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## **Chapter 11**

# **Managing Industrial Wastes**

## **“Dumped in Marine Waters”**

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# Managing Industrial Wastes Dumped in Marine Waters

## INTRODUCTION

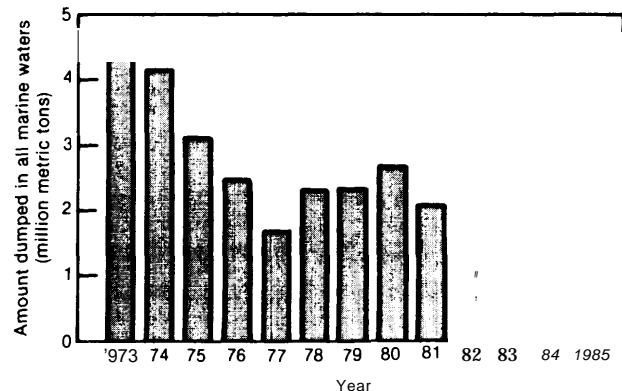
Marine disposal of industrial waste involves two primary modes of delivering wastes to marine waters. Dumping typically involves the use of barges to deliver industrial sludges and slurries directly to surface waters at designated marine dumping sites. In general, dumping of such wastes is not as significant in causing environmental impacts as are the far greater quantities of industrial waste directly *discharged* through pipelines or out falls into marine waters within a short distance of the coastline (ch. 8).

Marine dumping of industrial wastes has been greatly reduced in the United States in the last decade, with respect to both number of permittees and quantities of waste. Prior to 1973, over 300 firms used marine waters for dumping; by 1979 the number had fallen to 13 (6), and currently only 3 firms are dumping wastes in marine waters (139). The quantity of dumped industrial wastes has steadily declined from 4.6 million metric tons in 1973 to about 200,000 metric tons in 1985 (figure 36).

Numerous sites have been used by the United States for marine dumping of industrial wastes, but only three have received significant amounts since 1977. These sites, which are administered by EPA Region II, are: 1) the New York Bight Acid Waste Disposal Site, 2) Deepwater Industrial Waste Disposal Site, and 3) the Pharmaceutical Waste Site off Puerto Rico. Only the first two are in current use (see figure 3 in ch. 3), receiving waste from three firms (139). Use of the Puerto Rico site was discontinued in 1981 (594).

Industrial waste disposal planning involves considerable capital investment, and the decreasing availability of marine waters as a viable disposal option caused many firms to make long-term investments in land-based disposal or treatment options (140). However, some previously attractive land-based options are now subject to much stricter

Figure 36.—Quantities of Industrial Wastes Dumped in Marine Waters, 1973-85



SOURCES EG&G Washington Analytical Services Center, Inc., *Industrial Waste Disposal in Marine Environments*, contract prepared for U.S. Congress, Office of Technology Assessment (Waltham, MA: 1986); R. Schwer, E. I. du Pont de Nemours & Co., personal communication, November 1986; L. Mattioli, Allied Chemical, personal communication, December 1986; R. DeCesare, Office of Water, U.S. Environmental Protection Agency, personal communication, January 1987.

regulation and this may increase pressure to consider marine dumping. Indeed, for particular waste types in some regions of the country and for new generators, the marine option may be very attractive. It is difficult to predict the extent of future pressures to use marine environments for dumping or to gauge what effect a change in regulations might have on marine dumping.

This chapter discusses the marine dumping of drilling fluids, acid and alkaline wastes, pharmaceutical wastes, fish processing wastes, and coal ash and flue gas desulfurization (FGD) sludges.<sup>1</sup> For each waste type considered, the following topics are covered wherever data are available: waste composition; quantities generated and marine-disposed;

<sup>1</sup>Waste effluents and sludges resulting from the treatment of industrial process wastewaters prior to direct discharge into navigable waters or into sewerage systems are considered in ch. 8.

management and disposal practices currently used; the fate, availability, and impacts of waste constituents or contaminants; and the current regulatory framework. Table 28 provides a summary of cur-

rent management practices for the various wastes considered in this chapter. Table 29 summarizes the regulatory framework governing their marine disposal.

**Table 28.—Current Management Practices for Industrial Wastes**

Waste type	Drilling fluids	Acid/alkaline	Pharmaceuticals	Fish processing	Coal ash/sludge
Marine pipeline . . . . .	1 <sup>a</sup>		x	x	
Marine dumping . . . . .	2	3			
Land disposal <sup>b</sup> . . . . .	x	2			1
Land application . . . . .				x	
Physical, chemical, or biological treatment . . . . .		1	1	x	
Incineration . . . . .			x		
Recycling/reuse . . . . .				1	2

<sup>a</sup>Numbers indicate relative prevalence of use of an option; X indicates an option used to a lesser extent than the numbered options, but to an unknown extent relative to the other options.

<sup>b</sup>Land disposal includes landfilling, surface impoundment, and deep-well injection.

SOURCE: Office of Technology Assessment, 1987.

**Table 29.—Regulatory Framework for Marine Disposal of Industrial Wastes**

Waste type	Statute	Agency	Program or regulations
Drilling muds . . . . .	CWA	EPA	NPDES
	CWA	EPA	New Source Performance Standards
	Outer Continental Shelf (OCS) Lands Act	MMS	Ocs
Acid/alkaline . . . . .	MPRSA	EPA	Ocean dumping regulations
Pharmaceutical . . . . .	MPRSA (dumping)	EPA	Ocean dumping regulations
	CWA (pipeline)	EPA	NPDES
	CWA (sewer)	EPA	Pretreatment regulations
Fish processing . . . . .	MPRSA	EPA	Ocean dumping regulations
Coal ash/FGD sludge . . . . .	MPRSA	EPA	Ocean dumping regulations

KEY: CWA = Clean Water Act

MPRSA = Marine Protection, Research, and Sanctuaries Act

MMS = Minerals Management Service, U.S. Department of the Interior

SOURCE: Office of Technology Assessment, 1987

NPDES = National Pollutant Discharge Elimination System

FGD = flue gas desulfurization

## DRILLING FLUIDS

### Composition

The discharge of spent drilling fluids accompanies the exploration and development phases, but not the production phase, of offshore oil and gas activities. Hundreds of compounds are used in drilling fluids formulations, depending on the par-

ticular needs of each well. However, four materials account for over 90 percent of the mass of essentially all drilling fluids: barium sulfate (or barite), clays, lignosulfates, and lignites (50 FR 34592, Aug. 26, 1985).

Drilling fluids can be water- or oil-based. Water-based fluids are more commonly used for offshore operations, for both regulatory and technical reasons. EPA's chemical analysis of 8 generic water-based fluids detected no priority pollutant organic chemicals, but 10 priority pollutant metals were detected. In particular, mercury and cadmium were found in all formulations tested (50 FR 34592, Aug. 26, 1985; ref. 384).

Drilling fluids are one of several types of waste created by offshore drilling. Others include brine and sand brought up along with oil or gas; drill cuttings (the solids resulting from drilling); well treatment wastes (resulting from operations to enhance oil or gas recovery); and deck drainage and sanitary wastes. Most regulatory attention has focused on drilling fluids, and thus the discussion here is limited to this waste type. Although drilling fluids are often discharged through pipelines, the offshore location of such discharges justifies their consideration here with other dumping activities.

### ***Quantities of Waste Generated and Marine-Disposed***

About 2 million dry metric tons of drilling fluid components are used annually in offshore drilling activities and discharged directly into marine waters. About 3,900 offshore platforms currently produce oil and gas, accounting for roughly 20 percent of all domestic production (50 FR 34592, Aug. 26, 1985). Almost all (98 percent) such operations are located in the Gulf of Mexico, and over 90 percent of drilling fluid discharges occur there (384); however, increasing exploration in the waters of southern California and Alaska (the only other major sites for drilling fluid discharges) is expected to alter this distribution. EPA estimates that about 800 new platforms will be built between 1986 and 2000, a rate greatly reduced from that between 1972 to 1982, when an average of 1,100 new wells were drilled each year.

### ***Management and Disposal Practices***

Under existing regulations, used oil-based drilling fluids (or water-based fluids significantly contaminated with oil) are prohibited from marine discharge. Such fluids must be transported to land for disposal in a facility permitted under the Resource Recovery and Conservation Act or for reconditioning and reuse (40 CFR 435, Subpart A). In contrast, used *water-based* drilling fluids typically are dumped overboard or discharged from a pipe; both of these practices require a National Pollution Discharge Elimination System (NPDES) permit. Most coastal EPA Regions have prohibited direct offshore discharge near certain drilling sites because of ecological sensitivity at the sites (482). In addition, some State laws require land disposal for spent fluids generated in coastal waters (384). Using barges to transport used drilling fluids to shore or to distant ocean sites can be expensive and logistically difficult.

### ***Fate, Availability, and Impact of Waste Constituents***

In most areas on the continental shelf, the majority of particles present in drilling fluids and cuttings settle rapidly to the seabed, generally within 1,000 meters of the point of discharge (384).

Further dispersion may occur because of bottom currents or tidal action. A plume of particles, however, remains in suspension and is subject to relatively more rapid dispersion and dilution.

The main environmental concerns related to marine disposal of drilling fluids include potential toxicity of various chemical additives or trace metals, increased turbidity in the water column, physical burial of benthic organisms or alteration of physical substrates available to these organisms, and possible long-term accumulation of metals in sediments and marine organisms. The primary acute effects appear to be physical and limited to the benthic environment.

Evidence indicates that most water-based drilling fluids are relatively nontoxic to marine organisms at the concentrations that are achieved shortly after discharge (384). For those fluids exhibiting significant toxicity, it appears to be primarily attributable to the presence of diesel fuel, which can comprise as much as 2 to 4 percent of the total volume.

While most research has focused on acute effects, the concentrations of potentially toxic constituents present at most sites are in a range that is more likely to induce chronic or sublethal effects. Data are limited on such impacts, however, so considerable uncertainty remains regarding the long-term environmental impacts associated with marine disposal of drilling fluids.

### ***Regulatory Framework***

The principal authority to regulate marine disposal of drilling discharges lies with EPA, through the NPDES program of the Clean Water Act (Section 402). Such discharges are subject to the 'best practicable control technology' (BPT) and 'best available technology' (BAT) limitations of the Clean Water Act (ch. 7). Offshore oil and gas operations do not receive individual NPDES permits and instead are covered by a general NPDES permit (ch. 8), unless a facility requests its own permit. Prior to issuance of an individual NPDES permit, EPA must determine that the discharges will not unreasonably degrade the marine environment, in compliance with the Ocean Discharge Criteria of the Clean Water Act (40 CFR 125, Subpart M).

Using this regulatory authority, EPA has imposed a variety of permit conditions, including: limits on the amount of toxic substances or total hydrocarbons in drilling fluids, requirements to conduct toxicity testing of drilling fluid formulations prior to use, seasonal or zonal restrictions on discharges, and special monitoring and reporting requirements (482).

EPA recently proposed BAT effluent limitation guidelines and new source performance standards for offshore oil and gas facilities (50 FR 34592, Aug. 26, 1985). In addition to maintaining the prohibitions against the discharge of oil-based drilling fluids and water-based fluids containing oil, EPA proposed two further controls: a limit on the acute toxicity of drilling fluid discharges and a limit on the discharge of cadmium and mercury to a maximum of 1 part per million (ppm).

A recently renewed general permit covering drilling operations in the Gulf of Mexico (51 FR

24897, July 9, 1986) incorporates the proposed BAT limits, but not the proposed limit for mercury and cadmium. General permits incorporating the BAT limits on these two metals have been issued for Alaska (51 FR 35460, Oct. 3, 1986) and proposed for southern California (50 FR 34036, Aug. 22, 1985).

The Minerals Management Service of the Department of the Interior regulates drilling discharges through lease stipulations and Outer Continental Shelf operating orders, some of which prohibit the use of certain additives. In addition, individual States may impose further requirements on drilling discharges for operations taking place in their territorial waters.

While drilling fluids are not classified as hazardous, their disposal on land is regulated under the solid waste provisions of RCRA.

## ACID AND ALKALINE WASTES

### *Quantities of Waste Generated*

Most liquid acid and alkaline wastes are classified generically as corrosive wastes, a RCRA category that also includes sludges and solids. Corrosive wastes comprise almost half of the total hazardous waste generated in the United States (140,690), but it is not known what fraction of these are relatively uncontaminated acids and alkalis with potential for marine disposal.

### *Management and Disposal Practices*

Most corrosive wastes are disposed or treated on-site, using methods such as deep-well injection and neutralization. Only 1 to 2 percent of corrosive wastes are disposed off-site (140), including the acid and alkaline wastes that are currently dumped in marine waters. When disposed of in marine waters, these wastes are barged to the disposal site and then dumped in bulk at a permitted rate into the wake of the vessel.

### *Composition and Quantities of Waste Disposed of in Marine Waters*

Acid and alkaline wastes from three industrial firms are presently dumped in marine waters (table 30).<sup>3</sup> Under current permit schedules, about 200,000 metric tons from Allied Chemical, DuPont-Edge Moor, and DuPont-Grasselli will continue to be dumped annually after 1986 (139).

Quantities of waste dumped at the New York Bight Acid Waste Site by Allied Chemical have decreased from a high of 60,000 metric tons in 1973 to the current level of about 40,000 metric tons annually; no change is anticipated in the amount of waste to be dumped during the next several years (L. Mattioli, Allied Chemical, pers. comm., Dec. 1986). The current permit expires September 30, 1988; application for renewal of the permit is due

<sup>3</sup>Unless otherwise noted the following discussion is based on material from references 139 and 140.

**Table 30.—Origin and Quantities of Acid and Alkaline Wastes Currently Dumped in Marine Waters**

Company	Type of waste/process	Composition	Dumpsite	Annual quantity <sup>a</sup>
Allied Chemical	Hydrochloric acid from fluorocarbon refrigerants and polymer manufacturing	About 300/0 HCl 1 to 2.5% fluoride Suspended solids and total organic carbon in 10s ppm range Petroleum hydrocarbons in 1-10 ppm range Chromium, nickel, zinc in <0.1 to 3 ppm range Arsenic, cadmium, copper, lead, mercury in <0.01 to 1 ppm range pH <1.0	New York Bight Acid Waste Site	30,000 mt
Du Pont-Edge Moor	Iron and other acidic metal chlorides from titanium dioxide production	Chromium in 100s ppm range Zinc and lead in 10s ppm range Copper and nickel in 1-10 ppm range Cadmium in 0.001 ppm range pH 0.1 to 1.0	Deepwater Industrial Waste Site	s 50,000 mt
Du Pont-Grasselli	Sodium sulfate from agricultural chemical production	10% sodium sulfate Low molecular weight organics in 10s-1000s ppm range Chromium, copper, nickel, lead in 0.01 to 0.1 ppm range Cadmium in 0.001 ppm range pH 10 to 12.5	Deepwater Industrial Waste Site	110,000 mt

<sup>a</sup>Based on present permit limits.<sup>b</sup>The fluorocarbon polymer manufacturing facility was recently sold to Ausimont U. S. A., Inc. (L. Mattioli, Allied Chemical, personal communication, December 1986).SOURCES: R. Schwer, E.I. du Pont de Nemours & Co., personal communication, November 1986; L. Mattioli, Allied Chemical, personal communication, December 1986; and EG&G Washington Analytical Services Center, Inc., *Industrial Waste Disposal in Marine Environments*, prepared for U.S. Congress, Office of Technology Assessment (Waltham, MA: 1986).

by April 3, 1988. The only alternative to marine disposal currently being used is to sell the waste for use as hydrochloric acid; about 10 percent of the waste was sold in 1984 and about 6 percent was sold in 1985 (L. Mattioli, Allied Chemical, pers. comm., Dec. 1986).

DuPont-Edge Moor has dumped acid wastes at the Deepwater Industrial Waste Site since 1968. Since 1973, its permits have contained provisions for the cessation of ocean dumping and the development of feasible alternatives. By 1984, such changes had reduced ocean dumping by 70 percent, to less than 115,000 wet metric tons. The current permit expires June 30, 1987, but it can be renewed provided that, despite good-faith efforts, DuPont-Edge Moor has been unable to develop sufficient land-based alternatives to completely replace marine disposal; an application for a new 3-year permit is being submitted on this basis (R. Schwer, E.I. du Pont de Nemours & Co., pers. comm., Nov., 1986).

DuPont-Grasselli has dumped alkaline wastes from 1968 to 1973 at the New York Bight Acid Waste Site and from 1968 to the present at the Deepwater Industrial Waste Site. Between 1973 and 1983, amounts dumped ranged from 118,000 to 290,000 wet metric tons per year. The last permit, valid through the end of 1986, required the development of alternative treatment methods, but contained no deadline for halting dumping.

### ***Fate, Availability, and Impact of Waste Constituents***

The rationale for allowing marine disposal of acid and alkaline wastes is that they rapidly (within 1 to 4 hours) neutralize after coming into contact with seawater, which has a high natural buffering capacity (157). In addition, discharge into the turbulent wake of the vessel provides rapid mixing and a several thousand-fold dilution. Acute impacts due to transient changes in acidity may occur prior to

neutralization. Such effects, however, would generally be limited to the immediate vicinity of the discharge, and past monitoring has not detected any observable effects on marine life (83, 157). Trace pollutants, primarily toxic metals, may pose longer term risks, although such pollutants are generally rapidly and extensively diluted under typical disposal conditions. Some metals (primarily iron and magnesium) precipitate upon entering marine waters and can remain in suspension for several days or more.

### ***Regulatory Framework***

Most acid and alkaline wastes are generically classified under RCRA as hazardous due to their corrosivity. However, wastewater treatment sludges from the DuPont-Edge Moor facility, which are

usually disposed of by landfilling or ocean dumping, have been delisted and excluded from regulation as a hazardous waste (45 FR 72037, Oct. 30, 1980), and wastewater from the DuPont-Grasselli facility is not considered hazardous because it does not exceed the upper pH limit specified for corrosivity by RCRA (R. Schwer, E.I. du Pont de Nemours & Co., pers. comm., Nov. 1986). In all cases, however, dumping of acid and alkaline wastes in marine waters is allowed only after a case-by-case determination of compliance with the Ocean Dumping Criteria of the Marine Protection, Research, and Sanctuaries Act (MPRSA). Permits issued by EPA under authority of MPRSA do not contain requirements for specific treatment of acid and alkaline wastes that are to be dumped; rather they require that dilution to background levels be achieved in a specified length of time.

## **PHARMACEUTICAL WASTES**

### ***Composition***

Pharmaceutical wastes originate from the biological production of antibiotics and the chemical production of pharmaceuticals. They are typically aqueous suspensions near neutral pH; have densities similar to seawater; and contain about 1 percent suspended solids, 2 percent organic carbon, and very low (<1 ppm) levels of metals or high molecular weight organochlorines (relative to other industrial wastes). However, they can contain high concentrations (10 to 100 ppm) of any of several common industrial solvents (139,594).

### ***Management and Disposal Practices***

Most U.S. pharmaceutical companies responded to EPA regulations by investing in land-based disposal, including onsite incineration and secondary wastewater treatment (e. g., anaerobic digestion, activated sludge treatment). Marine dumping generally is only attractive to those pharmaceutical companies not yet having secondary treatment (138).

### ***Quantities of Waste Marine-Disposed***

Seven pharmaceutical companies in Puerto Rico dumped pharmaceutical wastes at the designated Pharmaceutical Waste Site (74 km north of Puerto

Rico) from at least 1973 until 1981. The amounts dumped increased from 38,000 wet metric tons in 1973 to over 300,000 metric tons in the late 1970s and early 1980s (594).

Because of lower disposal costs and EPA mandates, these wastes are now discharged into a secondary sewage treatment plant completed at Barceloneta in 1981 (Black and Veatch, cited in ref. 594). Almost half of the wastewater entering the plant is pharmaceutical wastes. Effluent from the plant is not disinfected and is discharged through a pipeline 800 meters offshore, in waters less than 30 meters deep (208). The volume of pharmaceutical wastes entering the plant is about fourfold higher than that previously marine dumped, but is about tenfold less concentrated in suspended solids, organic carbon, and nitrogen (594).

### ***Fate, Availability, and Impact of Waste Constituents***

The dispersive high-energy conditions at the Puerto Rico dumpsite diluted dumped wastes by a factor of up to 100,000-fold soon after dumping and by a factor of about 10,000,000-fold over a long-term period (594). However, one clearly demonstrated change at the dumpsite was the almost complete replacement, within 7 years after disposal



began, of resident bacteria with other bacterial species (including several human pathogens—e. g., *Salmonella* and *Vibrio*) (207). Some experts attribute the change to a selection for the other species able to degrade particular pharmaceutical waste components, but this conclusion has been questioned (594). Shifts also occurred in the composition and size of the phytoplankton community in the vicinity of the dumpsite (594).

Other potentially more serious impacts have been attributed to the discharge of pharmaceutical wastes into the Barceloneta secondary treatment plant. These include frequent disruption of the treatment process, reduced removal of bacterial pathogens prior to effluent discharge, and significantly elevated levels of fecal bacteria (including human pathogens) in coastal waters (208). Because discharge

now occurs close to shore in shallow waters, concerns have been raised that human health impacts under the current disposal system may be greater than those associated with the previous ocean dumping of untreated pharmaceutical waste. In particular, currents and wave action in the area of discharge have been demonstrated to carry waste constituents back to shore (208,594).

### ***Regulatory Framework***

Dumping of pharmaceutical wastes at the Puerto Rico dumpsite was regulated under the Ocean Dumping Criteria of MPRSA. The present discharge of effluent from the Barceloneta treatment plant is regulated under an NPDES permit.

## **FISH PROCESSING WASTES**

### ***Composition and Quantities of Waste Generated***

These wastes arise from the processing of seafood for a variety of products.<sup>4</sup> The large tuna and fishmeal industries engage in year-round operations; most other food waste generators are small, seasonal, specialized facilities. Prior to treatment, these wastes are composed entirely of organic matter and “conventional” pollutants: oil, grease, and solids (139). In 1980, 1.4 to 2.0 million metric tons of seafood processing material was produced, an increase of 35 to 41 percent since 1970 (138).

### ***Management and Disposal Practices***

Most seafood processing material is converted to marketable meal and fertilizer or is recycled (140). The remaining waste can be treated prior to NPDES-permitted discharge, or directly disposed of by landfiling, land application, or marine dumping. Data on the relative use of these options are not available.

Primary treatment using dissolved air flotation (DAF) systems is typically employed by large proc-

essing facilities (140). These systems use coagulant to remove solids from wastewater, thereby generating DAF sludges which are not exempt from ocean dumping regulations. The small quantity of DAF sludge currently generated is disposed of in landfills.

EPA is considering requiring DAF systems for virtually all seafood processing waste generators. If applied throughout the industry, about 2000 metric tons of DAF sludge would be produced annually (140).

### ***Quantities of Waste Marine-Disposed***

The only site designated for dumping of fish processing wastes is in the Pacific Ocean near American Samoa (45 FR 77435, Nov. 24, 1980; ref. 86). This interim site, which is administered by EPA Region IX, was approved for up to 118,000 wet metric tons per year and for a period of 3 years, pending completion of further studies. Actual quantities of waste dumped at the site were 17,000 wet metric tons in 1982 and 19,500 wet metric tons in 1983 (648).

Region IX expects an increase in requests to dump seafood processing wastes in marine waters, primarily DAF treatment sludge from tuna canneries (140). EPA has proposed to designate a dump-

<sup>4</sup>These wastes are distinguished from unprocessed wastes arising from seafood cleaning, which are exempted from ocean dumping regulations (40 CFR 220.1(c)(1)).

site in the Southern California Bight for cannery wastes generated by Star-Kist Foods, Inc. (102).

### ***Fate, Availability, and Impact of Waste Constituents***

Disposal of these wastes in poorly mixed or relatively enclosed coastal marine environments could

cause nutrient overloading. Proper disposal in well-mixed ocean environments appears to be essentially nonhazardous, although some concerns have been raised over potential impacts of the chemical coagulants introduced during DAF treatment (140).

## **COAL ASH AND FLUE GAS DESULFURIZATION SLUDGES**

### ***Composition***

**Coal** ash is the incombustible, inorganic, or mineral fraction of coal remaining after its combustion in industrial and public-owned boilers. It includes fly ash captured by stack scrubbers and bottom ash/slag that is left behind in the boiler. FGD sludges are produced when sulfur-containing flue gases react with air pollution control scrubber reagents (usually calcium carbonate or limestone).

The chemical composition of coal ash varies considerably with the type of coal from which it is derived (288). Primary constituents include the salts and oxides of silicon, aluminum, iron, calcium, magnesium, sodium, potassium, titanium, and sulfur. Other significant trace (<1 percent) constituents include barium, strontium, manganese, and boron. Coal ash leachate has a pH between 6 to 11.5. The composition and quantity of FGD sludge depends on the type of air pollution controls that are employed. It typically contains 5 to 15 percent solids initially and 30 to 80 percent solids after dewatering, and has a pH of 3 to 13 (139,141). Primary components are calcium sulfites, sulfates, and carbonate; major trace elements include barium, boron, copper, fluorine, manganese, molybdenum, nickel, and zinc (288).

Currently, coal ash and FGD sludge from electric utilities are characterized as nonhazardous under RCRA (40 CFR 261.4(b)(4)). However, EPA has proposed new procedures for testing the toxicity of leachates from wastes, which could lead to the classification of some utility wastes as hazardous. The original exemption of such wastes from regulation as hazardous wastes was intended to allow EPA to complete environmental impact studies and determine a course of action (141).

### ***Quantities of Waste Generated***

Estimates of the amount of coal ash and FGD sludge generated annually in the United States vary considerably, but they are clearly very high-volume wastes that will continue to increase in quantity at least through the end of this century (table 31). Coal-burning utilities are estimated to produce about 95 percent of total utility ash; the remainder arises from burning of other fossil fuels.<sup>5</sup> Rapid increases in the generation of these wastes are occurring, due to wider application and greater efficiency of sulfur dioxide removal technology, as well as increased coal consumption.<sup>6</sup>

The East Coast States, from Pennsylvania south, and the Gulf States of Florida, Alabama, and Louisiana, are the major sources of utility coal ash and FGD sludge. These States are also expected to exhibit the largest increase in waste generation through 2000 (141; Tobin, 1982, cited in ref. 140).

### ***Management and Disposal Practices<sup>7</sup>***

Most utility coal waste is presently disposed of onsite, in unlined landfills and impoundments (table 31); however, the use of unlined impoundments is declining because of concerns about ground-

<sup>5</sup>Nonutility industries generate much larger quantities of air pollution control dusts and sludges (257). Many of these are listed as hazardous under RCRA, however, and have not been discussed as candidates for dumping. Nonutility boilers generate an additional 8 million metric tons of coal wastes (257), similar in composition to that generated by utilities.

<sup>6</sup>Fly ash and FGD sludge together constitute 5 to 15 percent of the mass of coal from which they are generated. A typical, 1000-megawatt plant will consume 2.4 million metric tons of coal annually, and generate about 650,000 metric tons of ash and sludge (131).

<sup>7</sup>This discussion is limited to practices used for utility coal waste. Data on the disposition of coal wastes from nonutility industrial boilers are scant (257).

**Table 31.—Quantities and Current Management of Utility Coal Ash and FGD Sludge**

	Coal ash	FGD sludge	Reference <sup>a</sup>
Annual quantities: <sup>b</sup>			
1985 .....	85 mmt	18 mmt	USWAG, 1982; EG&G, 1986
2000 .....	155 mmt	52 mmt	
<b>Current management practices</b>			
Percent disposed onsite .....	75°/0	820/o	JRB, 1983
Percent disposed off site. ....	16°/0	180/0	
Percent sold .....	9°/0	—	EG&G, 1983; EPRI, 1985
Percent in landfills .....	40°/0	300/0	
Percent in wet ponds .....	39°/0	670/o	
Percent in mines .....	—	2 %	
Percent used commercially . . . .	21 %	<1 °/0	

<sup>a</sup>See list of references at end of report.<sup>b</sup>Quantities are in million metric tons (wet weight)

SOURCE Office of Technology Assessment, 1987

water contamination and land reclamation (141 ). These wastes are distinguished from unprocessed wastes arising from seafood cleaning, which are exempted from ocean dumping regulations (40 CFR 220.1(c)(l)).

Some 10 to 20 percent of utility coal wastes are currently recycled or reused in cement manufacture, building materials, road surfacing, sand blasting, roofing, and ice and snow control. While recycling and reuse will increase somewhat, it is not expected to keep up with increases in waste generation. By the year 2000, only an estimated 16 percent of utility coal ash and a much smaller fraction of FGD sludge will be recycled or reused (680). Thus, the vast majority of coal wastes will continue to require disposal.

In contrast to present practices, most future disposal—at least 80 percent—is expected to take place offsite because of insufficient onsite disposal capacity (Tobin, 1982, cited in ref. 140).

### **Potential for Marine Disposal**

**No** coal ash or FGD sludge is currently disposed of in marine waters, except for research purposes. However, with land for disposal becoming increasingly scarce, and with accelerating coal conversion taking place in New England, the use of the ocean for such disposal has recently received attention: in particular, ConEdison of New York has requested permission to dump fly ash at the 106-mile deepwater dumpsite (488). In the absence of regulatory restrictions on the ocean disposal of coal ash, over one-fourth of the total ash generated in the

coastal regions (representing over one-tenth of the national total) might be economically disposed of in the ocean by 2000. Estimates for FGD sludge are even higher: about 40 percent of all the FGD sludge generated in coastal regions in 2000, representing over one-fourth of the national total ( 140). Estimated costs for ocean disposal are about \$5 per metric ton, compared to about \$16 per metric ton for landfilling (1982 dollars),<sup>8</sup>

Utility coal ash has been dumped in marine waters for many years by the United Kingdom (131 ,401). In the United States, two research projects involving dumping of consolidated coal ash in the New York Bight have been conducted (131), and it is possible that coal-waste blocks could be used to construct artificial reefs in both marine and freshwater environments (131 ,213).

### **Fate, Availability, and Impact of Waste Constituents**

The principal problems associated with marine disposal of untreated coal ash or FGD sludge include dissolved oxygen depletion, increased turbidity, sulfite toxicity to marine organisms, smothering of benthic organisms, and release of metals. These concerns particularly limit the potential for disposing of FGD wastes in marine waters (131).

A promising potential option to address these problems involves the consolidation of a mixture

<sup>8</sup>This estimate, derived by ConEdison, includes tug and barge leasing and monitoring costs, and assumes that at least 500,000 metric tons per year are disposed at the Deepwater Industrial Waste Disposal Site (140).

of FGD sludge, fly ash, and lime into solid forms (433). The resulting material exhibits significantly decreased release rates for sulfite and metals, and resulting leachates show reduced toxicity to marine organisms. The consolidated material maintains

structural integrity over periods of years in the marine environment, and may therefore be an appropriate material for building artificial reefs to provide substrates for colonization by marine organisms and enhance fisheries.

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# Appendixes



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 Florida Institute of Technology  
 Jay Grimes, University of Maryland  
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 Willis Pequegnat  
 Resources For the Future  
 Science and Public Policy Program, University of Oklahoma  
 Science Applications International Corp.

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### ***Reviewers and Other Contributors***

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Talibah Adisa, Dade County Department of Environmental Resources Management  
 Ken Adler, Environmental Protection Agency  
 Lorenzo Alonzo, Houston Public Works Department  
 Blake Anderson, County Sanitation Districts of Orange County  
 Vyto Andreliunas, Corps of Engineers New England Division  
 Forest Arnold, National Oceanic and Atmospheric Administration  
 Judith Ayres, Environmental Protection Agency Region IX  
 James Bajek, Corps of Engineers New England Division  
 Dru Barrineau, Corps of Engineers Mobile District  
 Dan Basta, National Oceanic and Atmospheric Administration

Bob Bastian, Environmental Protection Agency  
 Warren Baxter, Corps of Engineers Seattle District  
 Ed Bender, Environmental Protection Agency  
 D. W. Bennett, American Littoral Society  
 Harvey Beverly, Corps of Engineers Los Angeles District  
 Rosina Bierbaum, Office of Technology Assessment  
 Allen Blume, Center for Environmental Education  
 Donald Boesch, Louisiana Universities Marine Consortium  
 Suzanne Bolton, Battelle Columbus Laboratories  
 Charles Bookman, National Academy of Sciences  
 James Borberg, Hampton Roads Sanitation District  
 Robert Borchardt, Houston Public Works Division  
 David Brailley, Environmental Defense Fund  
 William Brandt, Dade County Department of Environmental Resources Management  
 N. H. Brooks, California Institute of Technology  
 David Brown, Southern California Coastal Water Research Project  
 Robert Burd, Environmental Protection Agency Region X  
 Jack Campbell, South Dade Soil and Water Conservation District  
 Judy Capuzzo, Woods Hole Oceanographic Institution  
 Charles Carry, Sanitation Districts of Los Angeles County  
 Mike Champ, Science Applications International Corp.  
 Frank Covington, Environmental Protection Agency Region IX  
 Jerome Cura, Goldberg-Zoino & Associates, Inc.  
 Clif Curtis, The Oceanic Society  
 Phil Dagatano, New York State Department of Environmental Conservation  
 Tudor Davies, Environmental Protection Agency  
 Jack Davis, Gulf Coast Waste Disposal Authority  
 Ron DeCesare, Environmental Protection Agency  
 Stephen C. Delaney, Environmental Protection Agency  
 D.A. Dennis, Corps of Engineers Sacramento District  
 Harriet Diamond, Massachusetts Coastal Zone Management  
 Iver Duedall, Florida Institute of Technology  
 Al Dufour, Environmental Protection Agency  
 Robert Dyer, Environmental Protection Agency  
 Charles Ehler, National Oceanic and Atmospheric Administration

Robert Engler, Waterways Experiment Station  
 Dan Farrow, National Oceanic and Atmospheric Administration  
 Robert Fergen, Miami-Dade Water and Sewer Authority  
 David Fierra, Environmental Protection Agency Region I  
 Larry Fink, Environmental Protection Agency Region V  
 David Fluharty, University of Washington  
 Rod Frederick, Environmental Protection Agency  
 Jim Gallup, Environmental Protection Agency  
 Charles Ganze, Gulf Coast Waste Disposal Authority  
 William Garber, Management Consultant  
 Mary Jo Garreis, Maryland Department of Health and Mental Hygiene  
 Jack Gentile, Environmental Protection Agency  
 Roger Certh, Corps of Engineers Mobile District  
 Leonard Gianessi, Resources For the Future  
 Tim Goodger, National Marine Fisheries Service  
 Court Greenfield, Soil Conservation Service  
 Henry Gregory, Houston Public Works Department  
 Jay Grimes, University of Maryland  
 Philip Gschwend, Massachusetts Institute of Technology  
 LeeAnn Hammer, Environmental Protection Agency  
 Mary Hamrick, Science Applications International Corp.  
 Rixie Hardy, Corps of Engineers New Orleans District  
 Nan Harllee, Maritime Administration  
 Jakc Harari, Corps of Engineers San Francisco District  
 Fred Harper, Management Consultant  
 Irwin Haydock, Sanitation Districts of Los Angeles County  
 Thomas Healey, Philadelphia Water Department  
 Doug Hilderbrand, Seattle METRO  
 Charles Hollister, Woods Hole Oceanographic Institution  
 John Hoornbeek, Environmental Protection Agency  
 Mercedes Hsu, California Regional Water Quality Control Board  
 Fran Irwin, Conservation Foundation  
 Robert Johns, Dade County Department of Environmental Resources Management  
 Dennis Johnson, Agency for International Development  
 Peter Johnson, Office of Technology Assessment  
 Galen Jones, University of New Hampshire  
 David Kern, Corps of Engineers Pacific Ocean Division  
 Ken Kirk, Association of Metropolitan Sewerage Agencies

Jay Kremer, Sanitation Districts of Los Angeles County  
 Braxton Kyzer, Corps of Enginet'rs Charleston District  
 William Lahey, Palmer & Dodge  
 John Lampe, Seattle METRO  
 Ron Landy, National Oceanic and Atmospheric Administration  
 Dick Lee, Waterways Experiment Station  
 Tom Leschine, University of Washington  
 Leonard Levine, Gulf Coast Waste Disposal Author-it y  
 David Lim, Environmental Protection Agency Region I  
 Steve Lipman, Massachusetts Department of Environmental Quality Engineering  
 Carol Litchfield, E. I. du Pent de Nemours & Co., Inc.  
 John Lyon, Environmental Protection Agency  
 David Lyons, Environmental Protection Agency  
 Peter Machno, Seattle METRO  
 Gary Magnuson, Coastal States Organization  
 Donald Malins, National Marine Fisheries Service  
 Samual Maloof, Management Consultant  
 Bruce Mannheim, Environmental Defense Fund  
 Deborah Martin, Environmental Protection Agency  
 Dave Mathis, Corps of Engineers  
 Leon Mattioli, Allied Chemical Corp.  
 Gordon McFeters, Montana State University  
 Jeffrey McKee, Corps of Engineers Baltimore District  
 John McKern, Corps of Engineers Walla Walla District  
 Terrence McKiernan, Corps of Engineers North Pacific Division  
 Alan Mearns, National Oceanic and Atmospheric Administration  
 Richard Medina, Corps of Engineers Galveston District  
 Bob Miele, Sanitation Districts of Los Angeles County  
 Kathy Minsch, Environmental Protection Agency  
 Ralph Mitchell, Harvard University  
 Robert Mitchell, Resources For the Future  
 Joe Moran, Environmental Protection Agency  
 Robert Morton, Science Applications Inter-national Corp.,  
 Donald Mount, Environmental Protection Agency  
 William Murden, Corps of Engineers  
 Leonard Nash, Environmental Protection Agency Region III  
 Joel O'Connor, National Oceanic and Atmospheric Administration  
 Tom O'Connor, National Oceanic and Atmospheric Administration  
 Tom O'Farrell, Environmental Protection Agency



Linda O'Lear), Port Authority; of New York  
Robert Ottesen, Corps of Engineers Jacksonville  
District

Henry Peskin, Resources For the Future  
Carolyn Smith Pravlik, Terris & Sunderland  
Andrew Robertson, National Oceanic and  
Atmospheric Administration

Robert Robichaud, Environmental Protection  
Agency Region X

Gilbert Rowe, Brookhaven National Laboratory  
Marvin Rubin, Environmental Protection Agency  
Thomas Schine, Corps of Engineers Philadelphia  
District

Lewis Schinazi, (California Regional Water Quality)  
Control Board

Moir Schoen, Environmental Protection Agency  
Doug Segar, Aquatic Habitat Institute

Frank Senske, Philadelphia Water Department  
Peter Shelley, Conservation Law Foundation

Diane Sheridan, League of Women Voters of Texas  
Keith Silva, Environmental Protection Agency  
Region IX

Jerome Simpson, Corps of Engineers Portland  
District

Carl Sindermann, University of Miami

Kirvil Skinnarland, Puget Sound Water Quality  
Authority

John Spencer, Seattle METRO

Elisa Speranza, Massachusetts Water Resources  
Authority

Frank Steimle, National Oceanic and Atmospheric  
Administration

William Stelle, Jr., House Committee on Merchant  
Marine and Fisheries

Harold Stevenson, McNeese State University

Frank Sweeney, Science Applications International  
Corp.

Fern Summer, Water & Wastewater Equipment  
Manufacturers Association

Dennis Suszkowski, Environmental Protection  
Agency Region II

Wayne Sylvester, Sanitation Districts of Orange  
County

John Tavoraro, Corps of Engineers New York  
District

Nancy Taylor, Sierra Club Clean Coastal Waters  
Task Force

Joe Teller, Gulf Coast Waste Disposal Authority

Thomas Thornton, Environmental Protection  
Agency Region I

Peter Trick, Science Applications International  
Corp.

Glenn Unterburger, Environmental Protection  
Agency

Ron Varm, Corps of Engineers Norfolk District

John Waesche, Jardine Insurance Brokers, Inc.

Eric Washburn, Science Applications International  
Corp.

Thomas Walton, Philadelphia Water Department

Al Wastler, Environmental Protection Agency

Ginger Webster, Environmental Protection Agency

Judith Weis, Rutgers University

Bill Westermeyer, Office of Technology Assessment

Lee White, White, Fine, & Verville

Gene Whitehurst, Corps of Engineers Norfolk  
District

Richard Whitsel, California Regional Water Quality  
Control Board

Joe Wilson, Corps of Engineers

Douglas Wolfe, National Oceanic and Atmospheric  
Administration

Thomas Yourk, Corps of Engineers Savannah  
District

Chris Zarba, Environmental Protection Agency

### ***Participants in Dredged Material Workshop, July 23, 1985***

The following individuals participated in a workshop  
held by OTA on the disposal of dredged material:

Bill Conner, National Oceanic and Atmospheric  
Administration

Robert Engler, Waterways Experiment Station

Dan Farrow, National Oceanic and Atmospheric  
Administration

Tim Goodger, National Marine Fisheries Service

Frank Hamons, Maryland Port Administration

David Hankla, Fish and Wildlife Service

George Hanson, Fish and Wildlife Service

Jim Houston, Waterways Experiment Station

Kerr Kamlet, J. T. Kearney, Inc. (formerly with  
National Wildlife Federation)

Bob Morton, Science Applications International  
Corp.

Tom O'Connor, National Oceanic and Atmospheric  
Administration

Willis Pequegnat, Consultant

Ronald Vann, Waterways Experiment Station

Al Wastler, Environmental Protection Agency

# Acronyms and Abbreviations

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AO	—Administrative Order	NEP	—National Estuary Program
BAT	—Best Available Technology (Economically Achievable)	NEPA	—National Environmental Policy Act
BCT	—Best Conventional Pollutant Control Technology	NIMBY	—Not In My Backyard
BMR	—Baseline Monitoring Report	NMFS	—National Marine Fisheries Service
BOD	—Biochemical Oxygen Demand	NMPP	—National Marine Pollution Program
BPJ	—Best Professional Judgment	NOAA	—National Oceanic and Atmospheric Administration
BPT	—Best Practicable Control Technology (Currently Available)	NPDES	—National Pollutant Discharge Elimination System
CBP	—Chesapeake Bay Program	NRDC	—Natural Resource Defense Council
CEQ	—Council on Environmental Quality	NSPS	—New Source Performance Standards
CERCLA	—Comprehensive Environmental Response, Compensation, and Liability Act	OAD	—Ocean Assessments Division
CFR	—Code of Federal Regulations	OCPSF	—Organic Chemicals, Plastics, and Synthetic Fibers
COE	—U.S. Army Corps of Engineers	OMEP	—Office of Marine and Estuarine Protection
CSI	—Compliance Sampling Inspection	PAH	—Polycyclic Aromatic Hydrocarbon
CSO	—Combined Sewer Overflow	PCB	—Polychlorinated Biphenyl
CWA	—Clean Water Act	PCS	—Permit Compliance System
CZMA	—Coastal Zone Management Act	PFRP	—Process to Further Reduce Pathogens
DAF	—Dissolved Air Flotation	PIRT	—Pretreatment Implementation Review Task Force
DDT	—Dichlorodiphenyl Trichloroethane	POTW	—Publicly Owned Treatment Work
DMR	—Discharge Monitoring Report	PSES	—Pretreatment Standards for Existing Sources
DOJ	—Department of Justice	PSNS	—Pretreatment Standards for New Sources
EDF	—Environmental Defense Fund	PSRP	—Process to Significantly Reduce Pathogens
EIL	—Environmental Impairment Liability	PSWQA	—Puget Sound Water Quality Authority
EIS	—Environmental Impact Statement	QNCR	—Quarterly Noncompliance Report
EMS	—Enforcement Management System	RCRA	—Resource Conservation and Recovery Act
EP	—Extraction Procedure	RFF	—Resources For the Future
EPA	—U.S. Environmental Protection Agency	SAB	—Science Advisory Board
FDA	—Food and Drug Administration	SASSR	—Semi-Annual Statistical Summary Report
FDF	—Fundamentally Different Factor	SAV	—Submerged Aquatic Vegetation
FGD	—Flue Gas Desulfurization	SCCWRP	—Southern California Coastal Water Research Project
FR	—Federal Register	SNC	—Significant Noncompliance
FWS	—Fish and Wildlife Service	SPMS	—Strategic Planning and Management System
GAO	—General Accounting Office	TBT	—Tributyltin
GCWDA	—Gulf Coast Waste Disposal Authority	TCDD	—Tetrachlorodioxin
LDC	—London Dumping Convention	TCDF	—Tetrachlorodibenzofuran
LLW	—Low-level Radioactive Waste	TCLP	—Toxic Characteristic Leachate Procedure
MDSD	—Monitoring and Data Support Division	TSCA	—Toxic Substances Control Act
MPRSA	—Marine Protection, Research, and Sanctuaries Act	TSS	—Total Suspended Solids
NACOA	—National Advisory Committee on Oceans and Atmosphere	U.S.C.	—United States Code
NEA	—Nuclear Energy Agency	USGS	—U.S. Geological Survey
NEMP	—Northeast Monitoring Program	VRAC	—Violation Review Action Criteria