of the waste but can significantly reduce the quantities to be disposed.
Absorbent addition	Materials can be added to aqueous impounded wastes to absorb free liquids. Absorbents include sawdust; wood shavings; agricultural wastes such as straw, rice, and peanut hulls; and commercially available sorbents.

3-6. Tank Cleaning and Demolition. Tank cleaning and demolition procedures are site specific and depend largely on the nature of tank contents. A major consideration is whether the contents are ignitable or explosive. If possible, the contents of the tank should be removed by pumping or draining, then the tank can be decontaminated and demolished. Provisions must be made for treatment and disposal of contaminated washwaters.

a. Tanks Containing Sludges. If the sludge cannot be removed, water should be pumped into the tank to completely cover the sludge and the contents of the tank should be blanketed with nitrogen. The tank head space should then be checked with an explosion meter to ensure a safe working environment before proceeding. Then the top area of the tank should be cut using an oxyacetylene torch. Explosion meter checks should be made after each cut to ensure that no explosive gases are collecting during cutting operations. Successive "slices" of the tank should be removed until there is sufficient working room to remove the contents of the tank. Adequate fire protection should be available onsite along with a paramedic unit during tank demolition activities if there is a risk of fire or explosion.

b. Tanks Containing Liquids. Once the tank contents have been removed by pumping or draining, the tank can be decontaminated. Depending upon the contents, water and/or organic solvents may be used. The final decontamination process should be water flushing if the tank contained ignitable or explosive waste material. Chemical emulsifiers may be used to remove hydrophobic organics. Before proceeding with tank demolition, explosion meter checks should be taken. If an explosive hazard exists, the tank should be blanketed with water and nitrogen before being cut. Again, explosive checks should be made after each cut while the tank is cut away in "slices." Fire protection personnel and paramedics should be present any time there is the danger of fire or explosion.

3-7. Lagoon Management. Existing lagoons, ponds, and disposal pits have the potential to contaminate surface water, ground water, soil, and the surrounding air. Precipitation (rainwater and surface runoff) may increase the volume of the contaminated waste, increasing the potential for ground- and surface-water contamination, and increasing total cleanup costs. Background information on geology, hydrology, soils, and the character of the waste itself is most important in determining the potential for leachate generation and its vertical and horizontal migration through the ground-water system.

a. Management Plans. The contents of a lagoon may be contained, treated, or disposed of onsite or may be removed from the lagoons to an offsite treatment or disposal facility.

(1) Onsite remedial actions.

(a) Onsite management plans may include a no-action alternative with no treatment for the waste and establishment of a monitoring program to detect any surface or subsurface migration of contaminants. This option may be appropriate if it has been determined that the underlying aquifer is unusable and there is no imminent danger of contaminating nearby surface waters or residential wells. Long-term monitoring can be very expensive and the potential liability of the impounded waste may not decrease over time.

(b) The wastes may be pumped to an onsite treatment facility. Liquids may be pumped with one or more of many available pumps. However, the compatibility of the liquid waste with the pump*s materials that come in contact with the liquid should be considered to avoid equipment failures. Sludges and contaminated sediments at the bottom of the lagoon may or may not require dredging to remove them from the lagoon depending on viscosity. Onsite treatment of the liquid waste may be accomplished through physical, chemical, and/or biological methods. Treatment systems are further discussed in Chapter 4.

(c) The wastes may also be treated in situ using one of many options. These options include solidification, stabilization, or encapsulation. When preparing the contract for a project with in-situ treatment, a pilot-scale demonstration using the actual construction equipment proposed for the job should be required. Obtaining a sufficient mixing action with sludges using heavy construction equipment can be a difficult task with low quality control at hazardous waste impoundments.

(d) If the waste is left in place after being treated, it should be isolated from surface and ground water. Capping and surface water diversion can prevent most leachate generation. Ground water can be controlled with the use of subsurface barriers or by ground-water pumping.

(2) Offsite remedial actions. The contents of a lagoon may also be removed and transported to an offsite facility for treatment or disposal. Treatment processes may be applied to the waste during the removal operation depending on the treatment/disposal option being used. The additional handling and transportation problems should be considered. Also, once the liquid contents of the lagoon have been removed, the remaining sludge and underlying contaminated soil may have to be removed and treated at the same offsite facility.

3-8. <u>Excavation of Landfills and Contaminated Soils</u>. Excavation is a common technique used to move solid and thickened sludge materials. Where offsite treatment methods are to be used, excavation and transportation of the waste material will be required.

a. <u>Design and Construction Considerations</u>. Important factors that should be considered before excavation of a refuse site can begin are listed below.

(1) Density of solid waste in a landfill. Density is dependent on the composition of the waste and the degree of compaction achieved. Average densities of landfilled wastes generally range from 474 to 593 kg/m^3 (800 to 1,000 lb/yd^3) with moderate compaction.

(2) Settlement of the fill. As a result of decomposition of the waste and the addition of new waste material, settling of fine particles into voids between solid matter can occur.

(3) Bearing capacity of the fill. Bearing capacity is the ability to support foundations (and heavy equipment). Average values ranging from 23.9 KPa to 38.3 KPa (500 to 800 lb/ft^2) have been reported.

(4) Decomposition rate of waste. Most of the materials present in a refuse site will decompose. Decomposition of organic waste under anaerobic conditions predominantly occurs at the base of the site and can generate highly corrosive organic acids and toxic gases such as methane or hydrogen sulfide.

(5) Packaging of waste. Packaging of waste in barrels and tanks may present additional removal problems.

b. Mechanical Methods. Excavation of a landfill may be achieved by mechanical means. Typical excavation equipment includes draglines, backhoes, and clamshells.

(1) The dragline.

(a) A dragline excavator is a crane unit with a drag bucket connected by cable to the boom. The bucket is filled by scraping it along the top layer of soil toward the machine by a drag cable. The dragline can operate below and beyond the end of the boom.

(b) Maximum digging depth of a dragline is approximately equal to half the length of the boom, while digging reach is slightly greater than the length of the boom. Draglines are very suitable for excavating large land areas with loosely compacted soil.

(2) The backhoe.

(a) The backhoe unit is a boom or dipper stick with a hoe dipper attached to the outer end. The unit may be mounted on either crane-type or tractor equipment.

(b) The largest backhoe will dig to a maximum depth of about 13.7 m (45 feet). Deeper digging depth can be achieved by attaching long arms to one-piece booms or by adjusting the boom angle on two-piece booms.

(c) Some hydraulic backhoes having booms that can be extended up to 30.5 m (100 feet) or retracted for close work can be used to excavate, backfill, and grade.

(3) The clamshell. To achieve deeper digging depth, clamshell equipment must be used. A clamshell bucket is attached to a crane by cables. A clamshell excavator can reach digging depths greater than 30.5 m (100 feet).

c. Advantages and Disadvantages. Advantages and disadvantages of the excavation technique using dragline and backhoe are listed below.

Advantages	Disadvantages
Dragline	
Readily available	Difficult to spot bucket for scraping and dumping
Applicable for excavation of large area	Cannot backfill or compact

(Continued)

Advantages	Disadvantages
Easy to operate	Not applicable for digging depth more than 9.1 m (30 ft)

Backhoe

Readily available	Not applicable for digging depth over 9.1 m (30 ft)
Easy to control the bucket and thus control width and depth of excavation	Cannot be extended beyond 30.5 m (100 ft)
Can excavate hard and compacted material	
More powerful digging action than dragline	
Can be used to backfill and compact	

3-9. Removal of Contaminated Sediments.

a. Background.

(1) Uncontrolled waste disposal sites may directly or indirectly contaminate bottom sediments deposited in streams, creeks, rivers, ponds, lakes, estuaries, and other bodies of water. Sediment contamination by waste disposal sites may occur along several different pathways. Contaminated soil may be eroded from the surface of hazardous waste disposal sites by natural run-off and subsequently deposited in nearby watercourses or sediment basins constructed downslope of the site. Also, existing sediments along stream and river bottoms may adsorb chemical pollutants that have been washed into the watercourse from disposal areas within the drainage basin. Similarly, contaminated ground water may drain to surface watercourses and the transported pollutants may settle into, or chemically bind with, bottom sediments. Another possible source of sediment contamination is direct leakage or spills of hazardous liquids from damaged or mishandled waste containers; spilled chemicals that are heavier and denser than water will sink to the bottom of natural waters, coating and mixing with sediments.

(2) Dredging serves the same basic function as mechanical excavation: removal of hazardous waste materials from improperly constructed or sited disposal sites for offsite treatment or disposal. Several types of dredges are commonly used, including hydraulic, pneumatic, and mechanical dredges. Dredged material management includes techniques for drying, physical processing, chemical treatment, and disposal. Plans to remove and treat contaminated sediments must be designed and implemented on a site-specific basis. An evaluation of the need for placing fill or dredged materials in waters of the United States or by alternate routes must be made in accordance with the 404 (b)(1) Guidelines (40 CFR Part 230). Discharge of fill or dredged materials will not be permitted if a practicable alternative having less adverse environmental impact exists.

(3) A knowledge of the physical properties and distribution of contaminated sediments is essential in selecting a dredging technique and in planning the dredging operation. Information on grain size, bed thickness, and source and rate of sediment deposition is particularly useful. Such information can be obtained through a program of bottom sampling or core sampling of the affected sediment.

b. Description and Application of Dredging Techniques.

(1) Hydraulic dredging.

(a) Available techniques for hydraulic dredging of surface impoundments include centrifugal pumping systems and portable hydraulic pipeline dredges. Centrifugal pumping systems utilize specially designed centrifugal pumps that chop and cut heavy, viscous materials as pump suction occurs. The special chopper impeller devices within these pumps allow high-volume handling of heavy sludges and other solids mixtures without the use of separate augers or cutters.

(b) Cutterhead pipeline dredges are widely used in the United States; they are the basic tool of the private dredging industry. Cutterhead dredges loosen and pick up bottom material and water, and discharge the mixture through a float-supported pipeline to offsite treatment or disposal areas. They are generally from 7.6 to 18.3 m (25 to 60 feet) in length, with pump discharge diameters from 152 to 508 mm (6 to 20 inches). There are two basic types of portable cutterhead dredges: the standard basket cutters (Figure 3-4) and the smaller specialty dredges that use a horizontal auger assembly and move only by cable and winch.

(c) For dredging surface impoundments deeper than 6.1 m (20 feet), the standard cutterhead dredge (Figure 3-5) is required. This type of dredge moves forward by pivoting about on two rear-mounted spuds (heavy vertical posts), which are alternately anchored and raised. The swing is controlled by winches pulling on cables anchored forward of the dredge (Figure 3-6). The rotating cutter on the end of the dredge ladder physically excavates material ranging from light silts to consolidated sediments or sludge, cutting a channel of variable width (depending on ladder length) as the dredge advances. For deep surface impoundments containing only soft, unconsolidated bottom materials, a variation of the standard cutterhead dredge--the suction pipeline dredge--can be used to dredge the impoundment. Suction dredges are not equipped with cutterheads, or they simply operate without cutterhead rotation; they merely suck the material off the bottom and, like most dredges, discharge the mixture through a stern-mounted pipeline leading to a disposal area.

(2) Low-turbidity hydraulic dredging.

(a) Low-turbidity dredging is any hydraulic dredging operation that uses special equipment (dredge vessels, pumps) or techniques to minimize the

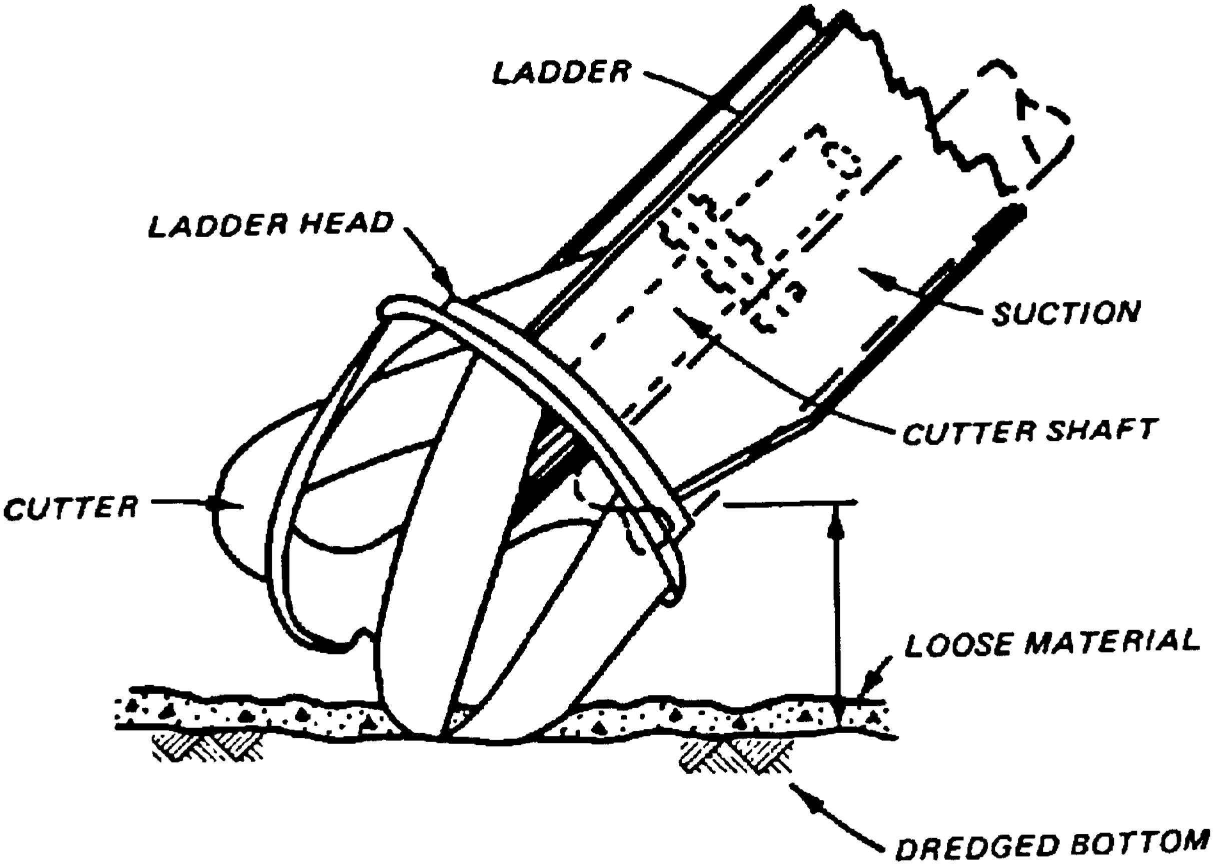


Figure 3-4. Standard Cutter Assembly, Spiral Basket Cutter

resuspension of bottom materials and subsequent turbidity that may occur during the operation. Conventional hydraulic dredging may cause excessive agitation and resuspension of contaminated bottom materials, which decreases sediment removal efficiency and which may lead to downstream transport of contaminated materials, thereby exacerbating the original pollution. Low-turbidity hydraulic dredging systems include small specialty dredge vessels, suction dredging systems, and conventional cutterhead dredges that are modified using special equipment or techniques for turbidity control.

(b) The Mud Cat dredge utilizes a submerged pump mounted directly behind a horizontal auger to handle highly viscous chemical sludges or thick, muddy sediments. The Mud Cat MC-915 (Figure 3-7) can remove sediment in a 2.7 m (9-foot-wide) swath, 457 mm (18 inches) deep, at depths as great as 4.6 m (15 feet) and as shallow as 508 mm (21 inches). The horizontal auger can be tilted left and right to a 45-degree angle to accommodate sloping sides of impoundments. With an auger wheel attachment, the Mud Cat can dredge in lined impoundments without damaging the liner. Two people are required to operate the 9.1 m (30-foot-long) machine, which moves by winching itself in either direction along a taut, fixed cable at average operating speeds of

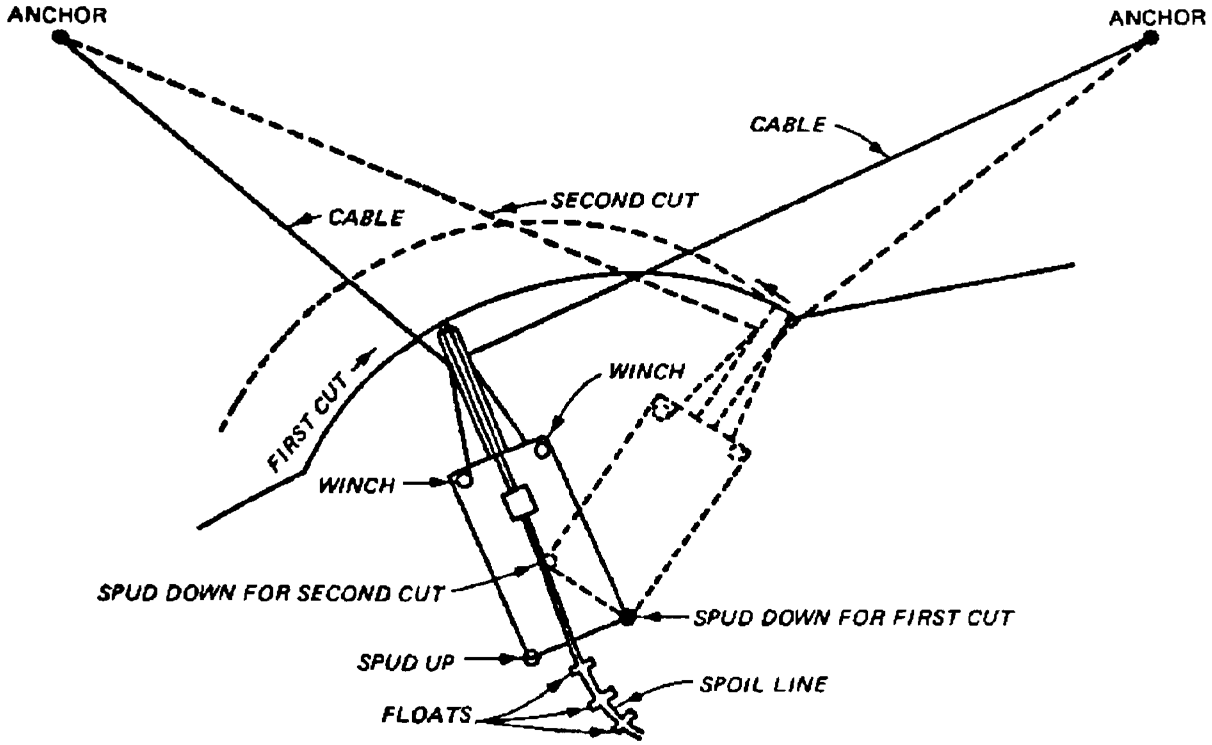


Figure 3-5. Standard Cutterhead Dredge Operation

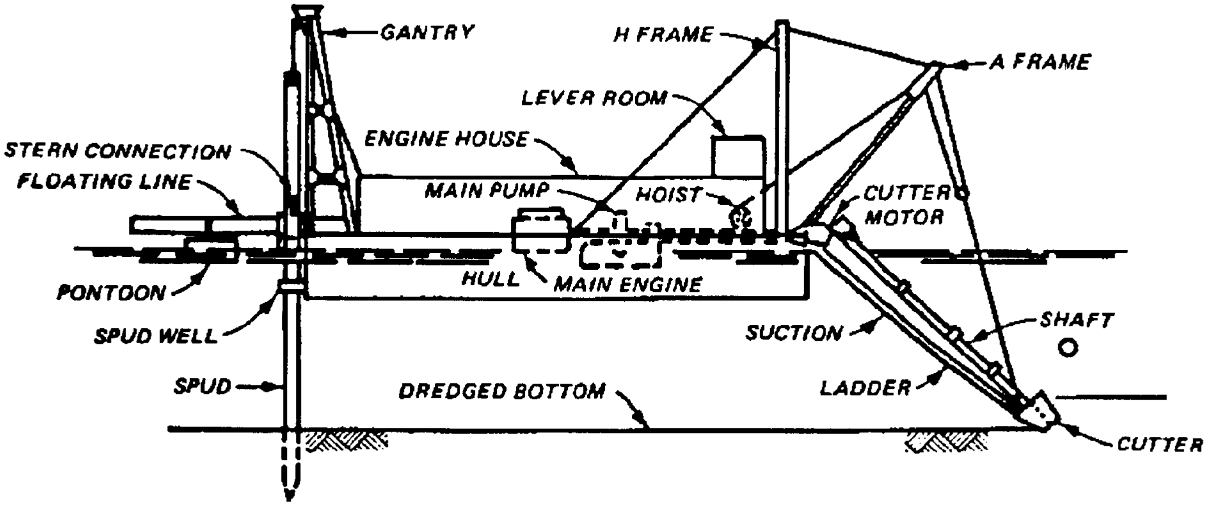


Figure 3-6. Standard Cutterhead Dredge Vessel

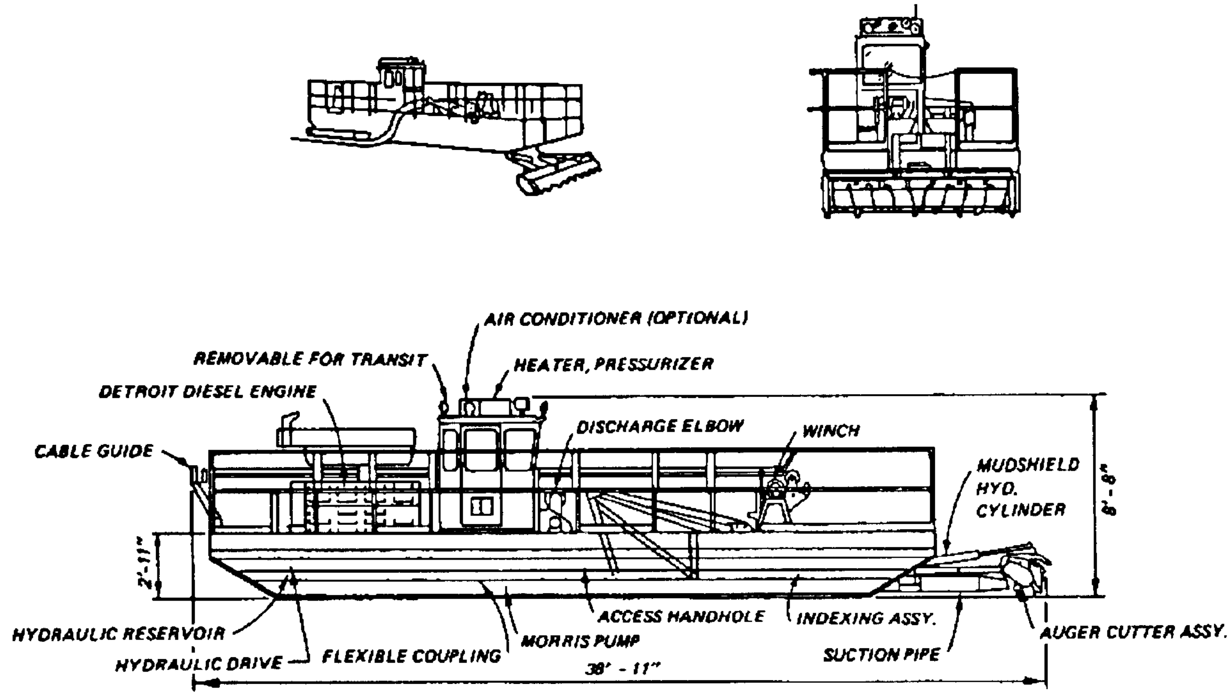


Figure 3-7. Views of the Mud Cat MC-915 Dredge

41 to 61 mm/s (8 to 12 feet per minute). The Mud Cat has a retractable mudshield, which surrounds the cutter head, entrapping suspended material, increasing suction efficiency, and minimizing turbidity. The Mud Cat can discharge approximately 95 ℓ/s or 5.7 m^3/min (1,500 gallons per minute) of slurry with 10 to 30 percent solids through an 203 mm (8-inch) pipeline and, depending on site-specific conditions, can remove up to 92 m^3/hr (120 cubic yards per hour) of solids. The Mud Cat dredge was 95 to 99 percent efficient in removing sediments and simulated hazardous materials from impoundment bottoms in field tests conducted for the EPA.

(c) A Japanese suction dredge, the "Clean Up" (Figure 3-8), uses a hydraulically driven, ladder-mounted submerged centrifugal pump to "vacuum" muddy bottom sediments (fine grained; high water content) from depths as great as 22.9 m (75 feet), with very low turbidity. This system can pump very dense mixtures 40 to 50 percent solids by volume at constant flow rates as great as 526 ℓ/s or 1895 m^3/hr (500,000 gallons per hour), removing up to 688.5 m^3 (900 cubic yards) of sediment per hour. A dredge vessel equipped with this pumping system may be used to remove contaminated sediments from large rivers or harbors in depths as shallow as 4.9 m (16 feet), with minimal pollution of the surrounding environment from dredgegenerated turbidity.

(d) Another Japanese dredging system for removal of high-density sludges is called the "oozer pump" which may have applications in very deep bodies of water such as large rivers or harbors. This system utilizes vacuum

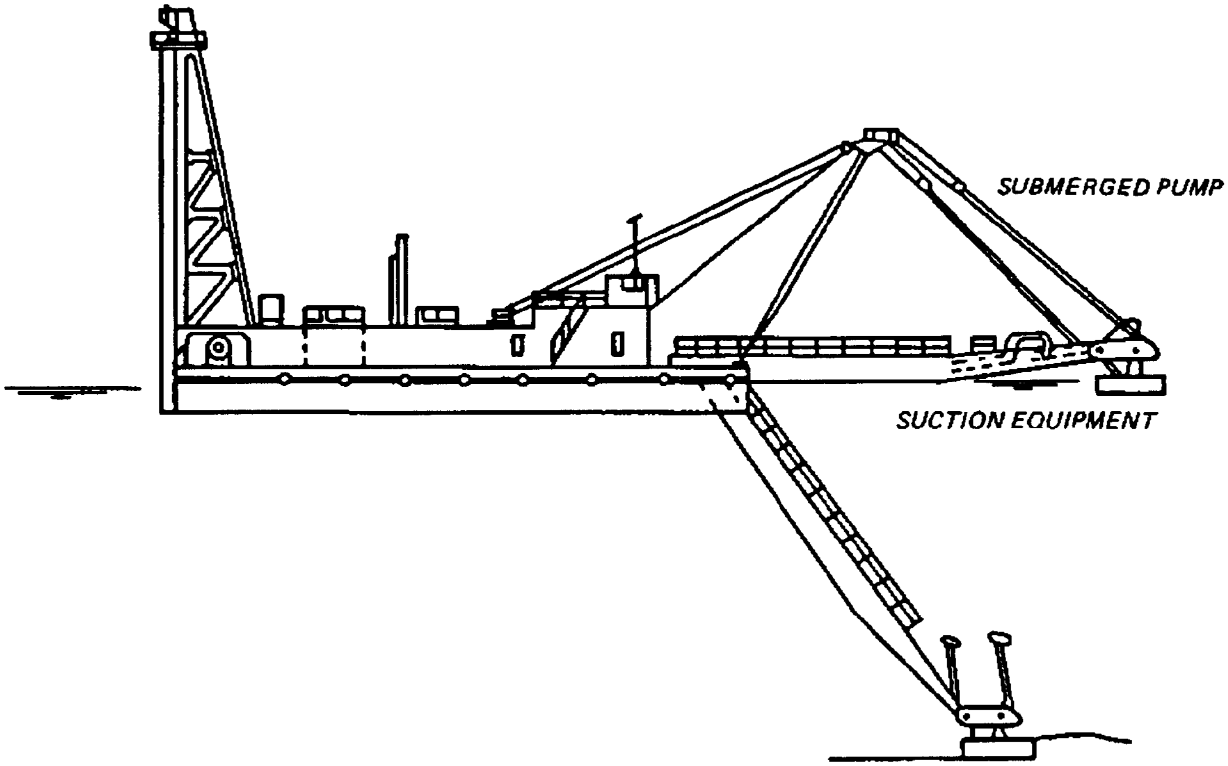


Figure 3-8. The Japanese Suction Dredge "Clean Up"

suction and air compression to efficiently remove muddy sediments (silt and clay) and sludges with low turbidity.

(e) A typical centrifugal pumps system (Figure 3-9) is 2.4 m (8 feet) wide, 4.3 m (14 feet) long, approximately 2.1 m (7 feet) high, and weighs about 2730 kg (3 tons); its 75 kw (100-horsepower) motor can pump up to 76 L/S or 4.5 m^3/min (1,200 gallons per minute) of 15 to 20 percent solids from depths up to 4.6 m (15 feet).

(f) Other specialty low turbidity dredges include the bucket-wheel-type dredge, recently developed by Ellicott Machine Corporation, that is capable of digging highly consolidated material and has the ability to control the solids content in the slurry stream. The Delta Dredge and Pump Corporation has also developed a small portable unit that has high solids capabilities. The system uses a submerged 305 mm (12-inch) pump coupled with two counter-rotating, low-speed, reversible cutters.

(3) Mechanical dredging.

(a) Mechanical dredging of contaminated sediments should be considered under conditions of low, shallow flow. Dredging should be used in conjunction with stream diversion techniques to hydraulically isolate the area of sediment

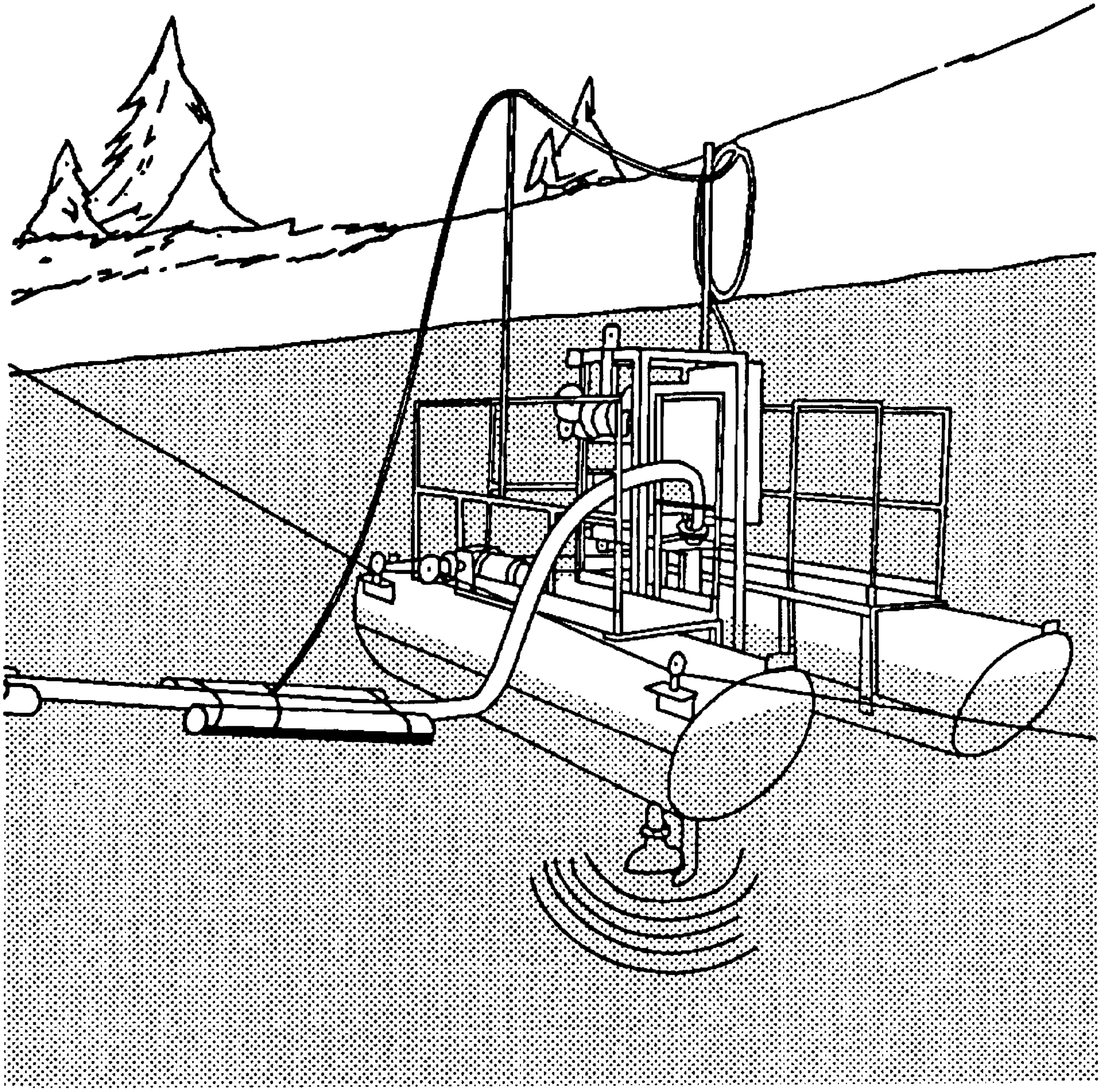


Figure 3-9. Portable Centrifugal Pump System for Lagoon Dredging

removal. Under any other conditions mechanical excavation with draglines, clamshells, or backhoes may create excessive turbidity and cause uncontrolled transport of contaminated sediments further downstream. Stream diversions with temporary cofferdams can be followed by dewatering and mechanical dredging operation for streams, creeks, or small rivers. Mechanical excavation can also be used to remove contaminated sediments that have been eroded from disposal sites during major storms and deposited in floodplains or along riverbanks above the level of base flow.

(b) For streams and rivers that are relatively shallow and whose flow velocity is relatively low, backhoes, draglines or clamshells can be used to excavate areas of the streambed where sediments are contaminated. The excavated sediments can be loaded directly onto haul vehicles for transport to a predesignated disposal area; however, the excavated material must be sufficiently drained and dried before transport. Backhoe and dragline operation requires a stable base from which to work. For these reasons, direct mechanical dredging of contaminated sediments in streams is not recommended except for small streams with stable banks, slow and shallow flow, and underwater structures, and where contaminated sediments are relatively consolidated and easily drained.

(c) A more efficient mechanical dredging operation with broader application involves stream or river diversion with cofferdams, followed by dewatering and excavation of contaminated sediments. Such an operation may prove quite costly; however, there is little chance of stirring up sediments and creating downstream contamination. Efficiency of sediment removal is much greater by this method than by instream mechanical dredging without diversion of flow.

(d) Sheet-pile cofferdams may be installed in pairs across streams to temporarily isolate areas of contaminated sediment deposition and allow access for dewatering and excavation (Figure 3-10). Alternatively, a single curved or rectangular cofferdam may be constructed to isolate an area along one bank of the stream or river (Figure 3-11); this method only partially restricts natural flow and does not necessitate construction of a temporary diversion (bypass) channel to convey entire flow around the area of excavation, as the first method does.

c. Design and Construction Considerations of Dredging Techniques.

(1) The selection of dredging equipment or pumping systems for the removal of contaminated materials will depend largely on manufacturer specifications for a given dredge vessel or pump system. Important selection criteria that will vary from site to site are:

(a) Surface area and maximum depth of the impoundment.

(b) Total volume of material to be dredged.

(c) Physical and chemical nature of sediments.

(d) Pumping distance and terminal elevation (total head).

(e) Presence of bottom liner in impoundment.

(f) Type and amount of aquatic vegetation.

(g) Power source for dredge.

(h) Ease of access and size and weight limits of roads.

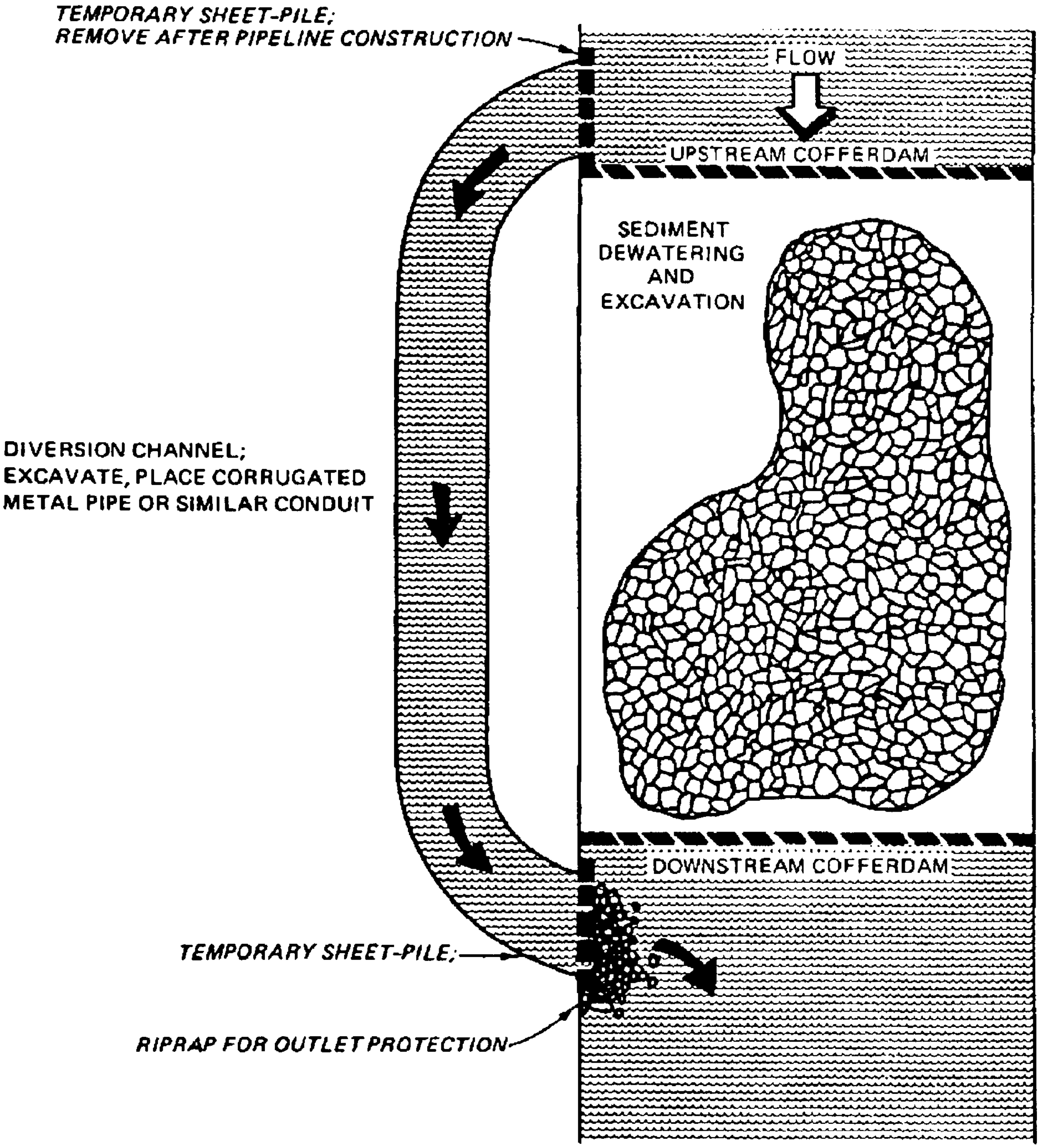


Figure 3-10. Streamflow Diversion for Sediment Excavation Using Two Cofferdams and Diversion Channel

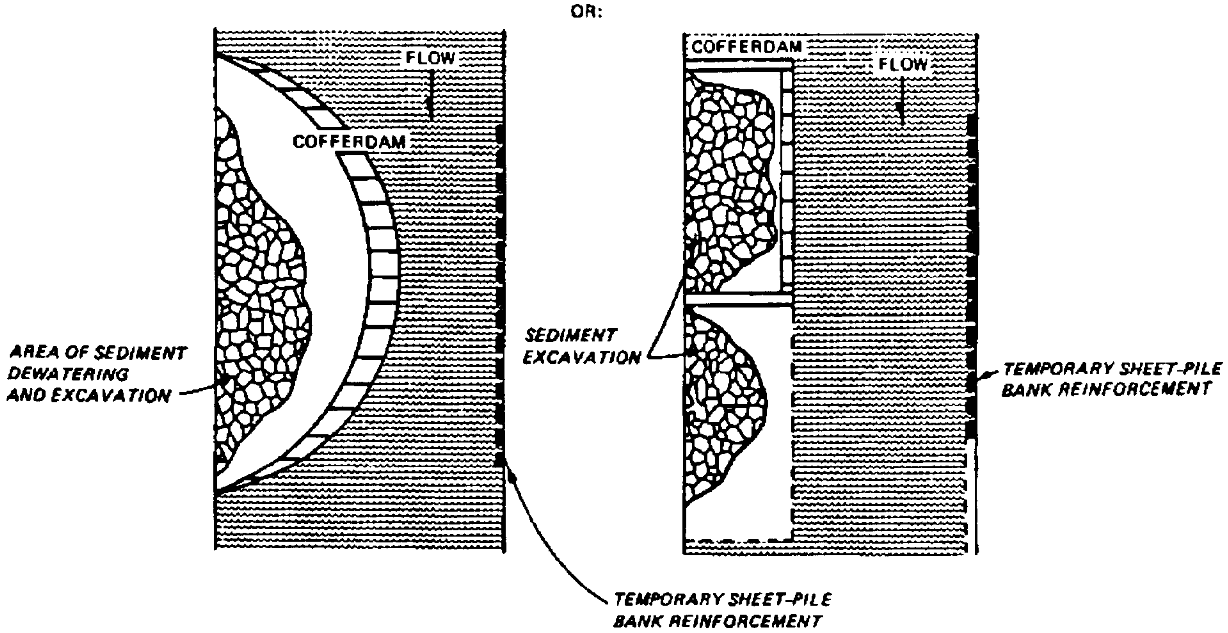


Figure 3-11. Streamflow Diversion for Sediment Excavation Using Single Cofferdam (Source: EPA 1982)

(2) All criteria must be considered before selection of a pumping system or dredge vessel of the appropriate size, efficiency, and overall capabilities can be made. The centrifugal pumps used in pumping systems or dredge vessels have a rated discharge capacity based on maximum pump speed (in revolutions per minute, rpm) and a given head against which they are pumping. The total head against which pumps must work is affected by the depth of dredging, the distance over which the material is pumped, and the terminal elevation of the discharge pipeline in relation to the water level within the impoundment.

(3) When preparing dredging contracts for contaminated sediment removal where turbidity control is essential, contract provisions should specify the use of special low-turbidity dredge vessels or auxiliary equipment and techniques designed to minimize turbidity generation. The bidder should be made to specify minimum sediment removal volumes and maximum allowable turbidity levels in the downstream environment to ensure an effective dredging operation.

(4) During dredging of stream or river sediments, agitation of the bed deposits during excavation may generate a floating scum of contaminated debris on the water surface, particularly if the chemical contaminant is oily or greasy in nature. The installation of a silt curtain downstream of the dredging site will function to trap any contaminated debris so generated; the debris can then be collected through skimming. Similarly, silt curtains can be employed to minimize downstream transport of contaminated sediments. A schematic of a silt curtain is shown in Figure 3-12. It is constructed of

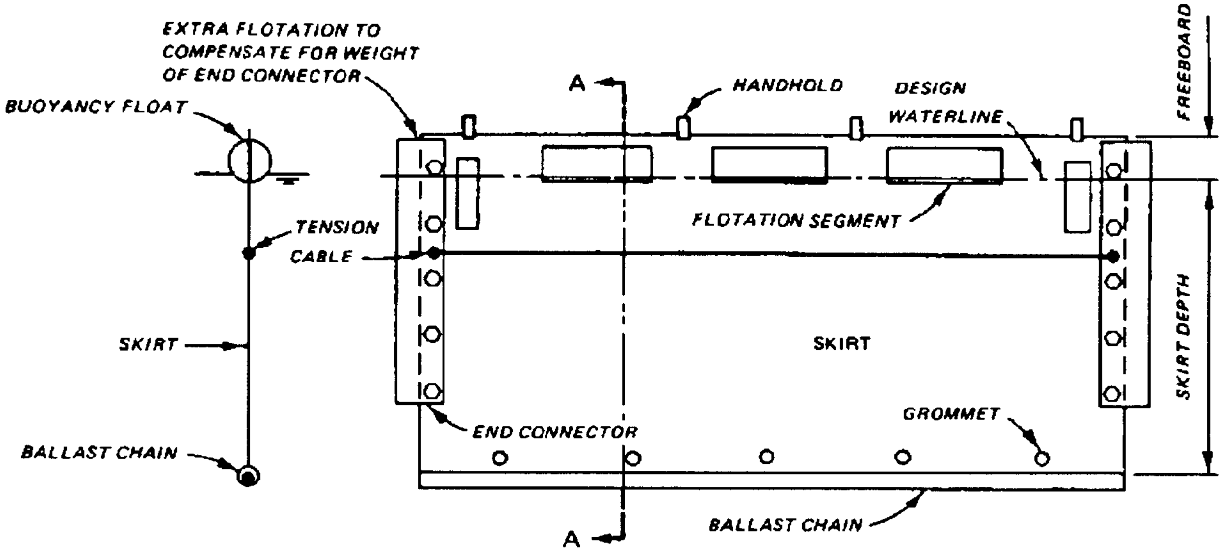


Figure 3-12. Construction of a Typical Center Tension Silt Curtain Section

nylon-reinforced polyvinyl chloride and manufactured in 27.4 m (90-foot) sections that can be joined together in the field to provide the specified length. Silt curtains are usually employed in U-shaped or circular configurations, as shown in Figure 3-13. Silt curtains are not recommended for flow velocities greater than 0.46 m/s (1.5 feet per second).

(5) Sheet-pile cofferdams are generally constructed of black steel sheeting, in thickness from 5.6 to 2.7 mm (5 to 12 gage) and in lengths from 1.2 to 12.2 m (4 to 40 feet). For additional corrosion protection, galvanized or aluminized coatings are available. Cofferdams may be either single walled or cellular, and can be earth-filled in sections. Single-wall cofferdams may be strengthened by an earth fill on both sides. Cellular cofferdams consist of circular sheet-pile cells filled with earth, generally a mixture of sand and clay. Single-wall sheet-pile cofferdams are most applicable for shallow water flows. For depths greater than 1.5 m (5 feet), cellular cofferdams are recommended.

(6) Mechanical excavation of dewatered, contaminated sediments can be accomplished with backhoes, draglines, or clamshells. Mechanical dredging output rates will vary depending on the size and mobility of the equipment, and on site-specific conditions such as available working area. Excavated sediments can be loaded directly into haul trucks onsite for transport to special disposal areas. Haul truck loading beds should be bottom sealed and covered with a tarpaulin or similar flexible cover to ensure that no sediments are lost during transport.

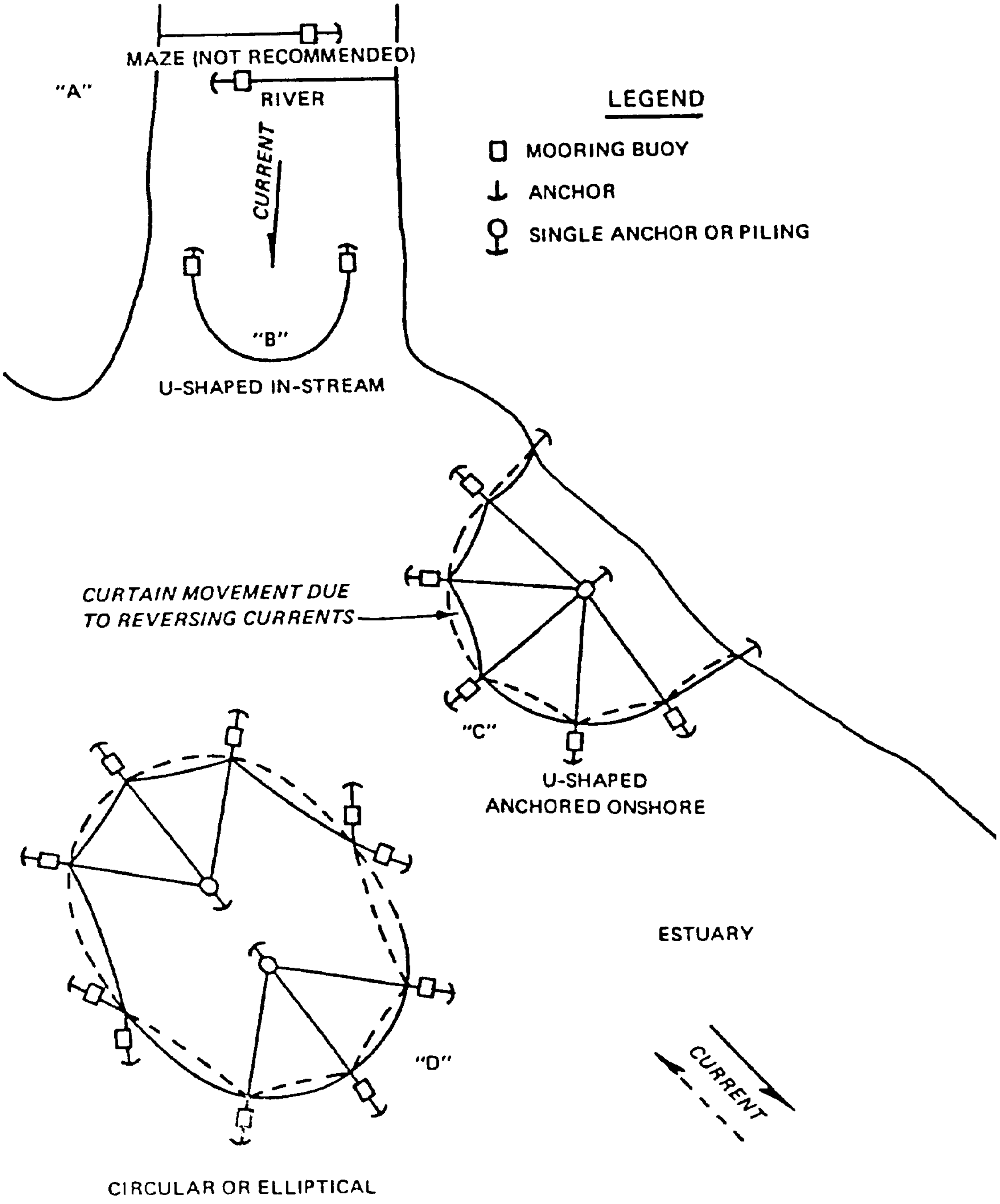


Figure 3-13. Typical Silt Curtain Deployment Configurations

d. Advantages and Disadvantages.

(1) The main disadvantage associated with hydraulic removal of materials from surface impoundments is the necessity of locating and/or constructing dewatering/disposal areas (or treatment facilities) within economical distances of the dredging site. Containment facilities must be able to handle large volumes of dredged material in a liquid slurry form, unless dewatering is performed prior to transport. Advantages and disadvantages of hydraulic dredging of surface impoundments are as follows:

Advantages	Disadvantages
Efficient removal of solids/water mixtures from impoundments	Necessitates locating dredge material management facilities (dewatering, disposal, treatment) nearby
Removes hazardous materials in readily processed form (slurry)	Necessitates high volume handling of solids/water mixtures
Suitable for removal of materials from surface impoundments in wide range of consistencies- -from free-flowing liquids to consolidated/ solidified sludges	May require booster pumps for long-distance transport of dredged slurries
Utilizes well-established, widely available technology	Mobilization and demobilization may be time-consuming and costly
	Cannot remove large items (such as drums)

(2) The advantages and disadvantages of direct instream mechanical dredging are listed below:

Advantages	Disadvantages
May be cost-effective for slow, shallow streams or sediments in dry streambeds or flood-plains	Generates excessive turbidity; may cause downstream transport of sediments
Also effective for small, isolated pools or ponds containing containmated sediments	Only feasible for low, shallow flows with stable streambanks and consolidated sediments
Barge-mounted operations may be used for large rivers	May require special dewatering methods (clamshell) lift and drain over haul (trucks)
	Efficiency of removal generally poor
	Generally not recommended for handling contaminated sediments instream

(3) Cofferdam diversion streamflow, with subsequent dewatering and mechanical excavation of contaminated sediments, is addressed below.

Advantages	Disadvantages
High efficiency of removal; low turbidity	May be quite costly for deep, wide flows and sites requiring diversion pipeline
Involves well-established construction techniques	Not feasible for fast stream flows (greater than 0.61 in/s (2 feet per second))
Structures easily removed and transported	Not recommended for flows deeper than 3 m (10 feet)
Cost-effective for slow-flowing streams and rivers with favorable access (stable banks; open areas)	Sediment dewatering may be required
	Access for mechanical excavation equipment may be difficult
	May require large excavation and loading area
	Transportation costs may be excessive (remote areas)
	Geologic substrate may prevent sheet-pile drive

3-10. Decontamination of Structures. Decontamination of structures is a common requirement at sites where the uncontrolled release of hazardous substances has occurred. A variety of techniques are available for decontamination surfaces and structures.

a. Decontamination of Surfaces.

(1) Absorption is widely used in industrial settings to clean up chemical and other liquid spills and is most applicable immediately following liquid contaminant spills. Contaminants rapidly penetrate most surfaces, and absorbents act to contain them. Depending on the surface and time elapsed since the spill, further decontamination procedures may have to be employed.

(2) Acid etching of a contaminated surface is used to promote corrosion and removal of the surface layer. Muriatic acid (hydrochloric acid) is used to remove dirt and grime from brick building surfaces in urban areas and to clean metal parts (e.g., pickle liquors from metal finishing operations). The resulting contaminated debris is then neutralized. Thermal or chemical treatment of the removed material may be required to destroy the contaminant before disposal. Although this technique is not known to have been applied to chemically contaminated building surfaces, it is believed to have good potential.

(3) Bleaching formulations (usually strong oxidants) are applied to a contaminated surface, allowed to react with contaminants, and removed. Application usually occurs in conjunction with other decontamination efforts, such as the use of absorbents and/or water-washing. Bleach has been used as a decontaminant against mustard, G and V chemical agents, and (experimentally) organophosphorus pesticides.

(4) Drilling and spalling can remove up to 5 centimeters of contaminated surface material from concrete or similar materials by drilling holes 2.5 to 4 centimeters in diameter approximately 7.5 centimeters deep. The spalling tool bit is inserted into the hole and hydraulically spreads to spall off the contaminated concrete. The technique can achieve deeper penetration (removal) of surfaces than other surface-removal techniques, and it is good for large-scale applications. The treated surface is very rough and coarse, however, and may require resurfacing (i.e., capping with concrete). The drilling and spalling method has been used in the decommissioning of nuclear facilities.

(5) Dusting/vacuuming/wiping is simply the physical removal of hazardous dust and particles from building and equipment surfaces by common cleaning techniques. Variations include vacuuming with a commercial or industrial-type vacuum; dusting off surfaces such as ledges, sills, pipes, etc., with a moist cloth or wipe; and brushing or sweeping up hazardous debris. Dusting and vacuuming are applicable to all types of particulate contaminants, including dioxin, lead, PCB*s, and asbestos fibers, and to all types of surfaces. Dusting/vacuuming/wiping is the state-of-the-art method for removing dioxin-contaminated dust from the interior of homes and buildings.

(6) Flaming refers to the application of controlled high temperature flames to contaminated noncombustible surfaces, providing complete and rapid destruction of all residues contacted. The flaming process has been used by the Army to destroy explosive and low-level radioactive contaminants on building surfaces. Its applicability to other contaminants is not well known. This surface decontamination technique is applicable to painted and unpainted concrete, cement, brick, and metals. Subsurface decontamination of building materials may be possible, but extensive damage to the material would probably result. This technique can involve high fuel costs.

(7) Fluorocarbon extraction of contaminants from building materials involves the pressure-spraying of a fluorocarbon solvent onto the contaminated surface followed by collection and purification of the solvent. RadKleen is an example of a commercial process that uses Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane or $C_2C1_3F_3$) as the solvent. The RadKleen process is currently used for cleaning radioactive material from various surfaces. It has been applied to chemical agents on small objects, and thus field capability has been demonstrated. Studies have been conducted for agent-contaminated clothing materials, such as polyester-cotton, Nomex, butyl rubber gloves, and charcoal-impregnated cloth. Although this method has not been demonstrated for removing contaminants from building surfaces, it looks very promising.

(8) Gritblasting is a removal technique in which abrasive materials (such as sand, alumina, steel pellets, or glass beads) are used for uniform removal of contaminated surfaces from a structure. Gritblasting has been used since 1870 to remove surface layers from metallic and ceramic objects and is currently used extensively. For example, sandblasting is commonly used to clean the surfaces of old brick and stone buildings. Gritblasting is applicable to all surface contaminants except some highly sensitive explosives such as lead azide and lead styphnate. This method is applicable to all surface materials except glass, transite, and Plexiglas.

(9) Hydroblasting/waterwashing refers to the use of a high-pressure (3500 to 350,000 kPa) water jet to remove contaminated debris from surfaces. The debris and water are then collected and thermally, physically, or chemically decontaminated. Hydroblasting has been used to remove explosives from projectiles, to decontaminate military vehicles, and to decontaminate nuclear facilities. Hydroblasting also has been employed commercially to clean bridges, buildings, heavy machinery, highways, ships, metal coatings, railroad cars, heat exchanger tubes, reactors, piping, etc. Off-the-shelf equipment is available from many manufacturers and distributors.

(10) Microbial degradation is a developing process whereby contaminants are biologically decomposed by microbes capable of utilizing the contaminant as a nutrient source. Conceptually, microbes are applied to the contaminated area in an aqueous medium and allowed to digest the contaminant over time; the microbes are then destroyed chemically or thermally and washed away. Microbial degradation as a building decontamination technique has not been demonstrated.

(11) Painting/coating/stripping includes the removal of old layers of paint containing high levels of toxic metals such as lead, the use of fixative/stabilizer paint coatings, and the use of adhesive-backed strippable coatings.

(a) In the first technique, paint containing lead in excess of 0.06 percent is removed from building surfaces by commercially available paint removers and/or physical means (scraping, scrubbing, waterwashing). Resurfacing or further decontamination efforts may be necessary.

(b) The second technique involves the use of various agents as coatings on contaminated surfaces to fix or stabilize the contaminant in place, thereby decreasing or eliminating exposure hazards. Potentially useful stabilizing agents include molten and solid waxes, carbo-waxes (polyoxyethylene glycol), saligenin (",2-dihydroxytoluene), organic dyes, epoxy paint films, and polyester resins. The stabilized contaminants can be left in place or removed later by a secondary treatment. In some cases, the stabilizer/fixative coating is applied in situ to desensitize a contaminant such as an explosive residue and prevent its reaction or ignition during some other phase of the decontamination process.

(c) In the third technique, the contaminated surface is coated with a polymeric mixture. As the coating polymerizes, the contaminant becomes entrained in the lattice of or attached to the polymer molecules. As the polymer layer is stripped or peeled off, the residue is removed with it. It may be possible, in some cases, to add chemicals to the mixture to inactivate the contaminants.

(12) Sealing is the application of a material such as paint that penetrates a porous surface and immobilizes contaminants in place. One example is K-20, a newly developed commercial product. The effectiveness of this product is not fully known. Although it acts more as a barrier than a detoxifier, K-20 may facilitate chemical degradation as well as physical separation of some contaminants.

(13) Photochemical degradation refers to the process of applying intense ultraviolet light to a contaminated surface for some period of time. Photodegradation of the contaminant follows. In recent years, attention has been focused on this method because of its usefulness in degrading chlorinated dioxins (TCDD in particular). Three conditions have been found to be essential for the process to proceed: the ability of the compound to absorb light energy, the availability of light at appropriate wavelengths and intensity, and the presence of a hydrogen donor.

(14) Scarification is a method that can be used to remove up to an inch of surface material from contaminated concrete or similar materials. The scarifier tool consists of pneumatically operated piston heads that strike the surface, causing concrete to chip off. This technique has been used in the decommissioning of nuclear facilities and in the cleanup of military arsenals.

(15) Solvent washing refers to the application of an organic solvent (e.g., acetone) to the surface of a building to solubilize contaminants. This technique has not yet achieved widespread use in building decontamination although it is beginning to be used in the decommissioning of nuclear facilities. The method needs further development in application, recovery, collection, and efficiency. The hot solvent soaking process has been shown to be effective in decontamination of PCB-contaminated transformers.

(16) Steam cleaning physically extracts contaminants from building walls and floors and from equipment. The steam is applied through hand-held wands or automated systems, and the condensate is collected in a sump or containment area for treatment. This method is currently used by explosives handling and manufacturing facilities. It has also been used to remove dioxin-contaminated soil from vehicles and drilling equipment.

b. Decontamination of Solid Materials and Buildings.

(1) Demolition of a building, structure, or piece of equipment includes complete burndown, controlled blasting, wrecking with balls or backhoe-mounted rams, rock splitting, sawing, drilling, and crushing. Many of these techniques have been employed for nuclear facility decontamination and for the cleanup of military arsenals.

(2) Dismantling refers to the physical removal of selected structures (such as contaminated pipes, tanks, and other process equipment) from buildings or other areas. It can be the sole decontamination activity (e.g.,

removal of contaminated structures from an otherwise clean building), or it can be used in the initial stage of a more complex building decontamination effort (e.g., removal of structures prior to flaming, hydroblasting, or other cleanup techniques).

(3) Asbestos abatement consists of four techniques: removal, encapsulation, enclosure, and special operations (e.g., maintenance and monitoring). In removal operations, all friable asbestos-containing building materials are completely removed to eliminate the release of asbestos fibers into the air. The other techniques leave the asbestos fibers in place but limit potential exposure levels through various treatment, maintenance, and inspection procedures.

(4) Encapsulation/enclosure physically separates contaminants or contaminated structures from building occupants and the ambient environment by means of a barrier. An encapsulating or enclosing physical barrier may take different forms; among them are plaster epoxy and concrete casts and walls. Acting as an impenetrable shield, a barrier keeps contaminants inside and away from clean areas, thereby alleviating the hazard. As a result, contamination of part of a structure will not result in the contamination of adjacent areas. Encapsulation has been used on damaged asbestos insulation, leaky PCB-contaminated electrical transformers, and open maintenance pits and sumps contaminated by heavy metals.

(5) Vapor-phase solvent extraction is a method in which an organic solvent with a relatively low boiling point (such as methyl chloride or acetone) is heated to vaporization and allowed to circulate in a contaminated piece of equipment or an enclosed area. The vapors permeate the contaminated materials, where they condense, solubilize contaminants, and diffuse outward. The contaminant-laden liquid solvent is collected in a sump and treated to allow recycling of the solvent. This method has not yet been applied to building decontamination, although it is believed to have good potential.

c. Data Requirements. Figure 3-14 summarizes the strategy for dealing with building decontamination, including guidance and information for selecting the least costly method that is technologically feasible and that will effectively reduce contamination to predetermined levels.

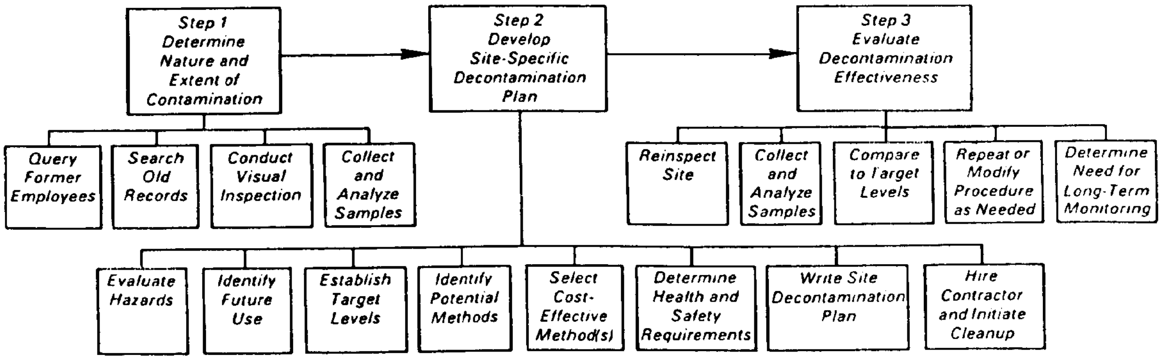


Figure 3-14. Flow Diagram for Developing a Structural Decontamination Strategy

(1) Sampling methods for determining the type and degree of contamination existing on building/structure/equipment surfaces, both before and after cleanup efforts, are poorly developed, documented, and verified. Similarly, subsurface sampling techniques (such as corings) or determining the depth of contamination in porous substances (such as concrete or wood floors) have not been adequately developed and documented. Although "wipe tests" are often referred to in site records, the actual methodology used is rarely described in enough detail to allow simulation or reproduction by others, and the technique itself is known to be inadequate for quantitatively transferring contaminants from surfaces to wipes or swabs.

(2) The applicability and effectiveness of decontamination techniques for treating various contaminant/structural material combinations encountered at Superfund sites have not been fully explored. For example, the degree to which steam cleaning removes dioxin-contaminated soil particles from drilling augers has not been established, even though this method is routinely used to clean equipment at dioxin-contaminated sites.

(3) The individual methods described above should be used as a general guide in evaluating the potential of each technique on a site-specific basis for efficiency, wastes generated, equipment and support facilities needed, time and safety requirements, structural effects, and costs. Also, each method or combination of methods should be pretested in the laboratory or at the site before full-scale implementation to determine the effectiveness of the strategy.

(4) A formal, systematic approach for determining acceptable levels of contaminants remaining in and on building and equipment surfaces does not currently exist. As a result, guidance on how clean is clean and the establishment of target levels must continue to be addressed case by case.

d. Design Criteria. There are no established design criteria for decontamination of structures. Specification of appropriate cleanup strategies depends highly on the professional judgment of the designer.

3-11. Decontamination of Miscellaneous Media. Sanitary sewers located downgradient from uncontrolled hazardous waste disposal sites may become contaminated by infiltration of leachate or polluted ground water through cracks, ruptures, or poorly sealed pipe joints. Typically the vitrified clay pipes (VCP) commonly used for gravity sewers are susceptible to cracking from root intrusion or settling. The interior cleaning of contaminated pipes will facilitate the location of cracks and joint failures which ultimately must be sealed to prevent further infiltration of contaminated soil and water. Available sewer-cleaning techniques include mechanical scouring, hydraulic scouring and flushing, bucket dredging, suction cleaning with pumps or vacuums, chemical absorption, or a combination of these methods. Manholes, flushing inlets, and unplugged residential service connections provide access points to sewers.

a. Mechanical Scouring. This is an effective method to remove pipeline obstacles such as roots, stones, greases, sludges, and corrosion modules.

Solidified masses of toxic chemical precipitates can also be removed by mechanical scouring. Mechanical scouring techniques include the use of power rodding machines ("snakes"), which pull or push scrapers, augers, or brushes through the sewer line. "Pigs" are bullet-shaped plastic balls lined with scouring strips that are hydraulically propelled at high velocity through water mains to scrape the interior pipe surface.

b. Hydraulic Scouring. Contaminated sewer lines can be cleaned by running high-pressure fire hoses through manholes into the sewer and flushing out sections. Hydraulic scouring is often used after mechanical scouring devices have cleared the line of solid debris or loosened contaminated sediments and sludges coating the interior surface of the pipe. When using hydraulic scouring techniques large volumes of contaminated water may be produced.

c. Bucket Dredging and Suction Cleaning. A bucket machine can be used to remove grit or contaminated soil from a sewer line. Power winches are set up over adjacent manholes with cable connections to both ends of the collection bucket. The bucket is then pulled through the sewer line until loaded with debris. The same technique can also be used to pull "sewer balls" or "porcupine scrapers" through obstructed sewer lines. Suction devices such as pumps or vacuum trucks may be used to clean sewer lines of toxic liquids and debris.

Section II. Contaminated Ground-Water Plume Management

3-12. Ground-Water Pumping Systems. Two common ground-water pumping systems use either wellpoints or extraction/injection wells.

3-13. Wellpoint Systems. Wellpoint systems are generally used to control ground-water levels or flow patterns at construction sites. They are inexpensive to install and use techniques and equipment that are readily available. Major disadvantages are the requirement for maintenance and the energy used for pumping.

a. Applications.

(1) Wellpoint systems may be used to lower the water table or to dewater a selected area. They consist of a series of wellpoints with one or more pumping systems and can serve a variety of purposes. The withdrawn water can be discharged with or without further treatment.

(2) These systems are generally used at sites with relatively shallow water tables and fairly permeable soils. In general, if the water table is near the surface and is to be lowered to a depth of 6.1 m (20 feet) or less, wellpoints and suction pumps can be employed. If deeper drawdown is needed, a well system using jet or submersible pumps or eductor wellpoints must be employed.