Managing Industrial Solid Wastes From Manufacturing, Mining, Oil and Gas Production, and Utility Coal Combustion

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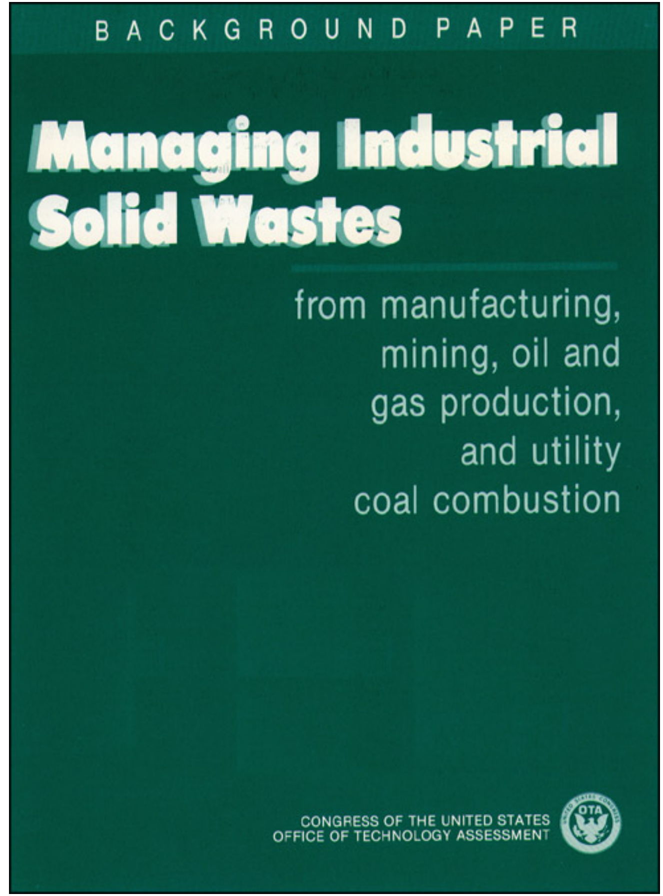

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Foreword

The 1976 Resource Conservation and Recovery Act (RCRA) is the major statute governing what are called solid wastes. Federal efforts to date under RCRA have focused on controlling the management and disposal of certain 'hazardous' wastes. The remaining solid wastestream, the subject of this background paper, dwarfs that defined as hazardous. Although not classified as hazardous, some of this remaining wastestream does contain toxic and other undesirable constituents.

This background paper was requested by the House Committee on Energy and Commerce, Subcommittee on Transportation and Hazardous Materials in anticipation of the reauthorization of RCRA. The paper examines wastes generated by industrial activities that play a dominant role in our national economy-oil and gas production, mining and mineral processing, coal combustion, and manufacturing. In previous reports on municipal solid waste and medical waste, OTA examined other solid wastes not classified as hazardous.

Improving the regulation and management of solid wastes that are not classified as hazardous, and preventing their generation where possible, poses many challenges for Congress, EPA and other Federal agencies, the States, and the involved industries. Major issues include how to best achieve environmental protection without impeding economic development, how EPA and other Federal agencies such as the Bureau of Land Management should interact in managing wastes generated on Federal lands, what the relative roles of EPA and the States should be, whether sufficient resources will be available to develop and implement effective programs, and whether the current regulatory structure under RCRA is an effective one.

OTA is grateful for the assistance provided by workshop participants, contractors, reviewers, and other contributors during the preparation of this paper. These individuals helped OTA obtain and examine a wide range of information and issues. OTA, of course, remains solely responsible for the contents of the paper.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the workshop participants. The workshop participants do not, however, necessarily approve, disapprove, or endorse this background paper. **OTA assumes full responsibility for the background paper and the accuracy of its contents.**

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Overview of RCRA and General "Solid" Waste Issues

INTRODUCTION

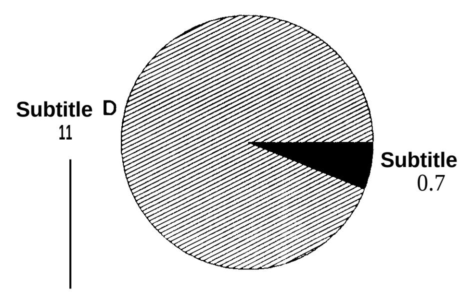
The Resource Conservation and Recovery Act (RCRA), the major Federal statute on solid waste, was passed in 1976.[1] RCRA broadly defines 'solid' waste-which actually can have any physical form-as, for example, garbage, refuse, sludge from treatment processes and other pollution controls, and discarded material from industrial, commercial, mining, and agricultural operations (see "The Resource Conservation and Recovery Act' below for additional details).[2] Today, efforts continue to refine the Federal system for regulating solid wastes and to fully achieve RCRA's goals of protecting human health and the environment and conserving valuable material and energy resources.

Federal efforts to date have focused primarily on controlling the management and disposal of certain wastes defined as "hazardous.' Yet such wastes, which are regulated under Subtitle C of RCRA, make up only a small portion of the wastes that Congress intended RCRA to address. The remaining solid wastestream, which statutorily is addressed by Subtitle D of RCRA, includes any 'solid' waste not currently regulated as hazardous under RCRA (e.g., medical, municipal, agricultural, construction and demolition, oil and gas exploration and production, mining extraction and beneficiation, mineral processing, coal combustion, and industrial manufacturing wastes; municipal combustion ash; cement kiln dust; pollution control sludges; and conditionally exempt hazardous wastes from small quantity generators). In 1980, Congress also exempted certain ''special wastes"—from mining, fossil fuel combustion, cement kilns, and oil and gas production—from regulation under Subtitle C, pending further study and regulatory determinations by the U.S. Environmental Protection Agency (EPA).

By weight, this highly diverse universe of Subtitle D waste dwarfs that of Subtitle C ("hazardous") waste. According to the best available EPA data, about 11 to 12 billion tons of Subtitle D waste is generated annually in the United States; this estimate is an approximation only, because it is based on data whose quality varies greatly among waste types. In comparison, approximately 0.7 billion ton of hazardous waste is generated annually (figure l-l). The new Toxicity Characteristic (see below and ch. 5) might double the amount of manufacturing waste that would be identified as hazardous but which is managed in units that are exempt from Subtitle C regulation.

Management of Subtitle D wastes is highly variable, depending on waste type and characteristics, location, costs, and other factors. However, much of this ''solid' wastestream-perhaps 70 percent—is wastewater that is at least temporarily

Figure l-l—The Universe of RCRA Wastes
(billions of tons)



SOURCES: Based on U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: Wastes From the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden From Uranium Mining and Oil Shale,* EPA/530-SW-85-033 (Washington, DC: December 1985); *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy,* EPA/530-SW-68-003 (December 1987); *Report to Congress: Wastes From the Combustion of Coal by Electric Utility Power Plants,* EPA/530 -SW-88-O02 (February 1988); *Report to Congress.' Solid Waste Disposal in the United States,* vols. 1-2, EPA/530-SW-88-01 1 (October 1988); *Report to Congress on Special Wastes from Mineral Processing,* EPA/530-SW-90-070C (July 1990); 1987 *National Biennial RCRA Hazardous Waste Report, EPA/530-SW-91-061* (July 1991); *National Survey of Hazardous Waste Generators and Treatment, Storage, Disposal, and Recycling Facilities in 1986, Hazardous Waste Management in RCRA TSDR Units,* EPA/530-SW-91-060 (July 1991).

[1] Acronyms used in this paper are listed in app. A; Public Law numbers for cited statutes are listed in app. B.

[2] Congress first established a Federal role in solid waste issues in the Solid Waste Disposal Act of 1965, as amended by the Resource Recovery Act of 1970.

managed, and sometimes disposed of, at on-site surface impoundments. The current, nationwide extent of pollution controls and monitoring at surface impoundments is unknown; as of 1985, however, many impoundments lacked sufficient design controls to prevent or detect contamination of the surrounding environment. Some wastewater is also injected underground, recycled, treated, stored in tanks, or discharged into surface waters and sewers. Other, more solid material is managed in landfills or waste piles, is spread on land, or is recycled.

Many public and private industry officials and public interest groups consider the management and regulation of these Subtitle D wastes to be the next item on the Nation's solid waste agenda. In general, EPA, some State officials, and environmental groups are concerned about the potential for leachate or other releases from surface impoundments and other management methods to contaminate groundwater and to cause health risks and various environmental impacts; for manufacturing wastes, though, EPA believes that it needs to collect additional information and evaluate relative risks before making any regulatory decisions. Many State officials, the Department of the Interior, and industry groups disagree about the significance of contamination from properly managed Subtitle D units and the need for additional Federal regulation.

At the Federal level, regulatory programs under other statutes cover certain wastes generated by the mining, manufacturing, electric power generation, and oil and gas industries. For example, wastewater discharges are regulated by the Clean Water Act, underground injection by the Safe Drinking Water Act, and air emissions by the Clean Air Act. In general, States have primary responsibility for implementing these programs. Under RCRA, EPA has developed an extensive regulatory program (i.e., Subtitle C) for hazardous wastes, issued criteria for municipal solid waste landfills, and made regulatory determinations about other, Subtitle D wastes generated by the mining and oil and gas industries. EPA is attempting to develop a Subtitle D program for active mining waste sites, but it has not yet proposed actual Subtitle D regulations for mining or any other industry. Thus, States currently are responsible for developing and implementing their own programs for Subtitle D wastes. Many States have improved various aspects of their programs in the past few years and now regulate many portions of the Subtitle D waste universe. However, the programs still vary in scope, stringency, and need for upgrading.

As part of the process to reauthorize RCRA, legislation introduced in both the 101st and the 102d Congresses included provisions on Subtitle D wastes. In this background paper, the Office of Technology Assessment (OTA) examines available information on the amounts, management, risks, and statutory and regulatory frameworks for wastes generated by the mining, coal utility, oil and gas, and manufacturing industries.[3]

To understand issues that are specific to these industries and cut across all industries, it first is essential to understand RCRA. This chapter outlines RCRA's general structure; discusses how wastes are identified and classified as hazardous under Subtitle C; discusses the general nature of Subtitle D; and briefly summarizes data on the amounts, management, risks, and regulatory status of Subtitle D wastes.[4] It then discusses a number of crosscutting RCRA issues, including whether separate regulatory tracks are required for different wastes; the relationships among various Federal and State agencies; efforts to promote pollution prevention and recycling; and alternative approaches to the current Subtitle C/Subtitle D system. Chapters 2 through 5 present more detailed information on mining, coal combustion, oil and gas, and manufacturing wastes, respectively; each chapter ends with a discussion of issues specific to that waste category.

THE RESOURCE CONSERVATION AND RECOVERY ACT

The definition and classification of hazardous and other "solid" wastes under RCRA directly affect the way in which different wastes are regulated and managed. Solid waste is defined broadly under RCRA (Sec. 1004(27)) as:

> . . . any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or con-

[3] OTA addressed aspects of municipal solid waste, medical waste, hazardous waste, and mixed nuclear/hazardous waste in several earlier reports (88, 89,90,91,94,95,96, 97).

[4] OTA did not attempt to gather or synthesize information on the costs of various methods of managing Subtitle D solid wastes.

> tained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved material in domestic sewage,or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under section 1342 of Title 33, or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923) [emphasis added].

Hazardous waste is defined under RCRA (Sec. 1004(5)) as:

> . . . a solid waste, or combination of solid wastes which because of its quantity, concentration, or physical, chemical, or infectious characteristics may [a] cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or [b] pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

The term "solid" thus does not necessarily refer to a waste's physical form but rather is a general, encompassing term that refers to all RCRA wastes except those excluded in the definition.

The Solid Waste Disposal Act (the precursor to RCRA) and initial drafts of RCRA itself focused on "non-hazardous" wastes, particularly on eliminating open dumps, improving materials management, and promoting resource conservation. However, Congress was also concerned that other Federal environmental protection statutes passed in the early 1970s were having unintended results. In some cases, implementation of the statutes resulted in greater amounts of hazardous and other solid wastes requiring land disposal and, subsequently, resulted in groundwater contamination through leaching; surface water contamination through runoff; and air pollution through open burning and evaporation (46, 48).

As a result, by the time RCRA was signed into law in 1976, an integral part was a national hazardous waste program-codified in Subtitle C of the statute--with extensive Federal involvement (47). Subtitle C granted EPA broad authority to develop a comprehensive, "cradle-to-grave" program to regulate the generation, transportation, treatment, storage, and disposal of hazardous wastes. EPA was also authorized to set minimum standards that States must adopt in order to run their own EPA-approved hazardous waste regulatory programs. Subtitle C tends to be highly prescriptive, with little flexibility to change various requirements. However, States can establish, and some have, broader or more stringent Subtitle C programs than required by EPA; for example, Wisconsin's regulations apply to very small quantity generators. Other States may feel that the scope of EPA's program is appropriate or that it is too expensive and time-consuming to regulate additional wastes as hazardous.

Subtitle D of RCRA dealt with wastes not identified as hazardous. State and local governments retained primacy in regulating these wastes. EPA's role was limited to establishing voluntary guidelines for State solid waste management plans and developing minimum standards necessary to protect human health and the environment from improper management of the wastes. The Federal Government was to provide incentives, in the form of financial and technical assistance, for States and localities to develop management plans.[5] EPA issued specific criteria and guidelines in 1979; while broadly applicable, these were aimed primarily at municipal landfill facilities.

In the Solid Waste Disposal Act Amendments of 1980, Congress designated certain 'special wastes' as exempt from Subtitle C regulation, until EPA studied their environmental and health effects and separately determined for each type whether or not Subtitle C should be applied. The Bevill amendment, Section 3001(b)(3), exempted high-volume/low-toxicity mining wastes, fossil fuel combustion wastes, and cement kiln dust. The Bentsen amendments, Sections 3001(b)(2) and 8002(m), provided a similar exemption to oil, gas, and geothermal production wastes. The exemptions were enacted because Congress was concerned, after the oil crises of the 1970s, about creating regulatory disincentives that would impede development of the Nation's energy resources.[6] Congress was also concerned about overregulating wastes as hazardous and believed that existing State and Federal regulations would provide sufficient protection while EPA

[5] OTA (95) discusses the Subtitle D program with respect to municipal solid waste.

[6] 54 *Federal Register* 15319, Apr. 17, 1989. The Bentsen amendments also specified that EPA could not regulate oil, gas, and geothermal wastes under Subtitle C without a subsequent act of Congress allowing such regulation.

conducted its studies and made regulatory determinations.[7]

A decade later, EPA had issued some of the required reports to Congress and made some regulatory determinations. As of 1991, EPA had submitted reports on mining extraction and beneficiation (111), mineral processing (127), oil and gas exploration and production (117), and coal combustion wastes (118). Their current regulatory status is discussed below (see ''The Subtitle D Universe' ').

The last major revision of RCRA was the Hazardous and Solid Waste Amendments (HSWA) of 1984, which made major midcourse corrections to the hazardous waste program.[8] HSWA also directed EPA to study Subtitle D waste management and disposal facilities and evaluate whether current guidelines and standards are adequate to protect human health and the environment; to review the domestic sewage exemption and determine whether existing regulations are adequate; and to revise the existing Subtitle D landfill criteria for those facilities that accept household hazardous waste or small quantity generator waste.[9] The implications of EPA's resulting regulatory actions are discussed throughout this report.

A major continuing tension in RCRA'S waste classification system (explained in "The Subtitle C Universe' below) is that management under Subtitle C is stringent and expensive, whereas management under Subtitle D is relatively less stringent and less costly. This does not mean that State regulations for Subtitle D wastes are necessarily less protective; that would depend on the characteristics of the waste; the geographic site and management facility; and the design and enforcement of State regulations.

The Subtitle C Universe

The "Listing" and "Characteristic" Approaches

EPA uses two approaches—' 'listing' and ' 'characteristic' '—to identify wastes to be regulated as hazardous under Subtitle C. As discussed later in this section, the Environmental Defense Fund has sued EPA over several important aspects of the Agency's efforts to carry out congressional mandates regarding these approaches.

In the "listing' approach, individual wastestreams or sets of wastestreams are specifically listed as hazardous (40 CFR 261, Subpart D). To date, EPA has listed 33 wastestreams from nonspecific sources (known as the F List);[10] more than 100 wastestreams from specific sources (the K List); and315 discarded commercial chemical products, off-specification species, container residues, and spill residues (the P and U lists for acutely hazardous and toxic commercial chemical products, respectively).[11]

In the "characteristic" approach, solid wastes from individual facilities are classified as hazardous if they exhibit one of four hazardous characteristics—corrosivity, ignitability, toxicity, or reactivity (40 CFR 261.21-24)—provided they are not listed and

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[7] Congress specified certain factors that EPA was to include in its studies of different special wastes. Sees. *8002(f)* and 8002(p) addressed mining wastes, Sec. 8002(m) addressed oil and gas wastes, See, 8002(n) addressed coal combustion wastes, and Sec. 8002(0) addressed cement kiln dust. In general, EPA was to address the following factors: sources and volumes of discarded material; present disposal and utilization practices; potential danger to human health and the environment from such materials; documented cases in which danger to human health or the environment has been proved; types and costs of alternatives to current disposal methods; and impacts of alternatives on the given industry's materials use and commodity production activities.

[8] Subtitle C provisions included, for e-pie, requirements that EPA make ''listing'' decisions for 22 wastestreams, establish restrictions on land disposal of hazardous wastes, and implement deadlines on permitting of interim status units. RCRA also was amended by the Medical Waste Tracking Act of 1988 (see ref. 97).

[9] This latter requirement is the reason EPA focused its revision on municipal landfills, because they generally accept at least some household hazardous waste.

[10] Including five recent listings: F037 and F038, wastes generated from separation of oil, water, and solids from petroleum refinery process wastewaters and oil cooling wastewaters (55 *Federal Register 46354, Nov. 2,* 1990, and 55 *Federal Register 51707,* Dec. 17, 1990); and F032, F034, and F035, wood preserving and surface protection wastes (55 *Federal Register 50450,* Dec. 6, 1990).

[11] 40 CFR 261.31, 261.32, and 261.33, respectively. Chemical products on the P and U lists are not considered hazardous when used for their intended purpose (e.g., pesticides); however, they are considered hazardous when, for example, they are discarded, mixed with waste oil and applied to land for dust suppression otherwise applied to land in lieu of their original intended use, or burned as fuel. Wastestreams containing these chemicals are not considered listed hazardous wastes unless the streams themselves are on the F or K lists or exhibit a hazardous characteristic, but they still are subject to other EPA regulations.

are not otherwise excluded from Subtitle C regulation.[12] Except for reactivity, which is defined in descriptive terms, characteristics generally are based on quantitative threshold levels. For the toxicity characteristic, for example, a waste is considered hazardous when the concentrations of certain toxic constituents in the waste exceed specified levels in laboratory leaching tests. The substances to be tested, threshold levels, and test procedures continue to be sources of controversy, as discussed below.

Two other rules and a procedure known as ''delisting' also determine whether a wastestream is considered hazardous.[13] Under the ''derived from' rule (40 CFR 261.3), any waste derived from the treatment, storage, or disposal of a listed hazardous waste is itself considered hazardous-regardless of whether the original listed waste is undetectable after the treatment or the final waste passes characteristic tests. Under the "mixture" rule (40 CFR 261.3), a mixture of a solid waste and a listed hazardous waste also is considered hazardous.[14] Delisting is the procedure by which EPA excludes or removes an individual facility's particular listed hazardous waste from designation as hazardous (40 CFR 260.22); this might be done, for example, for low hazard or very dilute wastes that are considered hazardous under the derived-from rule. The derived-from and mixture rules are often cited by industry as examples of Subtitle C's cumbersome nature (11, 13); this is one reason the Chemical Manufacturers Association petitioned EPA to establish ***de minimis*** regulatory levels for hazardous constituents in listed hazardous wastes (see ''From C and D Toward a New System?" below).

The Federal Government thus regulates as hazardous only those solid wastes that are specifically listed, that fail a hazardous characteristic, or that fall under the derived-from or mixture rules.[15] EPA estimated that listed and characteristic hazardous wastes totaled about 0.7 billion ton in 1986-87; some of these, however, were managed in units exempt from Subtitle C regulation.[16] The new Toxicity Characteristic (TC) might double the amount of wastes characterized as hazardous (see below and ch. 5); however, many of these additional wastes are managed in RCRA-exempt units and thus would not be subject to Subtitle C regulation.

Nevertheless, many States regulate more substances in their own hazardous waste programs and set more stringent regulations (31). Usually this means designating specific wastes, such as polychlorinated biphenyls (PCBs) or waste oil, as hazardous. A few States (e.g., California, Oregon, Rhode Island, Washington, Wisconsin) also include characteristics such as carcinogenicity and acute toxicity. California and Washington estimate that their definitions double their regulated hazardous waste universe.[17]

EPA's relative reliance on the listing and characteristic approaches has shifted several times. In its

[12]Some wastes are excluded by statute or rule from classification as hazardous. These include, for example, the ''special'' wastes, Conditionally Exempt Small Quantity Generator hazardous waste (which refers to facilities producing less than 100 kilograms of hazardous waste per month), industrial wastewater discharges mixed with domestic sewage (which are regulated under the Clean Water Act), household hazardous wastes, and other industry-specific wastes. Some exclusions, however, were based on assumptions that may no longer be valid. For example, specific chromium wastes from the tanning and finishing industry were excluded in 1980 based in part on the alleged inability of trivalent chromium to oxidize to hexavalent chromium under most plausible types of improper waste management. As a result of more recent evidence, however, EPA is now considering proposing the deletion of this exclusion for chromium wastes that contain virtually no hexavalent chromium (55 *Federal Register 11812*, Mar. 29, 1990).

[13]In December 1991, however, a Federal court of appeals ruled that EPA had not properly sought public comment when it promulgated the "derived-from" and 'mixture" rules; the court allowed EPA to maintain the rules temporarily if it chose to do so, while the Agency opened a new public comment period (*Shell Oil Co. v. U.S. EPA*, U.S. Court of Appeals, D.C. Circuit, 80-1532).

[14]This rule was developed in part to discourage dilution as a management option; outright dilution is permissible only when expressly allowed by a waste's treatment standards (40 CFR 268.3). The exception to the rule is a mixture of a solid waste and a waste that is listed as hazardous solely because it exhibits a hazardous characteristic; such a mixture is not defined as hazardous if the mixture itself does not exhibit the characteristic.

[15]Note, also, that the definition and identification of ''-dous' wastes under RCRA are narrower than the public's perception of what the term means.

[16]EPA's National Biennial Waste Report (132) estimated that 238 million tons of hazardous waste was managed in RCRA-regulated units in 1987; it did not estimate how much was managed in RCRA-exempt units. EPA's National Survey of hazardous waste generators and management facilities (133) estimated that 457 million tons of hazardous waste was managed in RCRA-exempt units, including discharges into publicly owned treatment plants for municipal sewage, which are regulated under the Clean Water Act. The survey also estimated that 290 million tons was managed in RCRA-regulated units, but EPA considers the National Biennial Waste Report estimate for these units to be more accurate (U.S. EPA, review comments, Aug. 22, 1991).

[17]V. Meinz, Washington Department of Ecology, personal communication, January 1991; C. Markson, California Department of Health Services, personal communication Sept. 13, 1991. Even after accounting for the new TC, the amount of waste regulated as hazardous in California remains about twice the amount that would be regulated as hazardous under RCRA, because the bulk of California hazardous waste is used oil.

first notice of proposed rules in 1978,[18] EPA stated its intent to use characteristics such as radioactivity, mutagenicity, toxicity to aquatic organisms and plants, bioaccumulation, toxicity to humans from chronic exposure to organic chemicals, and infectiousness. The final rule in 1980[19] reduced the scope, however, partly because test methods or laboratories to carry out testing were not available for many of these characteristics. EPA instead determined to use four characteristics ignitability, corrosivity, reactivity, and toxicity. EPA selected a leaching test, the Extraction Procedure (EP) toxicity test, to evaluate toxicity, because of concerns about the potential contamination of groundwater by leachate from hazardous wastes in landfills. The test covers 14 chemicals (8 metals, 6 pesticides) for which drinking water standards have been promulgated under the Safe Drinking Water Act.

EPA recently replaced the EP with the new TC. In 1984, as part of HSWA, Congress required EPA to promulgate more characteristics by November 1986 and to add organic chemicals to the EP (Sec. 3001(h)). In 1990, EPA responded by issuing the TC.[20] The TC uses a slightly different leaching procedure than the EP, retains the municipal landfill model, and covers 39 constituents-including 25 organic chemicals not covered under the EP. Regulatory threshold levels reflect health-based standards, with the same dilution attenuation factor for each constituent, based on an environmental fate and transport model.[21]

EPA also continued evaluating wastes to determine whether they should be listed as hazardous. In the 1980 rulemaking, based on data from production processes, EPA promulgated a long list of wastes, based on data from production processes, that were considered ‘hazardous’ by some criterion; much of the data came from work by the EPA Office of Water on effluent guidelines. In the early 1980s, EPA decided to develop additional listings to supplement the universe of regulated wastes, based on the sampling of wastestreams to determine whether they should be regulated as hazardous. In 1984, Congress set specific deadlines in HSWA (Sec. 3001(e)) requiring EPA to list or make listing determinations for 19 waste categories.[22]

Both the listing and the characteristic approaches have been criticized. Some people (e.g., 50,51, 141) believe that the four current characteristics are insufficient and some Subtitle D wastes that perhaps should be characterized as hazardous are not. For example, wastes with constituents that may exhibit non-RCRA characteristics such as carcinogenicity or mutagenicity are not subject to designation as RCRA hazardous wastes (5 1), although they maybe regulated under other statutes. With respect to toxicity, environmental groups believe that the EP and TC underestimate potential risks, whereas industry representatives believe that they overestimate risks.[23] Industry generally considers the listing process to be time-consuming, burdensome, and often inappropriate for a given wastestream. Environmental groups believe that some solid wastes would likely meet listing criteria but are either exempt (e.g., certain industrial wastewaters discharged into sewer systems, where they mix with domestic sewage, are regulated under the Clean Water Act), improperly classified, or not yet studied and listed by EPA.

[18] 43 Federal Register 58949, Dec. 18, 1978.

[19] 45 *Federal Register* 33107, May 19, 1980.

[20] 55 Federal Register 11804, Mar. 29, 1990.

[21] A different leaching test (the oily waste extraction procedure, or OWEP) is used for delisting oily wastes, because the EP and TC tests may underestimate the leaching potential of oily wastes (see ch. 5). However, the OWEP is not used to characterize or list oily wastes. In its Report to Congress on oil and gas wastes, EPA used the TC to evaluate the toxicity associated with these wastes, despite acknowledging the inappropriateness of doing SO (1 17).

[22] These included listing chlorinated dioxins and dibenzofurans by May 1985, halogenated dioxins and dibenzofurans by November 1985, and making deteruminations for 17 other waste categories by February 1986.

[23] For example, environmental groups criticized the EP because: 1) it only covers a few toxic constituents (in contrast, EPA can use almost 400 toxic constituents (40 CFR 261, App. VIII) as one means of determining whether to list wastestreams as hazardous on the basis of toxicity); and 2) its threshold levels are based on a dilution factor 100 times greater than the drinking water standards, rather than 10 times greater as first proposed, which means that fewer wastes are identified as having the toxicity characteristic. They criticize both EP and TC for not including other exposure pathways that might be associated with waste management sites—e.g., consumption of surface waters contaminated by runoff, consumption of fish taken from such waters, or air inhalation (29, 76). Many industry groups, however, contend that the EP and TC do not simulate true conditions at most disposal sites, because they are based on models that mimic codisposal in a municipal landfill, and thus do not accurately predict chemical behavior in the field. They also note that some other exposure pathways are regulated under the Clean Water Act, Clean Air Act, and Safe Drinking Water Act.

The Environmental Defense Fund (EDF) sued EPA in March 1989 for, among other things, failure to meet the deadlines for listing determinations and failure to fully meet the Sec. 3001(h) mandate to promulgate more hazardous characteristics.[24] The two parties proposed a consent decree in June 1991 that outlined a schedule for EPA to make listing determinations for 13 waste categories. However, EDF's claim regarding characteristics has not been decided, although a decision is pending.[25] EPA believes that the listing schedule will need substantial revision if the Agency is required to promulgate new characteristics beyond the TC; an industry group also contends that this would divert EPA resources from other Subtitle D efforts.[26]

Finally, HSWA also directed EPA to promulgate treatment standards for hazardous wastes destined for land disposal. The regulations prohibit placing hazardous waste residues in land-based units unless they meet treatment standards based on the most stringent controls that can be provided by the best demonstrated available treatment technology (BDAT). However, Subtitle D manufacturing wastes are not subject to the promulgated treatment standards, although they can sometimes contain levels of constituents that are higher than the standards (123). As a result, hazardous wastes that meet the treatment standards are managed in Subtitle C land-based units, whereas untreated Subtitle D wastes—which may contain higher levels of constituents-can be disposed of in surface impoundments and landfills with few or no environmental controls, depending on applicable State regulations. Because the BDAT standards are not health-based, some industry representatives argue that they may overregulate certain Subtitle C wastes rather than underregulate Subtitle D wastes.[27]

The Subtitle D Universe

Subtitle D generally covers solid wastes not regulated under Subtitle C. These include many diverse waste categories: "special" exempt wastes (certain mining, oil and gas, cement kiln dust, and fossil fuel combustion wastes); industrial manufacturing wastes; agricultural wastes; municipal solid and medical wastes; construction and demolition debris; Conditionally Exempt Small Quantity Generator (CESQG) and household hazardous wastes; municipal combustion ash; and pollution control residuals (e.g., wastewater treatment sludge). These wastestreams vary greatly in chemical composition and physical form. In the manufacturing sector, for example, wastes originate from industries as diverse as pulp and paper, transportation equipment, and organic chemical manufacturing, and they can be in the form of solids, sludges, wastewaters, or even contained gases. Some of these wastestreams are regulated by statutes other than RCRA.

The following sections briefly describe estimated amounts, current management practices, general risks, and regulatory status of Subtitle D wastes. More detailed information on these topics is presented by waste category in chapters 2 through 5.

Overall Waste Generation

Based on data obtained by EPA from industries and the States, it appears that more than 11 billion tons of Subtitle D waste was generated annually in the United States as of the mid- 1980s (figure 1-2).[28] This is a crude estimate, because the data are relatively poor and not necessarily comparable. The largest portion, about 6.5 billion tons, consists of manufacturing wastes not regulated as hazardous.[29] However, this does not include wastes that were recycled on-site or off-site or disposed of off-site (wastes for which EPA has no estimates), or other wastestreams such as tires and soil cleanup wastes.

[24] *Environmental Defense Fund v. U.S. EPA et al.,* U.S. District Court for the District of Columbia, Civ. No. 89-0598.

[25] K. Florini, EDF, personal communication, Oct. 1, 1991.

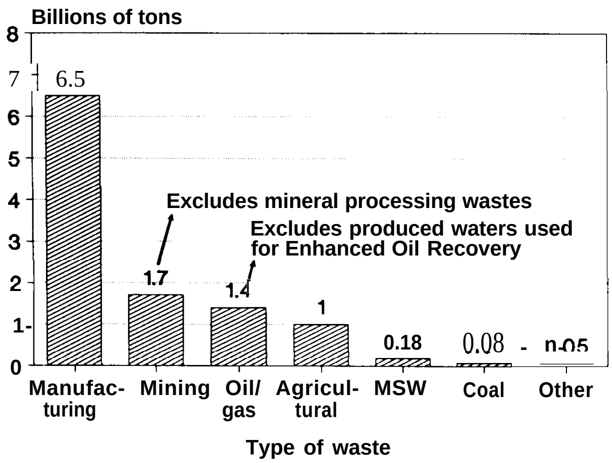
[26] A. O'Hare, American Petroleum Institute, review comments, July 26, 1991.

[27] E. Males, Chemical Manufacturers Association, review comments, Aug. 7, 1991; J. Murphy, Amoco, review comments, July 26, 1991.

[28] This excludes mineral processing wastes, whose amount cannot be estimated from the information available (see ch. 2). In addition, solid wastes mixed with domestic sewage are exempt from regulation under RCRA, although sludges from wastewater treatment are not.

[29] Based on discussions with EPA and the coal combustion utility industry, OTA assumed that the 1 billion tom of electric utility wastes included in EPA's industrial survey (116) consisted primarily of coal combustion utility wastes. Hence, OTA reduced the estimate of manufacturing wastes by 1 billion tons to avoid double counting. However, OTA also decided to use EPA's estimate (in EPA's 1988 Report to Congress; ref. 118) that coal combustion utility wastes amount to 85 million tons annually. The difference in the two estimates probably results from the inclusion of wastewater in the former (also see ch. 3). Water is added, after wastes are generated, to facilitate transport and management; generally the water is not disposed of in landfills or surface impoundments, but rather is discharged to surface water or recycled in electric power generating operations.

Figure 1-2—Estimated Quantities of Subtitle D Wastes, 1985



SOURCES: OTA, based on various review comments (see text in chs. 2 to 5) and on U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: Wastes From the Extraction and Benefication of Metallic Ores, Phosphate Rock, Asbestos, Overburden From Uranium Mining and Oil Shale,* EPA/530-SW-85-033 (Washington, DC: December 1985); *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy,* EPA/530-SW-88-003 (December 1987); *Report to Congress: Wastes From the Combustion of Coal by Electric Utility Power Plants,* EPA/530 -SW-88-O02 (February 1988); *Report to Congress: Solid Waste Disposal in the United States,* vols. 1-2, EPA/530-SW-88-01 1 (October 1988); *Report to Congress on Special Wastes From Mineral Processing,* EPA/530-SW-90-070C (July 1990). For agricultural wastes, The Conservation Foundation, *State of the Environment: A View Toward the Nineties* (Washington, DC: 1987).

Perhaps as much as 1.4 billion tons consists of oil and gas exploration and production wastes.[30] OTA estimates that the mining industry generated about 1.7 billion tons of extraction and beneficiation wastes in 1987 but cannot provide a comparable estimate for mineral processing wastes.[31] Coal combustion utility wastes amount to about 85 million tons.

These estimates are difficult to compare with each other. Enormous portions of manufacturing and oil and gas wastes, along with the unknown amount of mineral processing wastes, are in the form of wastewater. In contrast, most mining extraction and beneficiation wastes, sludges, and coal combustion utility wastes generally are solid rather than liquid.

Municipal solid waste (MSW), which OTA assessed elsewhere (95), totaled 180 million tons in 1988 (126). Estimated amounts of other Subtitle D wastes are much lower (119): perhaps 32 million tons annually of demolition and construction wastes; 12 million tons of municipal drinking water and municipal wastewater treatment sludges;[32] 4.5 million tons of municipal solid waste combustion ash;[33] 2 million tons of infectious medical wastes from hospitals; and less than 0.2 million ton of CESQG hazardous waste.[34]

The amount of agricultural wastes that would fall under Subtitle D has not been estimated by EPA, although the Conservation Foundation (15) suggests that more than 1 billion tons may be produced yearly, much of which is crop residue left on the field or animal manure used as fertilizer.

Current Management Practices

EPA examined Subtitle D waste management units that were active in the mid- 1980s (119); these were usually surface impoundments, landfills, waste piles, or land application units.[35] According to EPA data, almost 85 percent of all active Subtitle D units were surface impoundments (figure 1-3). Furthermore, although amounts and management tech-

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[30] EPA estimated that about 3.8 billion tons of such waste, almost 98 percent of which represented "produced waters," was generated in 1985. However, produced waters reused in underground injection for enhanced oil recovery (EOR) are regulated (at least from the wellhead down) under the Safe Drinking Water Act rather than RCRA. Because about 62 percent of produced waters are reinfected for EOR (6), this would leave about 1.4 billion tons of produced waters to be managed as RCRA wastes. Industry analysts, however, estimate that about 2.8 billion tons of produced waters was generated in 1985, of which 2.5 billion tons was used for EOR operations (ch. 4).

[31] EPA estimated that 2.0 billion tons of mineral processing wastewaster was generated annually, with 9 percent being phosphoric acid process wastewater (127). However, this represents the total amount of wastewater that cycles through various operations; much of this is process water that is used several times, making it difficult to estimate the amount of new water that is actually used initially (ch. 2). EPA included recycled process water in its total estimate, but the Department of the Interior believes that such water should not be characterized as wastewater.

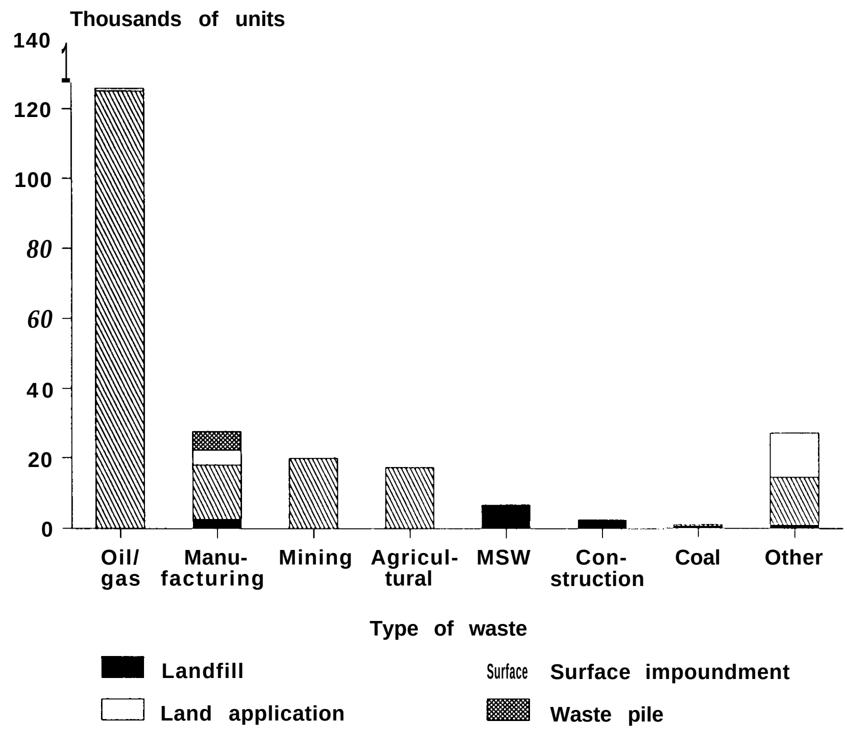
[32] 54 Federal Register, Feb. 6, 1989.

[33] EPA estimated that about 8.25 million tons of ash is produced annually, about half of which is water (S. Levy, U.S. EPA, Municipal Waste Combustion Inventory, Sept. 4, 1991). This is based on the design capacity for operating municipal combustion facilities and on the assumptions that 25 percent of municipal solid waste by weight is ash and the moisture content is 50 percent.

[34] Hazardous waste regulations in some States (e.g., Wisconsin) are more stringent than Federal regulations and apply to CESQGs.

[35] A surface impoundment is a depression in the earth or a diked area that contains liquid wastes for treatment, storage, or disposal. A landfill is an excavated area in the earth where wastes are permanently disposed. A waste pile is amass of waste generally placed on the ground for storage or treatment. A land application unit is an area of land where wastewater or sludge is placed on or mixed in the soil for disposal and sometimes treatment.

Figure 1-3-Estimated Number of Active Subtitle D Waste Management Units, 1985



NOTE: Construction = Construction and demolition debris. Manufacturing includes only on-site facilities. Mining does not include waste piles or land application units, which EPA did not survey. Mining also does not include impoundments from 8 States (California, Kentucky, Missouri, Minnesota, New York, Utah, Vermont, Wyoming). Oil and gas does not include impoundments from 11 States (the 8 listed for mining, plus Indiana, Montana, and Rhode Island). In addition, each oil and gas oil well also may have (at least temporarily) an associated surface impoundment (i.e., reserve pit), which would bring the number of oil and gas impoundments to over 800,000.

SOURCES: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Screening Survey of Industrial Subtitle D Establishments," unpublished draft final report (Washington, DC: December 1987); *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy,* EPA/530-SW-88-003 (December 1987); U.S. Environmental Protection Agency, *Report to Congress: Wastes From the Combustion of Coal by Electric Utility Power Plants,* EPA/530-SW-88-002 (February 1988); *Report to Congress: Solid Waste Disposal in the United States,* vols. 1-2, EPA/530-SW-88-011 (October 1988).

niques varied among waste types, the great majority of wastes by quantity were managed in on-site surface impoundments.

EPA (114) also compiled data on pollution controls and monitoring at Subtitle D units in the mid- 1980s. Although many changes have occurred since then, no nationwide compilation of current conditions exists (with the exception of a recent survey on liners, discussed below). Nor do the EPA data reflect site- or waste-specific conditions for which controls might not be needed. Nevertheless, they still are useful in indicating that the frequency of such controls varied greatly among waste management facilities, depending on the industry, waste type, and State requirements and enforcement.[36] Overall, 2 percent of the units contained a synthetic liner, 27 percent had a natural clay or dirt liner of unknown quality, and 1 percent had a leak detection system. Surface impoundments, which handled perhaps 70 percent of all Subtitle D wastes at some point, were frequently unlined and unmonitored (table l-l). Among all Subtitle D surface impoundments, 29 percent had synthetic or natural liners and 27 percent had some groundwater monitoring (119).

[36] In general, on-site facilities tend to receive less oversight from regulatory agencies than off-site commercial facilities. Any Subtitle D land-based unit located in a facility with a Subtitle C permit, however, is subject to RCRA corrective action requirements as a permit condition.

Table l-l—Number of Subtitle D Surface Impoundments Using Various Release Prevention Methods, 1985

Management method	Type of waste: Manufacturing	Mining	Oil or gas
Synthetic liner s.	756 (5%)	200 (l%)	2,950 (2%)
Natural liners	2,818 (17%)	868 (4%)	33,768 (27%)
Leak detection systems	896 (6%)	335 (2%)	1,406 (l%)
Groundwater monitoring	1,396 (9%)	5,399 (27%)	165 (<l%)
Surface water monitoring	3,151 (19%)	8,679 (44%)	20,030 (16%)
Air emissions monitoring	(<1%	(<l%	(<1%
Overtopping controls	3,672 (23%)	4,144 (21%)	28,541 (23%)
Bans on certain Subtitle D wastes	2,685 (17%)	4,358 (22%)	30,509 (24%)
Discharge permits	4,738 (29%)	4,970 (26%)	46,491 (37%)
Number of impoundments[a]	16,232	19,813	125,074

NOTE: These data indicate the status of pollution controls during the mid-1 980s. They do not indicate the current status of such pollution controls, nor the recent development of additional State requirements. They also do not indicate whether variation in site-specific conditions and potential risks might or might not warrant such controls.

[a]Percentages may total more than 100 because some establishments used more than one management method.

SOURCE: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: Solid Waste Disposal in the United States,* vols. 1-2, EPA630-SW-88-011 (Washington, DC: October 1988).

Table 1-1 indicates the variation in use of these controls among the manufacturing, mining, and oil and gas industries.

Clearly, updated information on the frequency of pollution controls and monitoring, and on their relationship to site- and waste-specific conditions, is needed. One recent survey examined State requirements for liners at Subtitle D industrial waste landfills (33).[37] The survey found that fewer States require liners at these landfills than at municipal solid waste landfills. Thirty States required some form of liner, 12 did not require any liner, and 8 assessed the need for liners on a case-by-case basis (figure 1-4). The survey did not determine the extent of compliance with these requirements.

Environmental and Human Health Risks

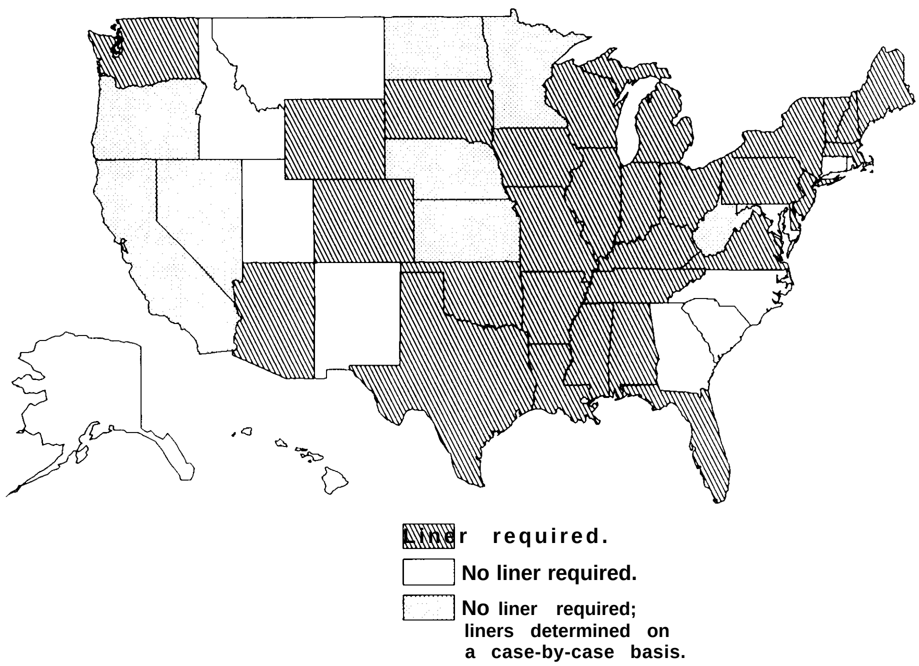
Potential environmental and human health risks associated with different Subtitle D wastes may be significant for several reasons-e.g., relatively few controls at Subtitle D waste management facilities, the broad range of toxic constituents in these wastes, and the large volumes involved. EPA admits that the size and diversity of the Subtitle D universe, the relative lack of information on facility controls and waste characteristics, and violations of State standards at facilities are of concern (1 19).[38] The presence of old waste management sites, some of which would be considered Subtitle D facilities, on the National Priorities List (NPL) indicates the ineffectiveness of some past management practices; however, hazardous wastes may have been disposed of at some Subtitle D units, making it difficult to evaluate the contribution of Subtitle D wastes to these sites' problems.

Current management techniques for some Subtitle D wastes are less protective than those for hazardous wastes, which may be warranted in some or even many circumstances. Yet some Subtitle D wastes do not differ notably from those currently regulated as hazardous under Subtitle C, or they may exhibit other characteristics that are of concern. For example, manufacturing wastes could contain toxic constituents at levels just below those regulated as hazardous that nevertheless may be harmful in some way; they might contain constituents at levels known by EPA to be toxic, in wastes that EPA has not yet listed or for which the TC is inapplicable (e.g., pesticide manufacturing waste); they could contain constituents at levels above those regulated as hazardous but be exempt from Subtitle C regulation by statute or rule; or they might contain

[37]The survey data do not distinguish between landfills that accept o@ manufacturing wastes and those that accept a broader range of Subtitle D solid wastes.

[38]Sec. 8002 under Subtitle D authorized EPA to study, for the required reports to Congress, potential dangers from disposal and reuse Of the special wastes. The authority, however, does not extend beyond the mandate for already-delivered reports. Even so, Sec. 3007 under Subtitle C allows the Agency to collect data on hazardous wastes, and EPA's broad interpretation that this applies to suspected or potential hazardous wastes has been supported by the courts (*National Standard* Co. v. *Adamkus*, 881 F.2d 352 (7th Cir. 19.39)), although it has not been tested in the courts for Subtitle D wastes generally. Regardless, EPA routinely conducts risk assessments in support of its rulemakings and has been trying to at least qualitatively rank human health and environmental risks (129).

Figure 1-4-States With Regulations Requiring Liners for Subtitle D Landfills, as of 1990



NOTE: Excludes municipal solid waste landfills; also excludes ash from coal and municipal solid waste combustion and residues from cement kilns. Does not reflect whether variation in site-specific conditions and potential risks might or might not warrant liners.

SOURCE: W. Gruber and G. Rigatuso, "Landfill Liner Requirements, A State-by-State Summary of Subtitle D Criteria," *El Digest,* February 1991, pp. 12-19.

chemicals such as sodium that are not considered hazardous but can affect groundwater quality if disposed of improperly (83). Some mining wastes also may exhibit high acid generation rates or high levels of cyanide; some oil and gas wastes may contain high levels of benzene, be highly saline, or exhibit some radioactivity. However, because Subtitle C regulations are designed to be protective when concentrations of toxic constituents are much higher than the regulatory thresholds, industry representatives argue that some wastes with concentrations just above threshold levels might still be overregulated.[39]

Of course, actual risks from Subtitle D wastes depend on numerous waste- and site-specific factors —the constituents in, and the physical form of, the waste; how it is managed; the design and monitoring controls at management facilities; the occurrence of leaks or emissions; hydrogeologic and topographic features; precipitation; exposure pathways, etc. Relatively little information is available on a national scale regarding risks associated with manufacturing wastes, although some States have gathered information about such risks. In contrast, EPA has evaluated, to some extent (in its reports to Congress), risks from the management of wastes from the mining, oil and gas, and coal combustion utility industries. In these reports, EPA has tended to focus on risks to human health from existing waste management facilities; some risks (e.g., due to releases from unlined surface impoundments or mismanagement of tank bottoms) often have not been assessed. Potential future risks posed by the construction of new facilities in other locations or by new suburban or recreational developments near existing facilities are rarely discussed, although it

[39] E. Males, Chemical Manufacturers Association, review comments, Aug. 7, 1991.

would be difficult to make such projections without a wide error range.[40]

Regulatory Status

Congress did not require that a cradle-to-grave regulatory system be developed for Subtitle D wastes. Instead, it focused on issues such as establishing criteria for Subtitle D land-based disposal facilities, closing open dumps, and developing a State solid waste management planning process. Its intent was to retain State primacy in regulating these wastes while ensuring that an adequate overall structure existed for such regulation.

In 1979, EPA promulgated Federal Subtitle D criteria (40 CFR 257) for all facilities handling Subtitle D wastes—including landfills, surface impoundments, land application units, and waste piles. Any facilities not meeting these criteria were defined as open dumps and required to close. The criteria established minimum national performance standards that addressed floodplains, endangered species, surface water, groundwater, land application, air emissions, and occupational safety.

The criteria were generally considered incomplete (e.g., see ref. 95). For example, although they prohibited contamination of groundwater used for drinking water, they did not require monitoring or specify corrective action requirements should contamination occur. Nor did they address closure of facilities, postclosure care, financial responsibility, or appropriate engineering controls to minimize contamination.

HSWA required EPA to revise the Subtitle D criteria for facilities that may receive household hazardous waste or small quantity generator hazardous waste, especially by taking into account potential effects on groundwater. In response, EPA recently issued revised criteria for municipal solid waste landfills.[41] The revisions address location restrictions; design criteria based on performance goals; operating criteria; groundwater monitoring and corrective action requirements; financial assurance requirements for closure, postclosure care, and known releases; and closure and postclosure care standards based on performance goals.[42]

The revision focuses on MSW landfills, even though only a small fraction of the Subtitle D universe consists of municipal solid waste (figure 1-2) and landfills are used to manage only a small fraction of the Subtitle D universe (figure 1-3). However, MSW landfills are the facilities most likely to receive hazardous wastes from households or small quantity generators (119).[43]

RCRA (Sec. 4002(b)) also required EPA to promulgate minimum guidelines to assist States in the development and implementation of solid waste management plans; the guidelines were promulgated in 1979.[44] To receive EPA approval, State plans were to address resource conservation and the collection and subsequent management of solid wastes, including hazardous and Subtitle D wastes. Through 1981, 25 States had EPA-approved solid waste management plans. In that year, the Federal Government ceased routine finding for the development of State plans; however, many States have continued to update and implement plans on their own.

As noted earlier, the 1980 Bevill-Bentsen amendments exempted "special" wastes from regulation as hazardous, pending study and regulatory determination by EPA. Thus far, EPA has determined that mining extraction and beneficiation wastes, certain mineral processing wastes, and oil and gas exploration and production wastes should not be regulated under Subtitle C (chs. 2 and 4). EPA expects these wastes to be controlled by a combination of new programs under Subtitle D, existing programs under the Clean Water Act and other Federal statutes, improved State regulatory programs, and possibly

[40] Nevertheless, considering this factor may be particularly important in rapidly growing States such as Florida, where considerable mining activities take place (J. Reese, State of Florida, review comments, February 1991).

[41] 56 *Federal Register* 50978, Oct. 9, 1991.

[42] The regulations as first proposed included a notification requirement for all industrial Subtitle D solid waste facilities and construction/demolition landfills, so that EPA could obtain information on their location, design, and environmental impacts. According to the preamble to the final rule, a notification requirement is no longer anticipated. Instead, EPA is exploring alternative information-gathering strategies, including a statistical survey or series of surveys to obtain detailed information that will enable the Agency to better assess potential risks and the need for developing any future industrial solid waste guidelines.

[43] EPA's 1987 screening survey (116) estimated that only 5 percent of all industrial solid waste managers managed CESQG waste in their on-site, land-based units.

[44] 44 Federal Register 45709, July 31, 1979.

some new Federal statutory authorities.[45] It has not yet proposed Subtitle D regulations for these wastes, although it has drafted approaches for mining extraction and beneficiation wastes.

EPA has not made a regulatory determination for coal combustion utility wastes, and it is not statutorily required to do so for manufacturing wastes. However, its 1988 Report to Congress recommended that high-volume coal combustion wastes (i.e., ash, bottom slag, flue gas desulfurization sludge) be regulated under Subtitle D and that low-volume wastes be studied further to determine if regulation under Subtitle C is warranted (118). Cement kiln dust, also temporarily exempted in 1980, has been the subject of some rulemakings (see box 5-A inch. 5).

How these special wastes should be regulated continues to be disputed. Many industry representatives are concerned about overregulation, even under Subtitle D. Many environmental groups believe that some of the wastes should be regulated under Subtitle C and doubt that the combination of Subtitle D, existing State, and other Federal programs will be sufficient. All are concerned about the availability of EPA resources to develop and implement Subtitle D regulations in a timely manner.

GENERAL RCRA ISSUES

For hazardous wastes, Congress long ago established the now-familiar goals of reducing risks to the public and the environment by minimizing generation of these wastes and safely managing (particularly by recycling and treatment, as opposed to land-based disposal) any that are generated. Most people consider these to be prudent policies from the long-term perspectives of protecting human health and the environment and reducing future liabilities from environmental damages. During the late 1970s and the 1980s, EPA developed and implemented an extensive regulatory program under Subtitle C for hazardous wastes.

EPA's progress in establishing a Federal Subtitle D regulatory program has been highly variable, depending on the waste type. The Agency recently revised its municipal solid waste landfill criteria and, during the last few years, has made regulatory determinations on the classification of most mining wastes and oil and gas wastes. However, it has not issued regulations or guidelines for a Subtitle D program for mining or oil and gas wastes. In addition, EPA has not made regulatory determinations for other special wastes (coal combustion ash, cement kiln dust), nor has it made significant progress in evaluating manufacturing wastes. Reasons for this include the magnitude of resources required to implement Subtitle C and the general lack of resources for work on Subtitle D wastes.

Thus, improving the management of Subtitle D wastes, including those covered under the Bevill and Bentsen amendments, poses many challenges for Congress and for EPA. One challenge facing EPA is how to devise a sufficiently stringent program(s) to attain the goals mentioned above without harming the economic viability of the regulated industries and facilities. This dilemma is reflected, for example, in EPA's recent decision to consider regulating mining wastes from phosphoric acid production under the Toxic Substances Control Act (TSCA), rather than under RCRA (ch. 2). To what extent should additional Federal regulation of Subtitle D wastes consider the impacts of such regulation on commodity production (e.g., domestic oil and gas, phosphate-based fertilizer), access to domestic reserves, domestic employment, balance of trade, and national security?

Another issue concerns the relationships among different Federal agencies and between the Federal Government and the States in regulating Subtitle D wastes. States already bear the primary responsibility for managing these wastes, and many have developed regulatory programs for specific Subtitle D waste categories. These and similar questions are even more germane given the relatively limited resources available to EPA to implement existing environmental protection programs or develop new ones.

Other challenges abound. Any discussion of Subtitle D wastes, for example, inevitably raises the questions of how wastes are identified as hazardous and whether the arbitrary division between Subtitles C and D is conducive to effectively reducing risks associated with solid waste management.

Issues specific to the mining, manufacturing, oil and gas, and coal combustion industries are discussed in chapters 2 through 5. This section is

[45] For example, *see* 53 *Federal Register* 25446, July 6, 1988.

concerned with issues that cut across these categories to the heart of the Subtitle C and D systems.

Issues Regarding RCRA's Design and Structure

Separate or Uniform Regulation of Wastes Under Subtitle D?

Federal (and most State) programs are generally on separate regulatory tracks for manufacturing, mining, and oil and gas wastes; some States have separate tracks for coal combustion wastes, whereas others include them in their manufacturing waste regulatory programs. The status of Federal regulatory determinations and programs for these different industries varies greatly: the most advanced is for mining wastes; the least advanced, for manufacturing wastes. One issue, then, is whether EPA should attempt to develop a single program that encompasses all Subtitle D wastes, with regulations tailored to specific waste types where appropriate, or continue with the current approach of separate regulatory tracks but—perhaps-simultaneously study the feasibility and appropriateness of consolidating the different Subtitle D programs into a single program at some time in the future.

Representatives of various industries, as well as some State and Federal officials, generally believe that focusing separately on each industry is the best approach—because of differences in waste types and characteristics, environmental hazards, site conditions, production processes, management techniques, and economics, and because regulatory and industrial personnel are often most knowledgeable about a single industry. Industry representatives also contend that industry -specific standards would enable better coordination between existing programs and statutes at the State and Federal levels. In contrast, environmental groups and some other government officials believe that largely consistent regulation of the different industries is preferable because:

1. it would facilitate similar reductions in health and environmental risks across all industries;
2. only a relatively limited number of overall technologies exist to manage waste anyway; and
3. developing several separate programs will be time-consuming and resource-intensive.

In addition, they believe that a tailored approach, where needed, can be accomplished within an otherwise generally applicable framework.

Federal and State Roles in Managing Subtitle D Wastes

Several factors influence one's view of State and Federal roles in regulating Subtitle D wastes. For example, how can a Federal program of any scope provide sufficient authority to EPA and direction to the States, without hindering existing State efforts that are proving effective? How can a need for minimum or ''baseline' national controls and programs be balanced against a need for flexibility to address the diverse situations found among or within States (e.g., climate, hydrogeology, regulatory resources) and industries (e.g., type and size, nature of wastes)?

States are already responsible for developing and implementing most of the existing regulatory framework for Subtitle D wastes, and EPA believes that States should, in general, have the lead on all programs under Subtitle D. At the same time, EPA is moving toward issuance of minimum Federal guidelines for State programs pertaining to certain wastes, particularly mining wastes, while trying to avoid superseding adequately designed and operated State programs.

Not surprisingly, the States and regulated industries tend to disagree strongly with environmental groups about the nature and scope of an expanded Federal program. The former argue that State-level programs can adopt regulations appropriate to the nature and types of waste practices and environmental conditions in a given jurisdiction. This inevitably means great variation among States in regulatory requirements, resource allocations, and enforcement efforts, which is not necessarily bad because diverse wastes disposed of under different conditions might require distinct controls. However, environmental groups argue that a more stringent Federal program is needed to ensure some degree of consistency in State programs (including performance standards and enforcement), as well as to

[46] EPA can already instigate enforcement actions under the substantial threat and imminent hazard provisions of RCRA (Sec. 7003), the Comprehensive Environmental Response, Compensation, and Liability Act (Sees. 104 and 106), and TSCA Sec. 7. However, this requires demonstration on a case-by-case basis, of a Federal cause for action and usually involves much litigation.

sufficiently regulate large companies that may have undue influence in some States.[46]

One problem is that, although significant legislative and regulatory activity on solid wastes has clearly occurred at the State level during the last 5 years, little comprehensive, up-to-date information exists about these developments. An expedited data collection effort on the extent and effectiveness of State programs—for all sectors, but particularly for manufacturing-could help Congress and EPA in their legislative and regulatory efforts, provided that adequate resources are available to collect and analyze the data.

If Congress decides to expand EPA's role in managing Subtitle D wastes, several issues concerning EPA's authority to carry out such a role may need clarification, including the following:

- Should EPA be given the authority to regulate production processes (e.g, heap and dump leaching in the mining industry) or treatment and storage facilities (e.g., reserve pits in the oil and gas industry) under Subtitle D, in addition to its existing authority to regulate disposal processes? Should it instead rely on TSCA and other statutes, or on existing closure regulations?
- Should EPA enforce Subtitle D programs if a State either does not do so or requests assistance in its own enforcement efforts?
- Should EPA receive more authority, in the absence of known or suspected hum-an health effects, to focus on environmental risks (e.g., bird and fish kills) and to regulate activities contributing to these effects? Or are programs of the U.S. Fish and Wildlife Service and other Federal or State agencies sufficient?

Another question is whether interim requirements are needed; precedent for such requirements at the Federal level exists in Subtitle C. Given the diversity of situations that could be regulated and the relative lack of Federal or State resources to finalize and implement programs, some wastes or practices that should be regulated may nevertheless remain unregulated for lengthy periods. In theory, interim requirements could be developed to address specific wastes (e.g., from manufacturing) or practices (e.g., groundwater monitoring, closure of surface impoundments), or they could be applied generally with exemptions as needed. Chapter 5 describes an ongoing effort to develop a consensus on interim requirements for manufacturing wastes, requirements that would be as self-implementing as possible. EPA is participating in this effort, although the Agency believes that it lacks sufficient data and resources to support the development of interim requirements for manufacturing wastes.

Finally, another factor to be considered is the situation in which two or more Federal agencies, as well as their State counterparts, have overlapping jurisdiction over an industry's waste management practices. This is most relevant for the mining and the oil and gas industries, particularly on Federal lands. Activities there may be overseen or affected by, for example, the Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, and EPA, as well as by several agencies within a given State. The relationships among Federal agencies are often poorly defined, as is the authority of State agencies to intervene on Federal lands (see chs. 2 and 4). A related issue is whether facilities owned or operated by Federal agencies should be subject to EPA enforcement actions and State-levied fines for noncompliance with RCRA corrective action requirements.[47]

Pollution Prevention and Recycling Under RCRA

RCRA's stated goal is to encourage the prevention of waste generation and the recycling or recovery of waste materials when possible. The Nation's experience with hazardous waste indicates that incentives to reduce waste generation and increase materials recovery have grown as the liabilities and direct costs of waste disposal and as right-to-know reporting under the Emergency Planning and Community Right-to-Know Act of 1986[48] have increased. To date, however, EPA has not strongly promoted prevention and recycling of Subtitle D wastes, which may reflect the general lack of resources and lower priorities given over the years to Subtitle D compared to Subtitle C wastes. In addition, EPA is unable under RCRA (see above) to regulate production processes in terms of their later

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[47] Legislation proposed in both the 101st and 102d Congresses would make Federal facilities subject to such compliance actions. Impetus fOr the legislation stems largely from hazardous waste conlamination problems at Department of Energy nuclear weapons production sites and Department of Defense facilities.

[48] This act was part of the Superfund Amendments and Reauthorization Act of 1986.

impacts on risks associated with the management of Subtitle D wastes (although EPA can regulate production processes under TSCA).

The success of pollution prevention efforts for Subtitle D wastes—at the Federal, State, and private sector levels—thus is likely to depend largely on the extent to which such efforts are accorded high priority and adequate resources. Many reports (e.g., 18, 38, 59, 86) suggest enhancing overall pollution prevention efforts, for example, by:

- increasing technical and financial assistance to businesses and States;
- increasing the use of market-based incentives (e.g., emissions taxes or trading systems) to encourage innovative technologies and practices, as well as to fund State and Federal pollution prevention programs;
- removing existing regulatory disincentives to prevention and recycling (e.g., overlapping and conflicting requirements under different statutes for pollution controls and compliance; see ref. 11); and
- increasing public disclosure of emissions.

In 1990, Congress enacted the Pollution Prevention Act,[49] requiring EPA to develop and implement a strategy to promote source reduction. This strategy is to include, among other requirements, development of a clearinghouse on managerial, technical, and operational approaches to source reduction; a program providing matching grants to States; and a data reporting provision covering the reduction and recycling of all toxic chemicals included in the Toxics Release Inventory (TRI) (which was established under Sec. 313 of the 1986 Superfund Amendments and Reauthorization Act). Significantly, the TRI and the reduction and recycling reports apply to many chemicals in both the Subtitle C and the Subtitle D universes.

EPA recently issued a pollution prevention strategy that has the stated goals of eliminating regulatory barriers to cost-effective investments in prevention efforts, encouraging voluntary actions by industry, and targeting up to 20 high-risk chemicals as an initial focus for these efforts (130). As part of this strategy, EPA intends to establish regulatory "clusters" (i.e., of different Agency offices with relevant jurisdiction) for certain chemicals and their sources to foster improved cross-media evaluation and earlier investment in pollution prevention technologies. It also intends to include pollution prevention conditions in enforcement settlements and to provide financial assistance to the States for multimedia pollution prevention programs.

No consensus exists about how to regulate or encourage the recycling of industrial residues and byproducts that are considered hazardous (see box 5-B and ch. 2). Some industry representatives argue that existing burdensome regulations, primarily under Subtitle C, discourage the recycling of these materials, and they are concerned about regulatory intrusions into production processes. EPA, too, is concerned about the technological, economic, and administrative feasibility of regulating recycling facilities under Subtitle C. However, EPA and many environmental groups also are concerned about "sham recycling" companies that claim to be recycling and thereby circumvent regulation under Subtitle C as hazardous waste treatment facilities. The situation is even more complex because considerable variation exists in the potential risks associated with different recycling activities. Suggestions about how to regulate recycling exhibit a wide range, from continuing to rely on existing programs under Subtitle C and other statutes to control solid wastes and water or air emissions from recycling facilities, to regulating the facilities themselves under Subtitle C, to setting tailored standards for recycling under Subtitle D or a new subtitle (e.g., more stringent standards for materials and processes with greater risks).

From C and D Toward a New System?

The present system of identifying hazardous wastes relies on two approaches: whether a waste exhibits certain characteristics or is specifically listed as hazardous. As discussed above (see "The Subtitle C Universe"), these approaches may exclude some wastes that should be regulated as hazardous and may overregulate others. Moreover, the gulf between Subtitles C and D in the stringency of regulatory requirements and subsequent management costs is enormous, even for wastes that differ only slightly in toxicity or some other measure of risk. These factors tend to focus the debate about

[49] As a part of the Omnibus Budget Reconciliation Act of 1990, Conference Report to accompany H.R. 5835, Report 101-964, Oct. 26, 1990, Sec. 6601.

how to regulate solid wastes on two contrasting views:

1. Include more wastes under Subtitle C, either by expanding the scope, or number of characteristics or listings; and/or by determiningg that some Bevill-Bentsen wastes are no longer exempt from Subtitle C.
2. Strengthen Federal and State Subtitle D programs, to avoid including more wastes in Subtitle C and/or to allow more flexibility in regulating relatively less hazardous wastes.

Subtitle D thus cannot be considered in isolation from the broader issue of whether we should continue to develop this system or should begin moving toward a different type of system. With this in mind, box 1-A describes two alternatives—"concentration-based' and "continuum of control" (or "tailored management standards") approaches—for regulating solid wastes. Admittedly, developing and implementing alternative approaches such as these could require major rethinking and restructuring of current regulatory programs. Not least, defining what types of risks should be evaluated, determining relative levels of risk, and fitting or tailoring regulations to those risks will be difficult and time-consuming.[50] In addition, how various social, economic, and political factors should be considered in any new regulatory or management scheme must also be addressed.

Any such system is thus likely to have important consequences for priority setting, resource allocation, data collection, regulatory development, and research. Currently, at both the State and the Federal levels, such activities are affected by the need to meet the most immediate statutory requirements, which may not always result in long-term improvements in managing Subtitle D wastes. For example, data gathering may focus on immediate requirements to characterize a particular waste, which is important but could mean that insufficient resources are available to investigate pollution prevention opportunities, current management practices, or potential risks associated with these practices.

Gaps and Inconsistencies Among Federal Statutes

Many Federal statutes besides RCRA affect the management of "solid" wastes generated by the industrial sectors of concern in this paper. These statutes include, for example, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Clean Water Act (CWA); Safe Drinking Water Act (SDWA); Clean Air Act; Toxic Substances Control Act; Surface Mining Control and Reclamation Act; and Federal Land Policy and Management Act. The States have primary responsibility for implementing some of these; the issue of Federal and State relationships has been discussed above.[51] However, not all aspects of managing Subtitle D wastes are necessarily covered by Federal statutes, regardless of who has primary implementation responsibility.

In some cases this can result in varying (and often unknown) levels of overall risk reduction, even for similar wastes or management practices. Examples of such "gaps" include (but are not necessarily limited to) the following:

- SDWA regulates the underground injection of produced water from oil and gas operations and of process water from mining, but neither it nor RCRA regulates ponds used for storing such water prior to injection.
- CWA generally regulates effluent discharges to surface waters, but no effluent limitations guidelines have been promulgated for oil stripper wells.[52]
- Few Federal (and apparently few State) regulations cover inactive and abandoned non-coal mining sites,[53] inactive and abandoned oil and gas pits, or inactive and abandoned waste sites containing naturally occurring radioactive material (NORM).

[50] EPA's ongoing effort to assess relative human health and environmental risks associated with different polluting activities (e.g., ref. 129) may shed light on some of these risk-related issues.

[51] State statutes and regulations generally are free t. be more stringent than Federal programs. In practice, the Underground Injection Control program under SDWA and the National Pollution Discharge Elimination System (NPDES) under CWA, which are either delegated to the States by EPA or run by EPA in nonauthorized States, tend to be very similar across States.

[52] However, permits breed on best professional judgment (seech. 4) can still be written for stripper wells.

[53] However, EPA's requirements for applying for stem water discharge permits (55 *Federal* Register 47990, Nov. 16, 1990) include inactive and abandoned mines; they also classify nonpoint source storm water discharges as point sources subject to NPDES regulations.

Box 1-A-Concentration-on-Based and Continuum of Control Approaches

In contrast to HSWA (which was passed in 1984), legislation proposed in the 101st Congress to reauthorize RCRA (i.e., H.R. 3735) did not require additional listing determinations. However, it did include two attempts to expand the Subtitle C universe: 1) explicit specification of additional characteristics (rather than authorizing EPA to determine them) for identifying hazardous waste,[1] and 2) a "concentration-based" approach.[2] The text of this chapter briefly discusses the issue of identifying these additional characteristics. This box discusses the concentration-based approach and a third approach known as "continuum of control" (EPA now uses the term "tailored management standards" for the latter). The overall potential for any of these approaches to move us toward RCRA's goals of waste minimization and resource conservation is unstudied.

Concentration-Based Approach

In a concentration-based approach, EPA would set threshold concentrations in wastestreams for each of the almost 400 "Appendix VIII" constituents that it can use in determining whether to list a wastestream as hazardous.[3] A threshold could be based on either a constituent's total concentration in a waste or its concentration in leachate derived from the waste, which is the current Toxicity Characteristic approach. Several exposure pathways, not just groundwater, could be included. Any waste with an Appendix VIII constituent above the level specified could be considered hazardous.

RCRA uses a concentration-based approach in a few instances! For example, two Appendix VIII constituents (warfarin and zinc phosphide) are designated as "P" wastes when present above specified concentrations and as "U" wastes when below. According to one report, EPA also used total concentration as a factor in listing some wastes, for example, the presence of heavy metals in wastewater treatment sludge from electroplating operations (ref. 29, citing an unpublished EPA background document for electroplating wastes). Furthermore, EPA is considering establishing de *minimis* levels of hazardous constituents in treated, listed hazardous waste-a process that would employ a related concentration-based approach.[5]

Proponents of the concentration-based approach cite EPA's slow progress in meeting HSWA's deadlines to list more wastestreams and specify additional characteristics (see "The Subtitle C Universe" above). They contend that this approach would do a better job than the listing system in relating the stringency of management requirements to a waste's hazard. Some suggest that the use of total concentration would acknowledge additional

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[1] Specified characteristics in the legislation included acute toxicity, persistence, bioaccumulation, aquatic toxicity, radioactivity, carcinogenicity, mutagenicity, and phytotoxicity.

[2] The provisions detailing this approach were dropped from H.R. 3735 (which itself was not passed) during the markup process in the 101st Congress.

[3] These constituents are listed in 40 CFR 261, App. VIII, hence the name.

[4] Several States have similar, although generally more limited, approaches. Rhode Island uses a threshold level of 0.1 percent by weight for known carcinogens (as identified by EFA, the Occupational Safety and Health Administration (OSHA), the Food and Drug Administration, or the Consumer Product Safety Commission) or teratogens (as identified by OSHA) (Rhode Island Department of Environmental Management, Rule 3.53 (L)(l)(2), amended Oct. 20, 1988). California uses a threshold limit of 0.001 percent for any of 16 carcinogens listed by OSHA (California Administrative Code Title 22, R. 666%(a)(5)). Oregon uses a level of 10 or 3 percent for any chemical on EPA's U and P lists, respectively (Oregon Administrative Code 340-101-033(2)(a), (2)(b)). The State of Washington uses a level of 1 percent for known or suspected carcinogens recognized by the National Institute of Occupational Safety and Health or the International Agency for Research on Cancer (Wash. Admin. Code R. 173-303-103, 1983). Pennsylvania is considering using both total concentration and leachate concentration to evaluate wastes in its proposed residual waste regulations (*Pennsylvania Bulletin*, vol. 20, No. 8, Feb. 24, 1990).

[5] During the TC rulemaking process, commentators contended that although wastes with very low (de *minimis*) concentrations of hazardous constituents can be excluded via delisting from regulation as hazardous, the delisting process is expensive, time-consuming, and sometimes impractical (55 *Federal Register* 11831, Mar. 29, 1990). Thus, in 1989, the Chemical Manufacturers Association (13) petitioned EPA to establish self-implementing *de minimis* exemption levels for hazardous constituents in listed hazardous wastes. The CMA proposed that EPA make such determinations for constituents on both the App. VIII and IX lists—i.e., those App. VIII constituents for which an analytical method exists to detect the constituent in groundwater (the CMA also suggested extending the TC to all App. VIII constituents as one way to provide more control and eventually replace the listing and delisting programs (E. Males, review comments, Apr. 30, 1991)). In such an approach, listed wastes that meet the exemption levels would not be considered hazardous and could be managed as non-hazardous wastes unless they exhibited a hazardous characteristic. The CMA suggested this would reduce overregulation of dilute wastes while still maintaining Subtitle C regulation of wastes containing constituents above *de minimis* levels. EPA recognized that some inequities of this type do occur but also maintained that its rules are appropriate for dealing with waste mixtures and treatment residues (55 *Federal Register* 11831, *Mar. 29, 1990).* Nevertheless, EPA stated that it would consider amending the definition of hazardous waste to establish self-implementing *de minimis* exemption levels for hazardous constituents found in listed wastes. However, EPA has not yet done so; i.e., it has not yet responded to the CMA's & *minimis* petition (A. Collins, U.S. EPA, personal communication Oct. 3, 1991).

possible exposure pathways such as volatilization, inhalation, ingestion, and food chain contamination. They also suggest expanding the Appendix VIII list to include additional constituents (e.g., active ingredients in pesticides).

Opponents contend that this approach would result in overregulation because it does not account for the probability that potentially hazardous constituents might be released and, if so, whether they would be mobilized and reach a point of exposure.[6] For example, some constituents can be in chemical or physical forms that restrict mobility or exposure (e.g., insoluble metal complexes, constituents encased in glassified slag). Opponents also contend that: 1) the approach would require great resource expenditures by waste generators because each wastestream would require testing; 2) the Appendix VIII list contains some constituents that it should not; and 3) EPA would find it difficult to set the required threshold levels within the proposed 18-month timeframe (and that using a default value in such cases would be arbitrary).[7] Setting threshold levels would depend on health-based standards, which are lacking for many constituents, and on the availability of analytical methods for testing wastes.[8]

Neither the listing/characteristic nor the concentration-based approaches really solve the problem of distinguishing between a low-volume waste with a constituent just over a threshold value and a high-volume waste with a constituent just below the threshold. For example, lead has a threshold level of 5.0 milligrams per liter (mg/L) of soluble lead in the TC extract. A large amount of waste containing 4.8 mg/L in the TC extract would be classified as non-hazardous, whereas a small amount containing 5.1 mg/L would be classified as hazardous.

Continuum of Control Approach

An alternative strategy to bridge the gulf between Subtitles C and D might be to consider that the universe of solid wastes exhibits a spectrum of risks and that management requirements should be related to case-specific risk levels. EPA has examined at least one such alternative, known as "continuum of control" or "tailored management standards" (115).

A continuum of control approach recognizes that solid wastes exhibit a continuum of risks based on case-and site-specific factors such as: 1) constituents in the wastes (and their physical and chemical characteristics); 2) subsequent toxicity and mobility of wastes and constituents of concern; 3) exposure pathways; and 4) unique management needs (e.g., waste volumes, certain technologies, economics) that may require special management standards. It might encourage use of those management practices best suited to a given situation or waste, with the overall goal of regulating wastes at a relatively similar risk level (1 15).

This is consistent with suggestions elsewhere that wastes be managed on the basis of their physical and chemical characteristics and that consideration be given to multimedia issues (58, 95). EPA suggested that such an approach would improve its ability to write permits based on potential hazards of specific facilities, to set waste minimization goals, to monitor progress accordingly, and to better minimize risks in more economically efficient ways (115). Concerns about the concept, particularly in comparison with the current system, include its complexity and resource-intensiveness; its equal or greater dependence on testing; the need for many design and performance standards; and, possibly, greater difficulty in enforcement.

[6] Utility Solid Waste Activities Group, review comments, Aug. 23, 1991.

[7] The proposed legislation specified a default concentration of 0.1 percent for any one constituent if EPA did not promulgate threshold levels within 18 months; this level was intended in part to minimize overregulation of non-hazardous wastes.

[8] These problems are not necessarily insurmountable. As of August 1990, EPA had developed health-based standards and analytical methods for 204 App. VII and VIII compounds (App. VII, a subset of App. VIII, lists the constituents that caused the listing of a given wastestream) (S. Cochran, U.S. EPA, personal communication August 1990).

Moreover, Federal statutes other than RCRA define the terms "hazardous" and "toxic" differently, given their particular goals, the environments being addressed, etc. As a result, they regulate some substances as hazardous or toxic that would not be designated hazardous by RCRA: for example, PCBs are regulated by TSCA; asbestos is regulated by the Clean Air Act and the Asbestos Hazard Emergency Response Act; and wastewater discharges are regulated by CWA. CERCLA (or "Superfund") designates as a "hazardous substance" any substance so designated by one of the other Federal statutes. This means that a waste that was legally managed under Subtitle D could contribute to the creation of a

Superfund site if it is mismanaged.[54] The TRI also requires companies to submit information on releases of specified toxic chemicals, many of which are not listed as hazardous under RCRA (128).[55]

The definition and management of hazardous waste discharges under RCRA and CWA further illustrate the complexity of this issue. RCRA covers storage, treatment, or management of such wastes prior to discharge.[56] CWA regulates discharges to surface waters (ch. 5). This is not necessarily a problem, except that the two acts cover different constituents and regulate them differently. CWA focuses on 126 "priority pollutants" and uses technology-based standards, which often specify a required removal percentage for a particular pollutant. RCRA focuses on a much different list or on testing leachable concentrations of specified constituents. This means that different constituents may be regulated at different points in the processing of one wastestream.

For example, hazardous waste discharges are exempt from RCRA requirements (under the domestic sewage exclusion) if they are discharged into municipal sewers, where they mix with domestic sewage on its way to publicly owned treatment works (POTWs), which are regulated under CWA. Pretreatment regulations require dischargers to not@ the POTW of hazardous wastes entering the sewer, and POTWs can require monitoring and treatment of any constituents that might cause problems (see ch. 5). However, hazardous RCRA constituents may not be adequately addressed by POTWs unless they are covered by local "pretreatment" requirements (which must be developed and implemented by the POTW) (ch. 5; ref. 92). Thus, a constituent that is contained in waste considered hazardous under RCRA could damage a POTW or pass through it and be discharged to surface waters if appropriate local limits were not in place.[57] (Also see the following section regarding the development of pretreatment standards themselves.) In addition, sewage sludges from POTWs are subject to RCRA to the extent that a sludge fails the TC leaching procedure and therefore is considered a characteristic hazardous waste.

HSWA required EPA to close these gaps by August 1987. In response, EPA promulgated regulations in 1990 that prohibit discharges to POTWs of pollutants that result in toxic vapors, require at least annual inspection and sampling of effluents from each of a POTW's significant industrial users, and require industrial users to report hazardous waste discharges to POTWs.[58] However, some environmental groups believe that EPA should include more industries (e.g., the hazardous waste treatment industry, petroleum refineries, textile mills, paint manufacturers, commercial solvent reclaimers) in its schedule for promulgating pretreatment standards (1).[59] The new rule does not address potential air emissions from POTWs, although they may be addressed under the Clean Air Act.[60]

Another potential problem concerns asbestos, which is considered a hazardous substance under Superfund because it is a hazardous air pollutant under the Clean Air Act. Under the Asbestos Hazard Emergency Response Act, asbestos removed as a result of abatement efforts should be disposed of in accordance with existing waste management regula-

[54] Although this is technically correct, EPA believes that its current listing and characteristic approaches cover most of the worst substances; many of the organic chemicals now included in the TC, for example, were chosen because they were present at current Superfund sites and are measurable in leachate tests, and because toxicological data exist for them (U.S. EPA, review comments, Aug. 22, 1991). However, other compounds of potential concern were not included because data were lacking or they could not be measured in a leachate test (M. Williams, Browning-Ferris Industries, review comments, July 23, 1991). As noted above, environmental groups contend that the new TC is still inadequate. An additional issue, the merits and demerits of the Hazard Ranking System used to place sites on the NPL, is beyond the scope of this paper.

[55] Since the TRI includes emissions into air and water, this should not be surprising, On the other hand, the TRI would not necessarily contain data on postproduction releases related to production transportation and use.

[56] Unless tanks are used, which maybe regulated as CWA wastewater treatment units.

[57] For e-pie, the organic chemical industry discharged an estimated 2.5 times more nonpriority pollutants than priority pollutants to sewers in the mid-1980s (113).

[58] 55 *Federal Register* 30082, July 24, 1990. At the same time, HSWA's prohibitions on land disposal of hazardous waste could result in SOme wastes being redirected to POTWs, making implementation of these requirements even more important.

[59] J. Landman, Natural Resources Defense Council, personal communication, October 1990.

@55 *Federal Register* 30082, July 24, 1990. Sec. 183 of the Clean Air Act Amendments of 1990 requires EPA to issue control technology guidelines for 11 stationary source categories of hydrocarbon emissions; POTWs may be one of the categories. States can use the guidelines as the basis for source-specific regulations required by the act.

tions. Although RCRA does not list asbestos as hazardous or specify special management requirements for it, the Clean Air Act includes some requirements on the transportation of asbestos wastes and the operation of disposal sites that accept such wastes (40 CFR 61.140ff). The requirements for disposal sites do not contain any provisions regarding liners, leachate collection, or monitoring. Although managing asbestos in accordance with these requirements may not necessarily pose a risk to human health, the need for more tailored requirements cannot be ruled out.

These inconsistencies might undercut RCRA's ability to improve solid waste management, particularly if exempted or non-RCRA wastes and substances are not managed adequately under other statutes. Taken together with the issue of moving the solid waste regulatory system in a new direction (see "From C and D Toward a New System?" above), this suggests that RCRA's definitions of solid wastes may need reexamination, that greater emphasis should be placed on filling the gaps, or that Subtitle D programs may require great flexibility to complement (or integrate) existing authorities under other statutes without becoming overly burdensome. It also raises the question of whether EPA should include a "multimedia" approach in its Subtitle D regulatory programs (also see ch. 2). On the other hand, if such wastes or substances are properly managed under other statutes, additional RCRA controls may not be necessary.

Implementation of Federal Statutes

Problems can also arise because regulations to implement existing statutory requirements are not fully developed. For example, some POTWs may not treat discharges from industries adequately because "categorical" pretreatment standards under CWA are lacking for that industry or the POTW does not develop and enforce its own local pretreatment standards for specific industrial facilities, rather than because of problems noted above in RCRA and CWA per se. Relatively few pretreatment standards fully cover priority pollutants, and some industries discharging priority pollutants are not covered by any standards (92). Another example involving the Clean Water Act is that effluent guidelines based on the best available technology have not yet been promulgated for coastal discharges of oil and gas exploration and production wastes (ch. 4). Of course, enforcement of existing regulations is a continuing problem, as well.

Research and Data Needs

Some information about waste types, management methods, some types of risks, and regulatory programs exists for certain Subtitle D wastes, as described above and in subsequent chapters. However, it still is often difficult to readily evaluate the adequacy of management techniques, their impacts on reducing risks to human health and the environment, and the quality and efficacy of State or Federal regulatory programs. This is particularly true for manufacturing wastes (ch. 5), although it can also apply to other waste types.

The difficulty sometimes stems from a lack of, or lack of easy access to, data on environmental monitoring of facilities, compliance, and State or Federal enforcement efforts. Whether this means that steps to improve the regulation and management of Subtitle D wastes can or cannot be taken today is a matter of opinion. It is clear, though, that a concerted effort to gather and synthesize more current, relevant information would help in making additional regulatory decisions. For example, requirements for reporting data from environmental and other compliance monitoring could provide important feedback on the adequacy of existing regulatory programs, and improving the overall quality of data collection and management could allow better access to this and other information.

These data needs might be addressed at either the Federal or State level, depending on factors such as how the data will be used, the availability of resources, and the need for data that are comparable across States. Data collection and research efforts could potentially focus on many issues, including:

- design characteristics of existing facilities, particularly those built since the mid-1980s;
- environmental impacts of existing facilities, based on rigorous environmental monitoring;
- characterization of certain wastestreams (particularly different manufacturing wastestreams);
- costs of current management techniques, and types and costs of alternative techniques;
- incentives and disincentives (whether technical, economic, or political) to pollution preven-

tion, recycling, and improvements in waste management;

- the quality and efficacy of current State Subtitle D regulatory programs; and
- the relative risks involved in managing wastes under different management schemes and statutes.

Chapter 2

Mining Wastes

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Mining Wastes

INTRODUCTION

The "hard rock" mining industry produces metals (e.g., copper, gold, iron, lead, magnesium, silver, zinc) and nonfuel minerals (e.g., asbestos, gypsurn, lime, phosphate rock, sulfur).[1] The number of production facilities in operation varies somewhat from year to year, mostly because of small operations beginning or ceasing. As of 1987, there were 276 metal and 279 industrial mineral mines, with an annual production value of almost $16 billion (106).

Mining wastes result from the extraction, beneficiation, and further processing of metal and industrial mineral ores.[2] Waste categories include:

- waste rock—material moved to gain access to the ore or mineral, including overburden (material overlying the area to be mined) but excluding topsoil and other soil materials that are reused in reclamation);
- tailings—residuals (usually generated in a slurry form) from beneficiation processes;
- mine water—groundwater or precipitation that infiltrates mines during extraction; and
- processing wastes-residuals from processing after beneficiation, such as smelting and electrolytic refining operations.

The first three are known as extraction and beneficiation (E&B) wastes. The Departments of the Interior and Agriculture (101) disagree on whether mine water is subject to the provisions of the Resource Conservation and Recovery Act (RCRA).[3]

The 1980 Bevill amendment to RCRA (see ch. 1) temporarily excluded mining wastes from regulation as hazardous waste until the U.S. Environmental Protection Agency (EPA) assessed the wastes in a Report to Congress and followed that with a regulatory determination. Through a lengthy series of rulemakings and court decisions, EPA has subsequently treated E&B wastes and processing wastes separately.

EPA addressed E&B wastes in a 1985 Report to Congress (termed the "1985 Report" in this chapter; ref. 111). The 1985 Report included dump and heap leaching piles (i.e., materials resulting from using chemicals to leach out metals) as waste.[4] In 1986, EPA agreed that this designation was incorrect; that is, active leaching operations are production processes (as long as the materials do not escape from the leaching pad) and leach liquor treated to recover metals is a production materials The significance of this is that EPA does not have authority under RCRA to regulate production processes. When leaching operations cease, the spent leach piles are considered E&B wastes. Leaching operations are thus unique in that cessation of the process changes the material's regulatory status.

In July 1986, EPA determined that Subtitle C regulation of E&B wastes was not warranted.[6] EPA declared its intention to develop a State-implemented

[1] Hard rock mining is distinguished from surface coal mining, which is regulated by the Department of the Interior and the States under the Surface Mining Control and Reclamation Act of 1977 (SMCRA).

[2] Beneficiation processes separate commodity metals or minerals from interbedded nonmineral material and unrecoverable or unwanted mineral matter. They include crushing, grinding, washing, dissolution, crystallization, filtration, sorting, sizing, drying, sintering, pelletizing, briquetting, calcining to remove water and/or carbon dioxide, roasting in preparation for leaching, gravity concentration, magnetic separation, electrostatic separation, flotation, ion exchange, solvent extraction electrowinning, precipitation, amalgation, and heap, dump, vat, tank, and in situ leaching (40 CFR 261.4(b)(7)).

[3] The Bureau of Land Management (BLM) also notes tbat in some cases it is not managed as a "waste" at all; for example, some mine water is potable and subject to State water rights (S. Lamson, BLM, review comments, Aug. 9, 1991).

[4] In heap leaching, which is used primarily in gold and silver mining, the material to be treated is placed in a pile on an impermeable pad over the ground. The leaching chemical solution for gold and silver is commonly sodium cyanide. In dump leaching, which is used primarily for low-grade copper ore, the material to be treated is placed on unlined foundations (i.e., directly on the ground). The leaching chemical solution typically is sulfuric acid but sometimes is water. In contrast to heap and dump leaching, vat leaching takes place in fabricated vessels (i.e., internal containment of the solution). Wiley fill leaching is similiar to heap leaching, except that it typically takes place in a hilly terrain where flat space for a heap pad is not available; the impermeable pad is constructed in a valley or other natural depression.

[5] 51 *Federal Register* 24496, July 3, 1986.

[6] 51 *Federal Register* 24496, July 3, 1986. This determination was upheld in 1988 by the D.C. Circuit Court of Appeals *(EnvironmentaZ DefenseFund v. U.S. Environmental Protection Agency, 852* F.2nd 1309 (D.C. Cir. 1988)).

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program for these wastes under Subtitle D but noted that it might still consider using Subtitle C if necessary. EPA issued a staff draft approach to a Subtitle D program ("Strawman I") in 1988 and, after receiving comments, issued a second draft approach (" Strawman II") in May 1990 (see "Current Regulatory Pathways" below).

Mineral processing wastes are subject to a separate rulemaking process, except for the six types already listed as hazardous wastes.[7] In January 1990, EPA eliminated all but 20 "high-volume, low-hazard" processing wastes from the Bevill exclusion, making the remainder subject to Subtitle C regulation if they exhibit one or more hazardous characteristics or if they are listed as hazardous wastes.[8] EPA addressed the 20 remaining processing wastes in another Report to Congress in July 1990 (termed the "1990 Report" in this chapter; ref. 127). On May 20, 1991, EPA finalized a regulatory determination that retained the Bevill exclusion for all 20 wastes and proposed regulating 18 of them under Subtitle D.[9] EPA concluded that the other two wastes (phosphogypsum and phosphoric acid process wastewater) had significant risks associated with current management practices and had caused environmental damage. However, EPA determined that the wastes were not amenable to Subtitle C regulation and decided instead to explore their regulation under the Toxic Substances Control Act TSCA; see "Current Regulatory Pathways" below).

Although this background paper focuses on RCRA and EPA, many mining operations (especially in the western United States) are on Federal lands managed under other statutes and by other agencies. Federal land management agencies, particularly the Bureau of Land Management (BLM), have developed surface management regulations for mining operations and guidelines or policies on cyanide management for any mining facility that uses cyanide, including for heap leaching. BLM's rules have been developed in response to requirements of the Federal Land Policy and Management Act of 1976. In addition, most States with mining operations have regulatory programs that address mining operations, wastes, and environmental conditions typical of each State. Some of these programs were developed under the Federal Clean Water Act and Clean Air Act, primacy for which has generally been delegated to the States. Other programs, particularly for Subtitle D wastes, were developed under specific State environmental statutes. Thus, the relationships among Federal and State programs are of critical importance in any evaluation of how RCRA should apply to mining wastes.

WASTE GENERATION

Extraction and Beneficiation Wastes

Ore production and waste generation vary yearly in response to market and other conditions, particularly for copper, gold, and silver mining. Given this, the following data simply illustrate the general nature of mining waste generation; they do not indicate long-term trends or current generation rates.

EPA's 1985 Report (111) included data on six metallic ores (copper, gold, iron, lead, silver, and zinc ores), uranium overburden, and two nonmetals (asbestos and phosphate rock) .10 It estimated that these mining segments produced 2.2 and 1.4 billion tons of E&B wastes in 1980 and 1982, respectively.[11] About 90 percent of the waste was waste rock and tailings (two-thirds waste rock, one-third tailings); 49 percent of the waste rock and tailings came from copper mining, 24 percent from iron ore,

[7] The six wastes are (40 CFR 261.32; also see 53 *Federal Register* 35412, Sept. 13, 1988) acid plant blowdown slurry/sludge from primary copper production (K064); surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilitie (K065); sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production (K066); spent potliners from primary aluminum reduction (K088); emission control dust or sludge from ferrochromiumsilicon production (K090); and emission control dust or sludge from ferrochromium production (K091). A 1990 court decision upheld the listing of K088 but remanded K064, K065, K066, and, in some respects, K090 and K091, to EPA for further explanation of the need for listing (Amen"can *Mining Congress v. United States Environmental Protection Agency, 907* F.2nd 1179, D.C. Cir. 1990). EPA expects to issue the required explanation in 1992 (R. Hill, EPA, personal communication, Apr. 29, 1991).

[8] 55 *Federal Register 2322,* Jan. 23, 1990.

[9] 56 *Federal Register 27300,* June 13, 1991.

[10] The report did not cover: 1) wastes from clay, sand and gravel, and stone* g, because EPA judged that these were less likely to pose hazards than other wastes; 2) uranium mill tailings, which are regulated by the Nuclear Regulatory Commission under the Uranium Mill Tailings Radiation Control Act of 1978, with assistance fromEPA; and 3) surface coal mining and beneficiation wastes, which are regulated by the Department of the Interior under the Surface Mining Control and Reclamation Act of 1977 (SMCRA), with concurrence from EPA. It also did not include detailed information on E&B wastes from other metal and nonmetal mining sectors.

[11] The Department of the Interior considered th&@ in the 1985 Report to be inadequate but did not provide alternative estimates (101).

Photo credit: Jenifer Robison

Open pit Copper mine in Arizona.

16 percent from phosphate rock, and the remainder from other operations.

The estimates of total E&B wastes are somewhat misleading because the remaining 10 percent was from dump and heap leach operations (98 percent from copper mining, small amounts from gold and silver production). However, as noted above, leach piles are not considered wastes while they are used in production. Thus EPA's estimates of total E&B waste and the relative proportion of waste rock and tailings should be slightly lower and higher, respectively. Because spent leach piles are considered wastes, however, the amount by which the estimates would differ is unclear.

Table 2-l—Estimated Amounts of Extraction and Beneficiation Wastes Generated in 1987 (thousand short tons)

Industry segment[a]	Waste rock (mine waste)	Tailings[b]
Metals		
Bauxite	W[c]	524
Copper	504,000	223,650
Gold		
Lode	197,000	76,190
Placer	10,400	16,532
Iron ore	40,400	123,400
Lead	2,870	5,510
Silver	20,100	—
Zinc	w	5,011
Others[c]	57,200	—
Minerals		
Asbestos	610	5
Phosphate	289,000	119,100
TOTAL	1,121,580	569,498

[a]The Bureau of Mines database did not include information on the amounts of waste generated for the beryllium, magnesium, manganiferrous, molybdenum, nickel, and tungsten segments.
[b]Calculated by OTA as the difference between the amount of crude ore and the amount of marketable product.
[c]W = data not reported for reasons of confidentiality.

SOURCE: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook, Vol. 1, Metals and Minerals* (Washington, DC: 1988).

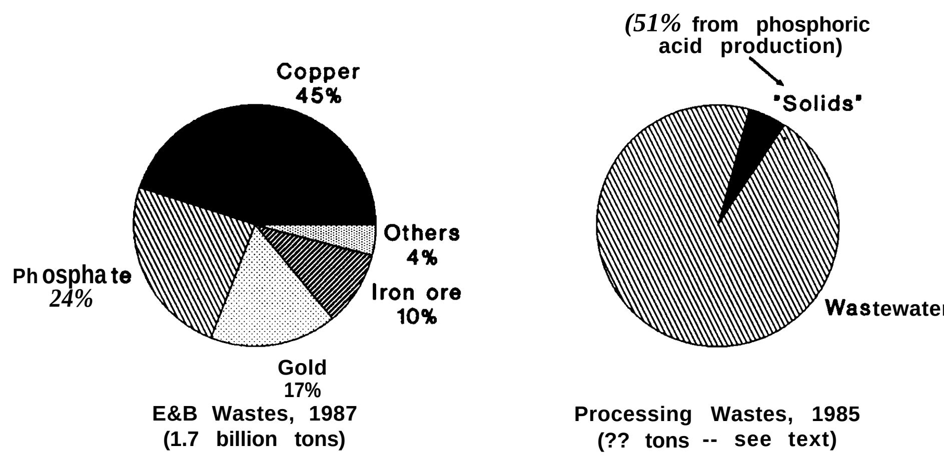
The U.S. Bureau of Mines (BOM) also collects data on waste rock, crude ore, and marketable products; the difference between crude ore and products provides a rough estimate of the amount of tailings. The Office of Technology Assessment (OTA) used BOM data to estimate that the nonuranium mining industry generated 1.7 billion tons in 1987, about two-thirds waste rock and one-third tailings (see table 2-1 and figure 2-1).[12] Copper accounted for 45 percent, phosphate 24 percent, gold 17 percent, and iron ore 10 percent. Although EPA and BOM data are not strictly comparable in scope and years of coverage, EPA's 1985 Report included the industry segments that generated 98 percent by weight of the nonuranium E&B wastes in 1987, according to BOM data.[13]

These estimates exclude mine water, for which no figures were given because amounts vary greatly and are difficult to estimate. However, the amount of mine water may be quite high at some sites, and effective management of acid mine drainage is a challenge at many active and inactive sites (1 11). As noted above, though, the U.S. Department of the

[12]Wastes from clay and stone mining totaled another 138 million tons. BOM data do not cover uranium mining, which has decreased significantly (western Governors' Association, review comments, Jan. 23, 1991).

[13]In 1987, waste rock and tailings for the six metals covered in the 1985 Report amounted to slightly more than 1.6 billion tons. Waste rock and tailings from metals and minerals not covered in the report (excluding clays, sand and gravel, stone) totaled 83 million and 15 million tons, respectively.

Figure 2-I—Amounts of Mining Wastes



SOURCES: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook, Vol. 1, Metals and Minerals* (Washington, DC: 1988); U.S. Environmental Protection Agency, *Report to Congress on Special Wastes From Mineral Processing,* EPA/530-SW-90-070C (Washington, DC: July 1990).

Interior (DOI) does not consider mine water an E&B waste.

Mineral Processing Wastes

Processing ore to obtain marketable products leaves behind waste residues, mostly in slurry form, that must be managed. EPA's 1990 Report covered the 20 mineral processing wastes that met EPA's high-volume, low-hazard criteria and therefore remained exempt under the Bevill exclusion from Subtitle C regulation, pending further study and rulemaking.[14]

The 20 Bevill wastes are generated by 91 facilities in 29 States. For these 20 wastes, about 103 million tons of solid waste (including slurry) is generated annually, primarily consisting of phosphogypsum from phosphoric acid production (51 percent), iron slag (20 percent), and steel slag (14 percent) (see table 2-2 and figure 2-1).[15] EPA also estimated that 2.0 billion tons of process wastewater is generated annually, 99 percent from phosphoric acid production. However, most of the phosphoric acid wastewater stream is recycled, either immediately or after being used to transport phosphogypsum or for process cooling. The 1.9-billion-ton estimate for phosphoric acid wastewater thus counts water that is used several times, but the amount of new wastewater generated is unclear.[16] According to the BOM, wastewater from phosphoric acid production generally is recycled every three to four days and fresh water inputs are typically less than 5 percent[17]; even so, inputs can still amount to millions of gallons per day at individual plants.

Mineral processing wastes that do not meet the high-volume, low-hazard criteria are no longer exempt from Subtitle C regulation; depending on their nature, they can be either hazardous or nonhazardous. EPA has not collated data on nonexempt mineral processing wastes, but various Federal Register notices contain information on more than 70 such wastes, with total waste generation of around 7.4 million tons (however, data on solids/

[14] The high-volume criterion is 45,000 metric tons (49,500 short tons) per year per facility for each nonliquid wastestream and 1 million metric tons (1.1 million short tons) per year per facility for each liquid wastestream *(54 Federal Register 36592,* Sept. 1, 1989). The low hazard criterion has two parts. For toxicity, if samples of a waste from tsvo or more facilities fail EPA's Synthetic Precipitation leaching Procedure, then the waste is withdrawn from the Bevill exclusion, unless evidence indicates that test results are anomalous. For corrosivity, liquid wastes with a pH less than 1.0 or greater than 13.5 are not considered "low hazard."

[15] These estimates may include some wastes that are processed for metals recovery or recycled in other applications (T.B. Larsen, Cyprus Miami Mining, personal communication Apr. 2, 1991).

[16] J.P. Stone, BOM, personal communication Apr. 12, 1991.

[17] T. Ary, BOM, review comments, July 19, 1991.

[18] 54 *Federal Register* 15316, Apr. 17, 1989; 54 *Federal Register* 36592, Sept. 1, 1989; 54 *Federal Register* 39298, Sept. 25, 1989; 55 *Federal Register 2322,* Jan. 23, 1990. EPA also reclassified 12 wastestreams as beneficiation wastes and 6 wastestreams as other nonprocessing wastes.

Table 2-2—The 20 High-Volume Mineral Processing Wastes Conditionally Exempted From Subtitle C Pending Final Rulemaking (amount of waste generated in thousand tons[a])

Waste	Solids and slurries	Liquids	Comments[b]
Red and brown muds from bauxite refining	3,080		
Treated residue from roasting/leaching of chrome ore	112		
Gasifier ash from coal gasification	270		
Process wastewater from coal gasification		5,313	
Calcium sulfate wastewater treatment plant sludge f from primary copper processing	154		Potential C by Audubon et al.
Slag from primary copper processing	2,750		Potential C by Audubon et al.
Slag tailings from primary copper processing	1,650		
Slag from elemental phosphorus production	2,860		Potential C by Audubon et al.
Fluorogypsum from hydrofluoric acid production	983		
Process wastewater from hydrofluoric acid production		14,960	Potential C by Audubon et al.
Air pollution control dust/sludge from iron blast furnaces	1,320		Potential C by Audubon et al.
Iron blast furnace slag	20,680		Not considered a waste by DOI
Slag from primary lead processing	516		Potential C by Audubon et al.
Process wastewater from magnesium processing		2,712	
Phosphogypsum from phosphoric acid production	52,360		Potential C by Audubon et al.
Process wastewater from phosphoric acid production		1,947,000	Potential C by Audubon et al.
Air pollution control dust/sludge from basic oxygen furnaces and open hearth furnaces from carbon steel production	1,540		Potential C by Audubon et al.
Basic oxygen furnace and open hearth furnace slag from carbon steel production	14,520		Not considered a waste by DOI
Chloride process waste solids from titanium tetrachloride production	455		Potential C by Audubon et al.
Slag from primary zinc processing	173		Potential C by Audubon et al.

[a] The names on this list, based on EPA rulemakings and EPA's 1990 Report, should not be considered exact; the names of individual Waste streams sometimes change between rulemakings, and it is not always clear from first glance whether the changes are simply nominal in character or represent actual additions or deletions in the waste stream being considered.

[b] "Potential C by Audubon et al." refers to wastes that the National Audubon Society, Environmental Defense Fund, and Mineral Policy Center considered potential candidates for regulation under Subtitle C as hazardous; "Not considered a waste by DOI" refers to materials that the Department of Interior suggests should not be considered wastes at all.

SOURCES: National Audubon Society, Environmental Defense Fund, and Mineral Policy Center, "Comments of the National Audubon Society, the Environmental Defense Fund, and the Mineral Policy Center on the Environmental Protection Agency's Report to Congress on Special Wastes From Mineral Processing," Washington, DC, Oct. 19, 1990; U.S. Department of the Interior, "Comments in Response to the Environmental Protection Agency Report to Congress on Special Wastes From Mineral Processing Released July 1990," Washington, DC, Oct. 19, 1990; U.S. Environmental Protection Agency, *Report to Congress on Special Wastes From Mineral Processing,* EPA/530-SW-90-070C (Washington, DC: July 1990); 54 *Federal Register 15316* (Apr. 17, 1989); 54 *Federal Register 36592* (Sept. 1, 1989); 54 *Federal Register 39298* (Sept. 25, 1989); 55 *Federal Register* 2322 (Jan. 23, 1990).

slurries versus wastewater are difficult to distinguish in the notices).[18]

The DOI (102) and the American Mining Congress (AMC) (4) object to the EPA classification of some mineral processing materials. DOI asserts that iron blast furnace slag and basic oxygen and open hearth furnace slags should not be considered wastes because they are byproducts that are processed and sold as such. The AMC believes that materials such as elemental phosphorus slag and copper slag are not wastes when beneficially reused or reprocessed, and that EPA's definition of Bevill processing wastes discourages recycling. EPA agrees that although some materials such as iron slag are largely sold for eventual off-site use, seldom (if ever) is 100 percent of the material sold, and unsold materials are typically stored on the ground (e.g., in waste piles).[19] In addition, the sold materials are usually destined for use as road aggregate, filler, etc. The Agency's current position is that these on-the-ground uses constitute disposal and that the materials therefore are solid wastes. EPA, however, is reevaluating its current definition of solid waste and intends to publish an Advance Notice of Proposed Rulemaking to solicit comments on revising the definition and the impacts of such revisions on recycling and reuse.

CURRENT MANAGEMENT METHODS

Extraction and Beneficiation Wastes

EPA's 1985 Report estimated that 56 percent of waste rock was disposed in on-site piles and 61 percent of tailings was disposed in on-site surface

[19] U.S. EPA, Office of Solid Waste, review comments, Aug. 22, 1991.

impoundments in the early 1980s.[20] About 4,000 surface impoundments were used for metal and nonmetal mining wastes in the early 1980s (110, 119). An estimated 9 percent of waste rock and 5 percent of tailings were used for backfilling previously excavated areas, often for support purposes. Off-site utilization-for example, as construction material-was limited (4 percent of waste rock, 2 percent of tailings). The remainder (31 percent of waste rock, 32 percent of tailings) was reused on-site.

These data do not necessarily represent current management practices. In addition, much of what EPA included as reused waste was dump leaching material, which is a raw material rather than a waste, at least until leaching operations cease. EPA (124) and the States (e.g., 139) suggest that jurisdiction over leach pads is necessary, even if the pad does not become a ''waste" until operations cease; however, the AMC (4) disagrees.

The 1985 Report included limited data from the early 1980s on the frequency of pollution controls at E&B waste sites. For example, groundwater monitoring occurred at 18 of 47 tailings ponds, runoff controls at 5 of 74 mine sites, and liners at 11 of 56 tailing ponds; the frequency of controls varied among different industries. Use of these controls probably increased during the last decade, but OTA is unaware of systematic data indicating the extent of current use. Most State mining regulations now require monitoring at new facilities and some require liners. Nevada's rules presume that an engineered liner system is needed for heap pads and process ponds (Nevada Administrative Code Section 445). Utah requires the use of best available technology to prevent seepage (Utah Administrative Code 26-11, Sec. R448-6); in its permitting process, the State interprets this requirement as mandating engineered liner systems for gold operations that employ cyanide solutions.[21] However, the extent to which States' regulations apply to previously existing E&B waste sites and the extent to which they are enforced are difficult to ascertain (see "State Regulatory Programs" below).

Quantities of mine water are unknown. In terms of active management, mine water may be recycled as milling process water, used on-site for other purposes (e.g., dust control, wildlife watering), or stored in surface impoundments and tanks. In some cases, stored mine water is then discharged (often after some treatment) to surface waters in accordance with National Pollutant Discharge Elimination System (NPDES) permit conditions (111); OTA is unaware of data on the amount of mine water discharged to surface waters. Some mine water, though, is not actively managed and instead enters the environment via drainage and nonpoint runoff.

Mineral Processing Wastes

By quantity, most processing wastes are wastewaters that are managed in surface impoundments or ponds (127). Depending on the nature of the material, some of it may then be reused on-site, treated and discharged to surface waters, injected underground, or treated and sold for off-site use.

Phosphoric acid production is the largest generator of processing wastes (table 2-2). The phosphogypsum component is mixed with process wastewater and pumped to impoundments, where the phosphogypsum solids settle.[22] The wastewater most often is reused on-site for processing and other activities; in these situations, no treatment or discharge is considered necessary. Some facilities treat and discharge the wastewater, along with runoff and leachate from gypsum stacks that is collected in perimeter ditches.

Furnace slag from iron and steel production makes up 34 percent of solid/slurry processing wastes; as noted above, DOI strongly asserts that this should not be classified as waste. It typically is processed (e.g., granulated, crushed, sized) and sold for use as an aggregate.

The 1985 Report included limited data from the early 1980s on pollution controls and monitoring used at mineral processing facilities. For example, groundwater monitoring occurred at 8 of 15 heap and dump leaching operations, and collection of secondary leachate occurred at 1 of 16 heap and

[20] The data did not distinguish between solids and liquids.

[21] S. Barringer and K. Johnson, Holland& Hart, review comments, July 29, 1991.

[22] The impoundments are located on top of on-site waste piles known as gypsum stacks. As an impoundment dries, dewateredphosphogypsum is used to buildup the impoundment dike, and the stack increases in height. EPA has issued regulations on radionuclide emissions from phosphogypsum stacks (see "Other Statutory Authority" below).

dump leaching operations.[23] As with E&B wastes, the frequency of specific controls varied among different industries.

Today, according to the Western Governors' Association (WGA) and representatives of the precious metals industries, liners are almost always used in precious metal heap leaching operations to confine the mineral-laden leachate and to maximize mineral recovery.[24] In addition, all new and virtually all existing ponds at gold and silver heap leaching operations have single or double liners (either a composite synthetic/earthen liner or two synthetic liners), and leak detection systems for ponds at silver and copper operations are generally checked once per shift.[25]

Pollution Prevention/Waste Reduction

The benefits of reducing hazardous waste generation in manufacturing are well documented (91, 93). However, the mining industry differs from most manufacturing because its processes generally require large amounts of raw material, with relatively low concentrations of ore, to obtain the finished product; furthermore, declining ore grades in the United States mean that relatively more waste is now associated with producing a given amount of ore.

Nevertheless, measures now used at some mining facilities may reduce the potential toxicity of some wastes (23, 52, 111).26 These include closed-loop recycling of solutions; chemical or biological treatment of acids or cyanides; the use of drip leaching instead of spray leaching; and the use of less toxic leaching and flotation reagents (e.g., BOM is studying substitutes for cyanide compounds used in leaching operations). DOI and the U.S. Department of Agriculture, however, believe that changing the reagents used in beneficiation "would require considerable research with little guarantee of success" (101). They also noted that little opportunity exists to reduce waste volume, most of which is waste rock, although possibilities include: 1) blasting techniques that make fewer small pieces; 2) expansion of underground mining to minimize exposed surface areas; or 3) in situ leaching instead of surface or underground mining. Underground mining is relatively costly and probably would be useful only for high-grade, shallow deposits, which are not common. In situ leaching poses other environmental problems; for example, gold and silver would require the use of cyanide, which is better handled in containers or lined units. Even so, biological in situ techniques may be possible for some metals.[27]

EPA can offer some assistance (e.g., information, R&D funds) in designing production processes to prevent pollution problems and has a policy of promoting pollution prevention in general.[28] However, EPA currently does not have authority under RCRA to regulate production processes, although it does have some authority under TSCA (also see "Other EPA Statutory Authority" below). DOI[29] believes that the Bureau of Mines might be a more appropriate agency to provide assistance in developing waste minimization techniques for the minerals industry.

RISKS FROM MINING WASTE MANAGEMENT

Extraction and Beneficiation Wastes

Some E&B wastes such as overburden and waste rock are earthen materials that are not processed; some of these may contain sulfides that can generate acid when exposed to oxygen and moisture, and/or metals that may be mobilized in surface or groundwater. Where precipitation is sufficient, uncontrolled runoff from storage piles of these materials can contribute to water quality problems in streams and groundwater. The potential for acid generation depends on factors such as the presence of sulfides

[23] EPA used the term "secondary leachate collection system" to refer to leachate collection sumps and ditches that collect liquids escaping from the primary recirculating leaching system.

[24] WGA, review comments, Jan. 23, 1991.

[25] WGA, review comments, Jan. 23, 1991; S.G. Barringer, Holland & Hart, review comments, Apr. 24, 1991; G. Enrick, American Barrick Resources Corp., review comments, July 23, 1991.

[26] Also see 54 *Federal Register 24498*, July 3, 1986.

[27] One prospect is t. use microorganisms in situ, which would leave the surrounding environment relatively undisturbed. More than 30 percent Of the copper produced in the United States results from a biochemical process involving a naturally occurring microorganism, *Thiobacillus ferroxidans, in an* acid leaching solution; currently, though, this is used after initial extraction and takes longer than conventional leaching processes (16).

[28] 54 Federal Register 3845, Jan. 26, 1989.

[29] S. Lamson, BLM, review comments, Aug. 9, 1991.

Photo credit: U.S. Department of the Interior

Cyanide mist sprayer on leach pad.

and the nature and frequency of precipitation at the site.

Releases from impoundments, leaching operations, and tailings ponds have generally been of greater concern. EPA (11 1) reviewed known environmental damage cases and concluded that releases (from failed impoundments, loss of liner integrity, pond overflow, seepage, dam failure) at both active and inactive sites have caused contamination of groundwater, degradation of aquatic ecosystems, and fish kills in some instances. However, these data are from the 1970s and early 1980s.

In the early 1980s, EPA also conducted short-term sampling of surface and groundwater for 40 parameters at eight mining sites and found that most sampled facilities leaked constituents to soils, groundwater, and surface water (111). The data, however, are based on conditions at the time of sampling and do not address the long-term mobility of substances in groundwater or the possibility of future urban or recreational developments near old sites. Thus the data do not demonstrate whether the constituents migrated over long distances or reached concentrations of concern to human health.[30]

EPA also estimated that about 11 million metric tons of waste from gold, lead, silver, and zinc mining-about 1 percent of all mining waste—exhibited one or more hazardous characteristics (e.g., Extraction Procedure toxicity) and that an unknown amount of escaped leach liquor is corrosive.[31] Some environmental groups contend that the Extraction Procedure (EP), Toxicity Characteristic (TC), and Synthetic Precipitation (SP) tests are inappropriate and that more mining waste would be classified as hazardous, or at least be better characterized, if leaching tests that are more representative of long-term weathering conditions were used.[32 33] However, such tests would not be legally applicable to wastes currently exempted from Subtitle C. In addition, EPA's determination to regulate E&B wastes under Subtitle D has been upheld by the courts (see 'Current RCRA Status of E&B Wastes' below).

EPA noted other potential hazards-acid generation; cyanide, radioactivity, and asbestos releases—not included in RCRA hazardous characteristics that also need evaluation. In the 1985 Report, EPA estimated that at least the following materials might be of concern:

. 25 million tons from gold and silver operations (28 percent of E&B waste from these segments, 2 percent of all E&B waste), because of high

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[30] In addition, although some of the environmental damage cases mentioned also involved potential human health effects (e.g., from drinking groundwater contaminated by heavy metals; inhaling air or ingesting soil contaminated with asbestos), they did not document known human health effects.

[31] 54 *Federal Register* 24498, July 3, 1986. The 1985 Report identified 61 million metric tom (67 millon short tons) of waste from these industries and the copper industry as exhibiting EP toxicity or corrosiveness. EPA's estimate of 11 million metric tons (12 million short tons) excluded dump and heap leach piles and process leach liquor, although EPA did not address how these materials should be considered after production.

[32] A. Maest, Environmental Defense Fund, personal communication, July 29, 1991.

[33] The Western Governors' Association has not adopted a position on the EP and other tests, but it is investigating methods for analyzing cyanide residuals in spent leaching wastes and for predicting the acid generation potential of wastes (R.D. Andrews, Boulder Innovative Technologies, personal communication, Apr. 16, 1991).

cyanide levels[34] and the potential for acid generation and release of heavy metals;[35]

- 387 million tons from phosphate mining and 100 million tons from uranium because of high radioactivity levels;[36]
- 105 million tons of copper mill tailings (7 percent of total E&B, 15 percent of copper E&B), because of potential for acid generation and release of heavy metals;[37] and
- 5.5 million tons of asbestos waste rock (less than 1 percent of total E&B waste), because of asbestos content greater than 1 percent.[38]

Box 2-A discusses the relationship among gold production, sodium cyanide, and wildlife mortality.

In its 1986 regulatory determination, EPA noted that threats posed by E&B wastes depend on site-specific factors. A 1984 survey (12) indicated more than 80 percent of active mines were west of the Mississippi River-generally in areas with relatively dry climates, where water tables are at greater depths than in the eastern United States, and well removed from current population centers, drinking water supplies, and surface waters.[39] These sites thus might not be expected to pose significant risks in the near future.

However, EPA was concerned about the potential risks of mining sites and E&B wastes that do not exhibit these characteristics-for example, sites located in nonarid regions or near groundwater.[40] It also was concerned about risks to resident populations of threatened and endangered species (also see box 2-A) and to relatively undisturbed natural environments, as well as surface water and groundwater contamination, environmental degradation and threats to human health from wind-blown dusts, and the effects of catastrophic failure of waste management units. A recent EPA report on relative risk (129) did not specifically address mining wastes but considered acid runoff into surface waters to be a relatively low-risk problem to humans (albeit not necessarily to aquatic life).

The presence of mining sites on the National Priorities List (NPL) indicates that mining activities or wastes have caused potential risks to human health and the environment in the past.[41] The Superfund effort in the Clark Fork Basin of Montana, for example, consists of four separate but contiguous sites encompassing the largest geographic area of all NPL sites (74). Some NPL mining sites involved production practices that are still in use today (e.g., froth flotation in copper mining), and to some observers this suggests that current operations could become future Superfund sites. This is possible but difficult to prove or to refute. Industry representatives contend that sites on the NPL indicate problems with past waste management rather than past or current production practices, and that current waste management is much improved.[42] BLM notes that although the basic process of froth flotation has not changed, the reagent addition rates and current monitoring or other controls result in a

[34] Based on liquid waste samples from gold metal recovery and heap leach operations, and on a cyanide concentratio greater than or equal to 10 milligrams per liter (mg/L). The concentration of 10 mg/L is 50 times greater tban EPA's ambient water quality criterion for the protection of human health (i.e., 0.2 mg/L, the same as the primary drinking water standard; the criterion for freshwater aquatic life is 3.5 micrograms per liter (μ g/L) as a 24-hour average, with concentrations not to exceed 52 μ g/L at any time) (45 *Federal Register 79331, Nov. 28, 1990).*

[35] However, the Bureau of Mines states that the effluents from gold and silver operations are normally alkaline and that the possibility of acid generation and release of heavy metals is unlikely (T.@, BOM, review comments, July 19, 1991).

[36] Levels greater than 5 picocuries (pCi) per gram (i.e., the cleanup standard in EPA's Standards for protection Against Uranium Mill Tailings). Using a level of 20 pCi per gram (i.e., the "disposal design" portion of the standards) lowers the figures to 13 million and 80 million metric tons for phosphate and uranium, respectively.

[37] EPA also estimated that 200 million tom of copper dump leach material has the same potential problems, but such material is not considered waste while being used in production; whether this estimate includes spent dump and heap leaching piles is unclear.

[38] The National Emission Standard for Hazardous Air Pollutants for asbestos. However, EPA's Effluent Guidelines Division earlier found that controlling suspended solids in discharges from mining operations also controlled asbestos fibers.

[39] More than 60 percent of the active mines were characterized by extreme aridity (i.e., net recharge of 0 to 2 inches), about 80 percent had a depth to groundwater of greater than 10 feet, and 78 percent did not have a drinking water system within 5 kilometers.

[40] Based on the 1984 survey (12), for example, 22 percent of the active mines had drinking water systems within 5 kilometers and most mines were located near surface waters.

[41] As of August 1990,68x sites were on the NPL; another 227 sites were in EPA's database (known as CERCLIS) of hazardous substance sites but not on the NPL (ref. 140, citing EPA memoranda). As of spring 1991, Science Applications International Corp. (SAIC) had completed, under contract to EPA, draft summary reports on 48 NPL mining sites.

[42] They also note the difficulty in establishing causal relationships, particularly at sites with many years of operations or complex hydrogeological and topographical features.

Box 2-A—Sodium Cyanide, Gold, and Wildlife

The environmental effects of cyanide use in gold mining operations have been of concern for many years, recently because of reports of wildlife mortality associated with such operations. In general, the precious metals industry, many State officials, and the U.S. Bureau of Land Management (BLM) believe that the industry has responded adequately during the last few years to minimize wildlife mortality. However, environmental groups, EEA, and the U.S. Fish and Wildlife Service (F&WS) disagree.

Wildlife mortality results when animals drink cyanide-contaminated waters derived from gold heap leaching and milling processes. In heap leaching, sodium cyanide is used to extract gold from the gold-laden ore; the cyanide solution is collected and placed in a "pregnant solution" pond. Other treatment processes are used to recover the gold, and the remaining liquid is placed in a "barren solution" pond for storage and adjustment of cyanide levels (in some cases, it may then be pumped back to a heap top and reused for leaching). Some milling operations also use sodium cyanide, with the resultant slurry being discharged to large tailings ponds. Pregnant and barren solution ponds tend to be small (generally less than 5 acres), whereas tailings pond are much larger (e.g., up to several hundred acres) (131).

In recent years, mining and processing of low-grade gold ore deposits has become more profitable, because of technological innovations in beneficiation, along with the depletion of high-grade ore deposits. As a result, gold production increased from 2 million ounces in 1983 (39) to 9 million ounces in 1989 (131).

At this time, most of these operations are located in arid areas, where the presence of open water attracts wildlife.[1] BLM estimated that in 1990 about 155 cyanide heap leach operations were located on public lands managed" by the bureau (39). The F&WS estimates that 200 to 300 cyanide-containing processing or waste impoundments are located in the entire Great Basin (107).

The only comprehensive data (of which OTA is aware) on wildlife mortality at these operations come from Nevada (some mines in Arizona and California also report mortality data to BLM). Between 1984 and 1989, Nevada gold mining operators voluntarily reported 7,224 wildlife deaths at ponds. These data consisted primarily of cyanide-related mortalities, although a few operations included road kills found on-site and animals that most likely died of natural causes.[2]

Some mine operators have taken steps to counter these problems. In some instances, nets have been placed over pregnant and barren ponds, and fencing is used to deter wildlife; however, tailings ponds, which may cover large areas, are often not netted.[3] In addition, some operations use chemical processes to degrade or neutralize cyanide compounds in effluents, ponds, and tailings (54). In Nevada, many, but not all, operators now use drip systems to distribute water others crush residues to finer grades to prevent pooling of solutions.

Several States, including Nevada and California, have begun to actively address the wildlife mortality issue. In 1989, Nevada enacted legislation that made the Department of Wildlife the permitting authority for impoundments or ponds containing chemicals that might be deleterious to wildlife and required mining operators to report wildlife mortality and subsequent corrective actions (62).[4] The State's regulations also require that pregnant and barren solution ponds either be covered (e.g., with netting) or that their contents be rendered nonlethal by dilution, chemical neutralization, or other means.[5] In 1990, after mandatory reporting of mortality was required, 98 mines reported 1,644 deaths.[6] Of these, 92 percent involved migratory birds and 8 percent involved snakes,

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[1] Some heap leach operations, however, are located in humid areas (e.g., South Carolina).

[2] R. McQuivey and J.W. King, Nevada Department of Wildlife, personal communication, Mar. 7 and 13, 1991.

[3] Most of these methods require long-tam maintenance. Poorly maintained nets may allow small mammals and birds to gain access to ponds; nets damaged by ice, snow, or wind also allow access. The F&WS and the State of Nevada do not consider hazing an acceptable preventive measure (35; R. McQuivey, Nevada Department of Wildlife, personal communication, July 26, 1991).

[4] The General Accounting Office (GAO) (87) concluded that Federal and State agencies generally have adequate authority to regulate cyanide operations and to protect wildlife or the environment from their potential hazards. However, GAO noted that, unlike Nevada, State regulatory agencies in California and Arizona lack the authority to require that cyanide operations be designed or operated so as to prevent wildlife mortality, although their authority to prosecute violators for killing game species without a license could help deter cyanide-related mortality.

[5] "Nonlethal levels" are difficult to define because tolerable concentrations of cyanide have not been determined experimentally, cyanide toxicity may be affected by the type of ore and the presence of heavy metals, and different animal species may exhibit varying sensitivities to cyanide (E. Hill, F&WS, personal Communication May 10, 1991).

[6] These data represent total reported mortality for 1990 (R. McQuivey, Nevada Department of Wildlife, personal communication, July 26, 1991). Mandatory reporting was implemented beginning April 1, 1990, but it took several months to bring existing operations into compliance with the new regulations, Since then, cyanide-related mortality has been lower.

lizards, mice, bats, and other small animals; no reports involved threatened or endangered species.[7] Although these data are self-reported by operators, Nevada officials consider them to be reasonably accurate, based on increased State enforcement and inspection to ensure compliance with the regulations.

At the Federal level, BLM's cyanide management policy encourages all mining operations using cyanide or other lethal solutions to be conducted in a way that protects the public and ensures compliance with the Migratory Bird Treaty Act (i.e., protect migratory birds and other wildlife) (103, 104, 105). The policy sets forth guidelines on fencing of all active and disturbed unreclaimed areas; monitoring of groundwater and surface water through closure and final reclamation; posting of bonds by operators for full costs of reclamation; neutralization or detoxification of cyanide solutions and heaps (but not tailings ponds); a minimum of quarterly inspections by BLM staff of cyanide operations on BLM lands; training for BLM employees involved in surface management of cyanide operations; and procedures for closure and reclamation. However, these guidelines have not yet been promulgated as regulations, except for the bonding requirements. The National Park Service also has guidelines on cyanide operations (42).

The F&WS, under the Migratory Bird Treaty Act, can cite or fine violators for killing migratory birds without a permit and has done so in conjunction with State authorities. For example, almost 1,000 deaths were reported in Nevada in the third quarter of 1989, largely from one operation.[8] The operation was cited for noncompliance by Nevada and the F&WS; the operator installed a cyanide detoxification process, and no subsequent mortality has been reported. The F&WS considers denying access to ponds or maintaining cyanide solutions at nontoxic concentrations to be appropriate preventive measures; it also suggests that the costs of such measures might be reduced if migratory bird protection was considered during the initial design of new facilities (35).

In general, State officials, mining industry representatives, and BLM contend that sufficient steps are being taken to control wildlife mortality. Many feel that although the problem was significant prior to increased State regulatory activity, the industry has spent millions of dollars to develop satisfactory control procedures and too much attention is now being given to the issue. To the extent that efforts such as those of Nevada continue to be developed and BLM enforces its policy, this maybe true.

However, EPA and the F&WS still believe that additional controls may be necessary, and EPA is also concerned about potential threats to surface water and groundwater posed by cyanide heap leaching. Questions have arisen about the extent of mortality occurring on top of heaps, as opposed to ponds; heaps can look like disked farm fields, with interspersed pools of water (from rainwater or from cyanide solutions pumped back to the top) that attract wildlife. In South Dakota, dead birds and mammals have been found on the tops or edges of heap leach pads, often in or near pools of water.[9] The F&WS has initiated research on wildlife mortality at heaps in Nevada.[10] The State of Nevada has investigated heap tops (including conducting aerial surveys), however, and found only isolated incidents of mortality due to inefficient operational procedures; State officials feel that this is not significant and that increased enforcement and inspection will minimize mortality.

EPA regulates discharges of wastewater from leaching operations into surface waters under the Clean Water ACT; however, EPA has limited authority to control mine leachate in order to prevent groundwater contamination and must rely on best management practices or State authorities unless a leak to groundwater is detected EPA also cannot regulate sodium cyanide use in leaching or in ponds under RCRA because the operations are production rather than waste management processes.[11] Under the Toxic Substances Control Act (TSCA), however, EPA can regulate a chemical when it presents or will present an unreasonable risk of harm to human health or the environment.

EPA believes that there is a possible case for regulation of sodium cyanide under TSCA Section 6, to minimize groundwater contamination and degradation of aquatic ecosystems. However, although much research has been

[7] Drought conditions in the late 1980s and 1990 may have affected mortality patterns (J.W. King, Nevada Department of Wildlife, personal communication, Mar. 13, 1991). Prior to 1987, reported mortality was highest during the spring waterfowl migratory period. In 1989 and 1990, when drought conditions in Nevada were the worst in recorded history, mortality was highest during the summer,

[8] R. McQuivey, Nevada Department of Wildlife, personal communication, Mar. 7, 1991.

[9] D. Fries, F&WS, personal communication, May 30,1991.

[10] C. Henny, Pacific Northwest Research Station, personal Communication May 23, 1991.

[11] Use of sodium cyanide in terms of worker safety, though, may be regulated under the Occupational Safety and Health Act of 1970 and the Mine Safety and Health Act of 1977.

Continued on next page

Box 2-A—Sodium Cyanide, Gold, and Wildlife-Continued

conducted on the fate of cyanide and cyanide complexes in soil and water (e.g., 24, 54, 136), EPA believes that insufficient information is available regarding the long-term effects on wildlife of sodium cyanide from mining operations to warrant regulation at this time (131). Additional field research is needed, for example, on the long-term persistence and fate of cyanide complexes in ponds (during and after leaching), patterns of wildlife exposure to toxic forms of cyanide, and related patterns of wildlife mortality.[12]

EPA and the F&WS are addressing this through TSCA and its Interagency Testing Committee. Sodium cyanide is exempt from TSCA reporting requirements, but Federal agencies can request through the Committee that testing of a substance's potential effects be conducted under TSCA (e.g., under Section 4). In response to a F&WS nomination, the Committee "designated" sodium cyanide in November 1990, with chemical fate and ecological effects as areas of concern (131). The F&WS proposed research to determine the tolerance of wildlife species to cyanide-contaminated waters; the feasibility of developing diagnostic indicators; the fate of cyanide compounds in heaps and tailings; and wildlife use of, and mortality at, heaps and ponds (107, 108). In 1989, the DuPont Co., the major sodium cyanide manufacturer, agreed to provide funding for F&WS field studies on sodium cyanide and migratory birds (131), although not on sodium cyanide's effects on terrestrial animals or its presence in soil. As of fall 1991, EPA had reached a tentative agreement for a consent order requiring chemical fate and terrestrial effects studies with DuPont, FMC, Degussa Corp., ICI Americas, and Cyanco Co.[13] Depending on the results, this research would be useful in determining whether a rulemaking under Section 6 on sodium cyanide production and use should be initiated.[14]

[12] Based on one model, cyanide concentrations in ponds might decline relatively quickly once leaching operations cease, but they would still be high while operations are ongoing because of continual inputs of cyanide solutions into the ponds (19; F. DeVries, Chem-Mining Consulting, Ltd., personal communication May 8, 1991). In waters with a pH of less than 9, free cyanide would convert relatively quickly to hydrogen cyanide, which would volatilize into the air; some cyanide complexes that are soluable in weak acids also would volatilize; and other cyanide complexes would precipitate in insoluble forms. Free cyanide in tailings ponds is known to degrade relatively easily (54).

[13] K. Cronin, U.S. EPA, review comments, Sept. 27, 1991.

[14] EPA could also develop "sudden release regulations" under Section 6, based on known acute effects of sodium cyanide on fish and other aquatic organisms (131). These regulations would address the prevention of releases rather than the production and actual use of sodium cyanide (e.g., EPA could require certain design features on ponds to prevent spillage).

much different set of chemical and physical characteristics for process materials and wastes. On the other hand, EPA concluded that "it is not clear . . . whether current waste management practices can prevent damage from seepage or sudden releases."[43]

Mineral Processing Wastes

EPA's 1990 Report (127) identified four mineral processing wastes for which some form of Subtitle C regulation might be warranted: 1) process wastewater from hydrofluoric acid production; 2) slag from primary lead processing; 3) calcium sulfate wastewater treatment plant sludge from primary copper processing; and 4) chloride process waste solids from titanium tetrachloride production. All exhibited one or more hazardous characteristics; EPA also documented damages from current lead slag management and suggested that some known groundwater contamination was possibly attributable to calcium sulfate sludge and chloride process solids. EPA was uncertain if current practices and regulations were adequate to prevent further health and environmental problems.

For the other 16 processing wastes, EPA concluded that regulation under Subtitle C was not warranted. Four wastes generally did not exhibit hazardous characteristics, although EPA documented adverse impacts from releases to surface water.[44] These releases, however, are addressed under existing State or Federal regulations (e.g., the Clean Water Act); in addition, industry representatives indicate that glasslike slags from copper processing

[43] 51 *Federal Register* 24499, July 3, 1986.

[44] Iron blast furnace slag; slag from primary copper processing; basic oxygen and open hearth furnace slag from carbon steel production and fluorogypsum from hydrofluoric acid production.

do not leach when stored in piles in arid environments.[45] Four other wastes exhibited some hazardous characteristics but had no documented damage cases.[46] Two of these (dusts/sludges from iron blast furnaces and carbon steel production), infrequently exhibited hazardous characteristics, some wastes were being recycled, and facilities generally were not located in high-risk settings; the other two wastes are covered by existing State regulations. EPA also noted that phosphogypsum and phosphoric acid process wastewater sometimes exhibit hazardous characteristics and that managing them in impoundments or cooling ponds had caused groundwater contamination at many facilities. EPA concluded, however, that regulating them under Subtitle C would "significantly" increase expenses at several fertilizer production facilities (see "Current RCRA Status of Mineral Processing Wastes' below).

EPA also considered the radionuclides and associated potential for radiation risk in six wastes to be of concern under some circumstances.[47] Among these wastes were phosphoric acid process wastewater and phosphogypsum, which account for most of the mineral processing wastes that remain subject to the Bevill exemption (see "Amounts" above). For phosphogypsum, radon associated with air releases from gypsum stacks is regulated by a National Emission Standard for Hazardous Air Pollutants (NESHAP; see "Clean Air Act" below).[48] The NESHAP does not address slag or other radionuclide sources, so EPA noted its intent to investigate potential risks from such sources and to take steps, if needed, under RCRA and other statutes to limit such risks.

The AMC (4) concluded that none of the 20 Bevill wastes warranted Subtitle C regulation. DOI (102) criticized EPA's conclusion that calcium sulfate sludge might warrant such regulation.[49] Both AMC and DOI considered EPA's risk and damage assessments to be overly conservative. They argued that:

- The Extraction Procedure and Toxicity Characteristic tests are inappropriate because they rely on a municipal landfill disposal scenario and on the use of acetic acid, and the Synthetic Precipitation leaching procedure is inappropriate because it was developed for soils; the AMC suggested using a distilled water leaching test developed by the American Society for Testing and Materials;
- EPA relied on a linear nonthreshold model for estimating carcinogenic risks that the AMC believes lacks credence for low exposure levels; DOI criticized several assumptions (e.g., including in inhalation pathways some materials that occur as large particles or that form surface crusts) and believes the model is not applicable to groundwater because it was developed for soils at hazardous waste sites; and
- The damage cases cited in the 1990 Report cannot be attributed to Bevill processing wastes or waste management practices.

In contrast, the National Audubon Society, Environmental Defense Fund, and Mineral Policy Center (60) believe that at least 11 mineral processing wastes (noted in table 2-2) warrant Subtitle C regulation. They criticized EPA's risk and damage assessments as inadequate because:

- Risks posed by off-site disposal (e.g., of iron blast, steel furnace air control dust/sludge, slags from primary lead and zinc processing) were not assessed, nor were future risks (e.g., to currently unused groundwater sources of drinking water);
- EPA's model was developed for other situations and underestimates the potential for subsurface migration of contaminants, does not account for evaporation as a pathway, and does

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45 R.D. Judy, Cyprus Copper Co., personal communication, Jan. 17, 1991; T.B. Larsen, Cyprus Miami Mining Corp., personal communication, Apr. 2, 1991. No slag generated by the Cyprus Miami Mining Corp. has failed the EP or TC tests.

46 Slag from primary zinc processing; process wastewater from primary magnesium processing by the anhydrous method; air pollution control dust/sludge from iron blast furnaces; and air pollution control dust/sludge from basic oxygen and open hearth furnaces in carbon steel production.

47 Fluorogypsum from hydrofluoric acid production; red and brown muds from bauxite refining; gasifier ash from coal gasification; Slag from elemental phosphorus production and phosphogypsum and process wastewater from phosphoric acid production.

48 The 1989 NESHAP included a provision requiring that phosphogypsum be disposed in stacks or old phosphate mines. However, because phosphogypsum is used by some farmers as a relatively inexpensive source of calcium, EPA revised the NESHAP in 1990 to provide a limited class waiver for the use of phosphogypsum in agricultural practices (55 *Federal Register 13480*, Apr. 10, 1990).

49 EPA concluded that although hazards associated with the sludge at existing facilities were generally low, Subtitle C regulation might still be warranted 1) because of the "intrinsic hazard" of the waste; and 2) because other primary copper facilities might generate the sludge in the future, in settings where risks could be higher than at current facilities.

not include the effects of episodic events (e.g., storms);

- Monitoring generally has been insufficient to identify damage cases, and EPA failed to review State Superfund sites for damage cases; and
- The EP procedure may vastly underestimate the leaching potential of some processing wastes.

CURRENT REGULATORY PATHWAYS

State Mining Waste Programs

Several organizations contend that most States with significant levels of mining have well-developed programs for active sites, including substantial management, closure, and postclosure requirements (refs. 4, 43, 138, 139).[50] Moreover, these are implemented in conjunction with existing Federal regulations under the Clean Water Act and the Clean Air Act. Many States have also enacted new legislation or promulgated new regulations in the last few years (table 2-3).

The Western Governors' Association (WGA) and the Interstate Mining Compact Commission (IMCC) both surveyed State non-coal mining regulations, with responses from 17 and 47 States, respectively (43, 138).[51] The surveys show that States vary in their regulation of mining activities, due partly to independent development of regulations and to differences in ores mined, processes used, hydrogeology, and climate.[52] EPA, DOI, the States, and the mining industry consider these differences to support the need for flexibility in Federal regulations for mine waste management.

Despite the variations, many elements are shared by most States:

- Permitting—Most States require a permit, license, or reclamation plan for each mining site; permit duration varies from 1 year (usually renewable) to the life of the mine (43). Usually more than one agency is responsible for permitting. Some States issue a comprehensive permit covering all environments; others issue separate permits for different media, often with little coordination among agencies. Some States provide exclusions or waivers based on the operation's size, mineral categories, or waste characteristics (138).
- Plans—Most States in the WGA survey require companies to submit plans describing intended activities. The plans vary in form and content, and States differ in how they review them. Of the 17 responding States, 16 require a plan defining the operator's course of action; 15 require a baseline monitoring plan prior to initiation of mining; and all require an operational monitoring plan that provides for compliance verification.
- Standards—All 17 States in the WGA survey have some standards, mostly water quality standards, to protect groundwater and surface water. Sixteen regulate Clean Air Act criteria pollutants from mining operations. Many, but not all, require groundwater monitoring to determine compliance; requirements vary by location, monitoring parameters, and processes during which monitoring is required (138). Many States consider impoundments to be wastewater treatment facilities and regulate their construction and operation.
- Closure and Enforcement-Sixteen States in the WGA survey require a closure plan; requirements vary considerably and may include physical stabilization, waste neutralization, flood control, revegetation, restoration of wildlife habitat, and long-term monitoring. All States with regulations have enforcement mechanisms to correct or penalize violations, including civil penalties, permit suspension or revocation, injunctions, or administrative orders (43, 138). Most States can take corrective action in the event of an imminent hazard to human health and the environment, but it is unclear whether they can take action prior to releases that lead to these hazards.
- Financial Responsibility—Most States in the IMCC survey and 13 in the WGA survey have, or are developing, requirements that operators provide financial assurance (e.g., by posting

[50] The WGA reiterated this contention in review comments on this background paper (WGA, review comments, Jan. 23, 1991).

[51] The WGA represents 18 western States, many with active mining industries; it surveyed 13 of its members and 4 nonmember States (Florida, Missouri, South Carolina, Wisconsin). The IMCC represents the natural resource interests of its 17 member States, all with significant mining activity; it surveyed all 50 States.

[52] Even so, some States have borrowed approaches from other States, for example, in regulating cyanide heap leaching (138).

Table 2-3-State Non-Coal Mining Legislation and Regulations[a]

States	Areas of legislation[b]	Most recent statute or amendment[b]	Most recent surface mining regulations
Alabama	Surface mining	1969	1969
Alaska	Mining and reclamation	1983	1984
Arizona	Environmental	1986	Guidelines-1989
Arkansas	Mining and reclamation	1987	1973
California	Mining and reclamation	1987	1976
Colorado	Mining and reclamation/groundwater[c]	1988/recent[c]	1988
Connecticut	N/A		N/A
Delaware	N/A		N/A
Florida	Reclamation	1986	1989
Georgia	Mining	1985	1976
Hawaii	N/A		N/A
Idaho	Mining	1987	1988[d]
Illinois	Mining and reclamation	1989	1975
Indiana	Mining and reclamation	1968	Guidelines
Iowa	Mining	1968	NIA
Kansas	N/A		N/A
Kentucky	Mining	1966	1975
Louisiana	N/A		N/A
Maine	N/R		N/R
Maryland	Mining	1985	1989
Massachusetts	N/R		N/R
Michigan	Mining and reclamation/sand dune mining	1972/1989	1976
Minnesota	Mining and reclamation	N/R	1980
Mississippi	Mining and reclamation	1977/1979	1978
Missouri	Limestone, etc./metallic minerals	1971/1989	N/A
Montana	N/R		N/R
Nebraska	None/uranium in future		N/A
Nevada	Water law/reclamation	1973/1 989	1989
New Hampshire	Mining and reclamation	1989	Regulated by towns
New Jersey	Uranium exploration and mining prohibition	1988	N/A
New Mexico	Mining and reclamation	1989	Drafting in 1991
New York	Mined land reclamation law	1979	1976
North Carolina	Mining and reclamation	1987	1976
North Dakota	Subsurface mineral	1987	1976
Ohio	Mining and reclamation	1989	1974
Oklahoma	Mining lands reclamation	1983	1983
Oregon	Reclamation	1989	Yes-no date
Pennsylvania	Mining, reclamation, health, safety	1984	1990
Rhode Island	N/R		N/R
South Carolina	Mining and reclamation	1985	1980
South Dakota	Mining and reclamation	1989	1988
Tennessee	Mining and reclamation	1972	1973
Texas	Mining and reclamation of uranium/iron ore	1979/1987	Yes-uranium/no-iron
Utah	Mined land reclamation	1987	1989 (C)
Vermont	Mining	1981	N/A
Virginia	Health and safety/reclamation	1989/1983	1989
Washington	Reclamation	1971	1971
West Virginia	Mining and reclamation	1985	1981
Wisconsin	Metallic mining and reclamation	1978	1978 (metals only)
Wyoming	Reclamation/safety	1988/1 983	1975

NOTE: N/A = not applicable, usually because State regulations do not exist; N/R_ no response to question.
[a]Responses indicate program elements that may or may not be explicitly stated in statutes or regulations.
[b]Interstate Mining Compact Commission, Mav 1990.
Western Governors' Association, August 1990.
[d]State of Idaho, 1988.

SOURCES: Interstate Mining Compact Commission, Mineral Resources Committee, "Non-Coal Mineral Resources Questionnaire & Report," Herndon, VA: May 1990; State of Idaho, Department of Health and Welfare, "Idaho Code Title 67, Chapter 52: Ore Processing by Cyanidation, Effective Date Jan. 1, 1988"; Western Governors' Association, Mine Waste Task Force, "State Non-Coal Mine Waste Regulatory Programs: Tabulated Survey Results," Denver, CO: August 1990.

bonds) that a facility can be closed successfully. The type and amount of assurance vary greatly: sometimes they are arbitrary amounts; sometimes they are based on factors such as projected closure costs or the magnitude or type of operation. The IMCC survey showed that State performance bond requirements range from $150 to $5,000 per acre, although the sufficiency of these requirements was not assessed.

Although these surveys described the variety and elements of many State programs, neither assessed overall program quality or implementation. For example, the IMCC obtained data on inspection frequency (table 2-4) but not on violations or subsequent enforcement actions. The WGA (139) acknowledged some gaps in coverage (e.g., remediation of inactive and abandoned mines). EPA found that the scope of State programs was not always clear in States' statutory and regulatory language; based on its analysis of 18 States, for example, EPA concluded that there was relatively little coverage of mineral processing wastes under existing State hazardous and solid waste rules (127).

Additional analyses across all relevant States are necessary to evaluate the adequacy of environmental controls imposed on mining facilities; the extent to which permits contain relevant regulatory conditions; the availability of sufficient State personnel; the quality of inspections and adequacy of enforcement actions; and the scope of financial responsibility requirements (e.g., for postclosure care, reclamation, corrective action, and financial adequacy) .53 One possibility is to have independent, publicly available audits of State regulatory and enforcement programs, perhaps following federally set guidelines for audits.

Whether gold heap leaching is adequately regulated has received news media attention (e.g., ref. 2). However, the WGA and others note that most affected States (e.g., California, Idaho, Nevada, Oregon) have specific regulations on heap leaching, including requirements for liners, monitoring, and structural stability analyses (139; also see box 2-A).[54] Nevada, with the largest concentration of gold and silver mining operations, requires impermeable barriers such as liners for new impoundments and other units; groundwater monitoring and remediation; and design and maintenance of tailings ponds, heap pads, and other units so that they are nonthreatening to wildlife.

Departments of Interior and Agriculture

Several land management agencies in the U.S. Department of the Interior (i.e., Bureau of Land Management and National Park Service) and the U.S. Department of Agriculture (i.e., U.S. Forest Service) regulate mining development and waste management on Federal lands.[55] The relationships among these agencies (especially BLM), EPA, and the States are important because most current mining in the western United States, and potentially most future mining or oil and gas development, is on Federal lands. OTA is unaware, however, of systematic analyses of the implementation and effectiveness of BLM, National Park Service, and Forest Service mining regulations.[56]

BLM regulates hard rock mining activities on Federal lands under statutes such as the 1872 Mining Law and the 1976 Federal Land Policy and Management Act (FLPMA).[57] BLM's actions are also subject

[53] The WGA and IMCC are continuing their surveys and attempting to develop such analyses. The Environmental Law Institute (22), with a grant from EPA, is studying regulatory programs in 10 States to determine the quality and efficacy of various approaches to regulating mining wastes.

[54] Also breed on: WGA, reviewcements, Jan. 23, 1991; J.P. Stone, BOM, review comments, Jan. 25, 1991. The WGA did nOte that dump leaching, which is common in copper mining, is potentially less well controlled, although it is becoming subject to more State regulations.

[55] The Bureau of Indian Affairs, Bureau of Mines, and Bureau of Reclamation also administer some Federal lands with mining operations or conduct operations at mining sites.

[56] The National Research Council is evaluating BLM's program for managing hazardous materials on Federal lands but has not released its findings (61; R. Smythe, National Research Council, personal communication, Mar. 14, 1991). However, this program is distinct from BLM's program for mining development and mining waste, although internal coordination exists between the two programs, and all State and most district BLM offices have hazardous materials coordinators assigned to minerals divisions or, recently, other organizational units (J. Craynon, BLM, personal communication, May 14, 1991).

[57] Legislation introduced in the 102d Congress would amend the Mining Law. S. 433 would require the BLM and the Forest Service to revise land use plans to consider impacts ofmining on natural resources; to prohibit or restrict mining depending on the extent of the impacts; to require restoration of the original landscape once mining was completed; and to establish a fund (similar to that for surface coal mines under SMCRA) for reclamation of abandoned hard rock mining sites. The fund would be financed in part by “hoMing” fees paid by mining operators. H.R. 918 contains similar provisions, although the reclamation fund would be financed slightly differently.

Table 2-4-interstate Mining Compact Commission Survey Data on Non-Coal Mining Inspections

States	Number of inspections per year[a]	Number of regulated mining operations	Number of acres under permit[a]
Alabama	293	312	6,943
Alaska	10	450	Thousands
Arizona	768	867	Unknown
Arkansas	111 (1 per site)	111	5,473
California	Unknown	1,600	Unknown
Colorado	7% to 10% of sites	2,005	110,000
Connecticut	N/A	N/A	N/A
Delaware	N/A	N/A	N/A
Florida	5 per mine	38	85,000
Georgia	900	526	42,932
Hawaii	N/A	N/A	N/A
Idaho	N/R	N/R	N/R
Illinois	400	132	10,000
Indiana	40	6	9,233
Iowa	150 to 200	1,600	60,000
Kansas	N/A	N/A	N/A
Kentucky	1,100	172	18,363
Louisiana	N/A	N/A	N/A
Maine	N/R	N/R	N/R
Maryland	842	380	19,756
Massachusetts	N/R	N/R	N/R
Michigan	100	120	10,000
Minnesota	40	13	150,000
Mississippi	600	275	9,793
Missouri	35% of sites	700	6,937
Montana	N/R	N/R	N/R
Nebraska	N/R	694	N/R
Nevada	N/R	N/R	N/R
New Hampshire	N/A	N/A	N/A
New Jersey	Ail mines	100	N/R
New Mexico	Unknown	400	Unknown
New York	1,800	2,400	25,500
North Carolina	1,143	780	100,000
North Dakota	>12	1	40
Ohio	2,100	808	26,962
Oklahoma	3,987	495	20,014
Oregon	600	620	4,143
Pennsylvania	2,865	1,462	62,475
Rhode Island	N/R	N/R	N/R
South Carolina	2 per mine	530	15,000
South Dakota	1,200	2,000	10,000
Tennessee	1,120	128	N/R
Texas	24	3	3,873
Utah	80	184	19,426
Vermont	N/A	N/A	Unknown
Virginia	2,471	663	58,707
Washington	800	1,200	20,000
West Virginia	2,400	100	5,000
Wisconsin	4 per mine	5	1,500
Wyoming	1,300	822	583,000

NOTE: Datadonotindicate ifa single mining operation was inspected more than once annually, nor do they indicate whetherthe number of inspections includes inspections of all environmental media by all agencies having responsibility over mining activities.

[a]N/A = not applicable; N/R = no response to question.

SOURCE: interstate Mining Compact Commission, Mineral Resources Committee, "Non-Coal Mineral Resources Questionnaire & Report," Herndon, VA:May 1990.

to the procedural requirements of the 1969 National Environmental Policy Act. BLM's surface management regulations under FLPMA (43 CFR 3809) establish three levels of mining activities-casual use, surface disturbances of 5 acres or less, and disturbances of more than 5 acres. For proposed operations that would entail disturbances of more than 5 acres per year, operators must submit a plan that describes the operation, including waste management and reclamation. BLM must assess the operation's likely environmental impacts and approve the plan (104).[58] For proposed operations that would entail smaller disturbances, operators must notify BLM and complete the reclamation of operations conducted under previous notices prior to commencing new operations, but BLM approval of the new operation is not required. BLM also requires, at a minimum, quarterly inspection of operations using cyanide, biannual inspection of other producing operations, and biannual inspection of nonproducing activities that result in a disturbance requiring reclamation (39); BLM considers this policy as binding, although it has not issued formal regulations. As with State programs, an independent audit might provide an indication of the effectiveness of BLM's enforcement efforts.

As part of its surface management program, BLM issued a Cyanide Management Policy in 1990 requiring that all mining operations comply with the Migratory Bird Treaty Act's requirements to protect migratory birds and other wildlife (103, 104, 105) (also see box 2-A). The policy institutes bonding requirements for all new operations using cyanide or other toxic leaching solutions and phases in the requirement for existing operations. Some aspects of the policy are "discretionary" in that they may be superseded by equivalent requirements in existing State programs, including those of the National Pollutant Discharge Elimination System (N'PDES).[59]

In July 1991, BLM proposed to amend its bonding (i.e., financial guarantee) policies in the surface management regulations.[60] The proposed rule would mandate submission of financial guarantees for all operations greater than casual use, would create additional financial instruments to satisfy this requirement, and would necessitate the filing of plans of operations by operators with a record of noncompliance.[61]

BLM is also reviewing the status of reclamation and the efficacy of different reclamation methods at non-coal operations authorized and closed under its surface management program, and is developing a policy manual and technical handbook to address reclamation issues (39).[62] BLM intends that the cyanide management, bonding, and reclamation policies complement and reinforce each other.

The National Park Service is responsible, under the 1976 National Park System Mining Activity Act, for regulating mineral development on claims located under the 1872 Mining Law within park boundaries.

The U.S. Forest Service requires mining operators to submit a' 'notice of intent to operate' if proposed activities on Forest Service lands might cause surface disturbances. A proposed operating plan is also required if the Forest Service judges that the operations would cause ''signitica.nt" surface disturbance; the plan must address operational impacts and their management, and must include a reclamation plan for closure. All operations are required to minimize environmental impacts to the extent feasible and to consider reclamation of disturbed lands.

Under the National Environmental Policy Act (NEPA), EPA can evaluate likely environmental impacts from "major' activities on Federal lands. As provided by Section 309 of the Clean Air Act, for example, EPA reviews BLM's environmental impact assessments for proposed projects on BLM lands. According to both agencies, EPA has accepted some BLM assessments and provided negative comments on others. In theory, conflicts be-

[58] Some States have memoranda of understanding (MOUs) between State regulatory and Federal land management agencies that are designed to assure consistent and timely review of operating plans prior to commencement of the operation.

[59] The General Accounting Office (GAO) (85) questioned whether BLM and the Forest Service have adequate staffer resources to inspect more than 1.2 million active claims in support of their land management regulations. However, GAO (87) also concluded that BLM oversight and enforcement had increased since the Cyanide Management Policy was issued.

[60] 56 *Federal Register 31602, J@'* 11, 1991.

[61] Bond amounts would be capped at $1,000 per acre fo, exploration activities and $2,000 per acre for mining activities. However, an exception to the caps would exist for those portions of operations that use cyanide or other leachates; bonds to cover 100 percent of reclamation costs would be required for operators with cyanide operations.

[62] J. Craynon, BLM, personal communication, May 14, 1991.

tween Federal agencies about NEPA assessments can be adjudicated by the Council on Environmental Quality.

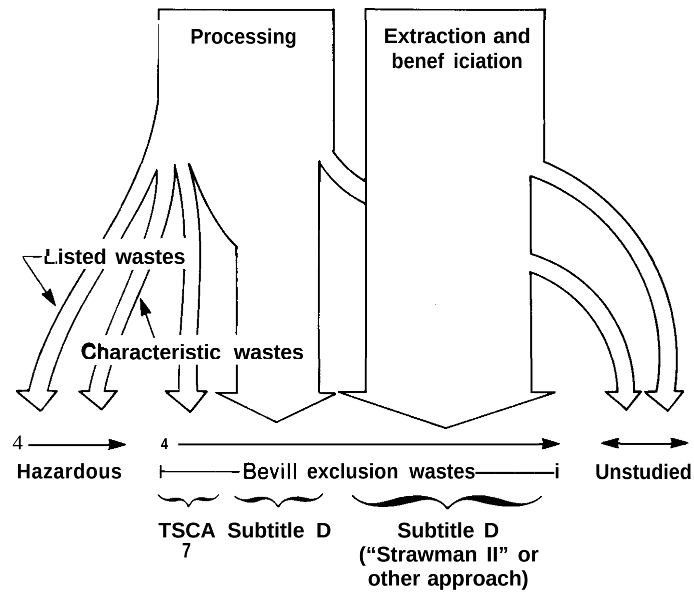
Current RCRA Status of Extraction and Beneficiation Wastes

In 1986, EPA concluded that universal application of current Subtitle C requirements to E&B wastes was not warranted at that time.[63] EPA's determination was supported by a U.S. Court of Appeals as consistent with congressional intent.[64]

EPA instead decided to attempt to develop a Subtitle D mining waste program (see figure 2-2). BOX 2-B summarizes ''Strawman II, ' EPA's May 1990 staff-level approach to a possible Subtitle D program. However, EPA's 1986 regulatory determination stated that it might still develop Subtitle C regulations if an effective Subtitle D program could not be developed-e. g., if State resources to develop and implement programs or Federal oversight and enforcement authority over State-implemented programs are inadequate. With respect to the latter, EPA might use existing enforcement authority under Section 7003 of RCRA and under Sections 104 and 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to respond to substantial threats and imminent hazards to human health or the environment, but the Agency questions whether this will be sufficient. EPA also questions whether Section 4004(a) of RCRA provides it with authority to regulate storage impoundments, as opposed to disposal facilities such as landfills and open dumps.

The WGA received $1.8 million from EPA in order to provide grants to 20 States to: 1) analyze the potential impacts on each State of a Strawman II type of Federal mining regulatory approach; 2) fund four special projects conducted by individual States (e.g., on acid mine drainage, cyanide processes, and inactive and abandoned mine sites); and 3) hold meetings of mining States to discuss Federal approaches and to share regulatory ideas. In addition,

Figure 2-2—Regulatory Status of Mining Wastes Under RCRA



SOURCE: OTA, after C. McKinnon (Western Governors' Association, personal communication, Apr. 17, 1991).

EPA recently chartered a Policy Dialogue Committee under the Federal Advisory Committee Act that involves parties interested in mining waste issues.[65]

Current RCRA Status of Mineral Processing Wastes

A 1988 court order directed EPA to narrow the scope of mineral processing wastes covered by the Bevill exclusion.[66] In 1989 and 1990, EPA published final rules defining the "high-volume" and ''low-hazard' criteria by which such wastes were to be identified.[67] It identified 20 mineral processing wastes that met the criteria (table 2-2; see "Waste Generation" above). All other mineral processing wastes (i.e., all non-Bevill wastes) are subject to regulation as hazardous waste if they exhibit a hazardous characteristic, are otherwise listed as a hazardous waste, or are "mixed with" or "derived from" a listed hazardous waste even if the mixture

[63] 51 *Federal Register* 24496, July 3, 1986.

[64] *Environmental Defense Fund v. U.S. Environmental Protection Agency, 852* F.2nd 1309 (D.C. Cir. 1988).

[65] 56 *Federal Register* 19358, Apr. 26, 1991.

[66] *Environmental Defense Fund and Hazardous Waste Treatment Council* v. *U.S. Environmental Protection Agency,* 852 F.2d 1316 (D.C. Cir. 1988).

[67] 54 *Federal Register* 36592, Sept. 1, 1989; and 55 *Federal Register* 2322, Jan. 23, 1990. However, these rules are under challenge in the D.C. Circuit Court of Apperds (*Solite Corporation v. U.S. Environmental Protection Agency, Civil No. 89-1629).*

Box 2-B—EPA'S "Strawman II" Strategy

EPA's 1990 staff-level "Strawman II" document (124) outlined a possible Subtitle D program for mining wastes-including extraction and beneficiation (E&B) wastes; mineral processing wastes that either remain within the Bevill exclusion or are non-Bevill, non-Subtitle C wastes commingled with E&B wastes; active heap and dump leaching operations and associated leaching solutions; mine water mill tailings; and stockpiled or subgrade ores. This group of "regulated materials" and "regulated units" is broader than the one addressed by the 1985 Report (111) and subsequent regulatory determinations. The strategy applies only to active units (new and existing), not to closed, inactive, or abandoned units (unless they are reactivated after the program's compliance date or a State includes them in its own program).

EPA intended Strawman II to be a tailored, risk-based strategy that would allow the Agency and the States to respond to site-specific conditions. Major features included:

- EPA codification of a State management plan that meets Agency requirements (e.g., coordination with Federal and State agencies; procedures to comply with Federal technical criteria; permits with enforceable standards, reviewed every 5 years; public participation), after which the State would have primacy in implementing and enforcing the plan;
- limited EPA oversight and enforcement in codified States (with intervention based on "triggers' '), but broader EPA authority to develop State plans and to issue and enforce permits in noncodified States;
- State numerical performance standards for groundwater (e.g., for parameters such as acid generation, radioactivity, asbestos, and cyanide levels for specific mining industries) or Federal standards, such as maximum contaminant levels, for groundwater used as drinking water;
- minimum Federal technical criteria for groundwater protection (e.g., design and operating standards, performance standards, monitoring, closure and postclosure care, financial responsibility, corrective action); and
- a multimedia approach, with States expected to incorporate site-specific performance standards (e.g., State water quality standards for surface waters) into permits.

The Western Governors' Association (WGA) (139), American Mining Congress (AMC) (3), the Department of Interior (DOI), and the Department of Agriculture (USDA) (101) each criticized Strawman II for various reasons, several of which were common to all critiques:

- providing overly prescriptive requirements, rather than guidance, for the development of State plans;
- imposing uniform technical criteria (e.g., on monitoring and inspection frequency, permit lengths, closure periods) that restrict States' flexibility to address site-specific conditions and might disrupt existing State programs;
- proposing overly broad triggers for EPA oversight of State programs, particularly for intervention in permit issuance and enforcement; and
- failing to distinguish between existing and new facilities, other than to grant a 5-year compliance period for the former.

The AMC, DOI, and USDA also criticized Strawman II for: 1) imposing performance standards and monitoring requirements on environments (air, soil, surface water) already regulated under Federal and State statutes other than

or derivation does not exhibit a hazardous characteristic.[68]

In its 1990 Report, EPA suggested two appreaches to regulating these Bevill wastes: 1) regulate all 20 under a State-implemented Subtitle D program, or 2) regulate 16 under Subtitle D and 4 others (noted in "Risks from Mining Waste Management" above) possibly under Subtitle C. EPA concluded that the economic impacts of full Subtitle C regulation probably would not be significant for hydrofluoric acid process wastewater but would be for the other three wastes that might warrant Subtitle

[68] EPA promulgated land disposal restrictions and treatment requirements for hazardous wastes in 1990 (55 *Federal Register* 22520, June 1, 1990) (also see ch. 5).

RCRA; and 2) expanding the universe of regulated materials to include process materials (e.g., from leaching operations), exploration wastes, mine water, stockpiled and subgrade ores, and tailings.[1]

DOI and USDA also criticized EPA for failure to address: 1) the possibility that Federal agencies (such as BLM, U.S. Forest Service, and Bureau of Indian Affairs) could be held jointly liable, on the basis of their trustee or leaseholder status for Federal lands, for compliance with remedial action requirements under CERCLA (also see ref. 53); 2) the manner in which Strawman II would be coordinated with existing regulations of these agencies for mining on Federal land; and 3) the way that State responsibilities would be carried out on Federal lands, in concert with BLM and Forest Service surface reclamation requirements. To underscore differences between mining and other wastes, DOI has supported a Federal program of State-based management under legislative authority **separate** from Subtitle D, possibly as a separate RCRA subtitle (39, 137).

Environmental groups represented by the Environmental Mining Network (23) generally do not believe that States will design and enforce effective regulatory programs. They would like to see a Subtitle D program with stronger oversight authorities for EPA and increased public participation provisions. They favor performance-based design standards (as opposed to risk-based standards) to limit releases; a multimedia approach; greater specification of the required technical components of State programs (e.g., regarding design, operation, monitoring, closure, postclosure); minimum reclamation standards to ensure effective closures; and stronger financial responsibility requirements, as well as enforcement standards for these requirements.

Considerable disagreement exists on whether materials in heap and dump leaching operations should be regulated under RCRA. The WGA believes they should be regulated from the beginning of the process, because they typically are not relocated for treatment and disposal after leaching and a leach pad or dump must be properly designed before it is built to effectively regulate subsequent disposal. The AMC disagrees, contending that these production processes should not be subject to EPA statutory authority and furthermore, are already subject to State water quality regulations. However, DOI and USDA suggested that heap and dump leaching operations might be unique enough for regulation of a production process to be justified, and that RCRA be modified to allow EPA to address processes or materials. Another possibility is regulation under Section 6(b)(2) of TSCA, which addresses manufacturing quality control issues.

With **respect to** pollution prevention, EPA suggested that the costs of monitoring, corrective action, closure, postclosure care, and financial responsibility requirements in Strawman II would encourage operators to undertake measures prior to disposal that reduce the risks posed by mining wastes. The Environmental Mining Network (23), however, felt that Strawman II fell short in this area and recommended that EPA include specific provisions to promote pollution prevention—for example, establishing pollution prevention performance standards; requiring owners/operators to identify prevention technologies and demonstrate that they will use the technologies unless such use is infeasible; imposing permit fees proportional to waste volume, toxicity, and environmental degradation; and requiring owners/operators to report prevention measures undertaken. These provisions would require that EPA be given statutory authority under RCRA to regulate production.

[1] AMC contends that mine waters are sufficiently regulated under existing State programs and that tailings used for construction or agricultural purposes do not present a threat and need not be regulated under Subtitle D. DOI and USDA contend that mine waters are appropriately addressed under the Clean Water Act. AMC also believes that all relevant mining wastes (i.e., E&B wastes, non-Bevill mineral processing wastes) should be subject to a single Subtitle D program rather than to several different RCRA programs that apply simultaneously to individual facilities.

C regulation.[69] EPA also concluded that it lacks authority to adopt or enforce a Federal program if a State fails to adopt and enforce its own program.

As noted above (see "Risks From Mining Waste Management"), the AMC and environmental groups disagree about whether any mineral processing wastes should be classified as hazardous. They also disagree on the design of a Federal program for these wastes. The AMC (4) contends that Bevill processing wastes are controlled by other State and Federal regulatory programs; it favors continued development of State programs, with any Federal

[69] The AMC (4) and DOI and U.S. Department of Agriculture (101, 102) contend that the costs of Subtitle C regulation would be greater than estimated by EPA, for example because of corrective action requirements tbat would subject miningoperations to Subtitle C land disposal restrictions and minimum technical requirements. Environmental groups (60) assert that corrective action requirements might be equally expensive under either Subtitle C or D.

program being very flexible and focused on site-specific conditions. Environmental groups (60) contend that although some States are improving their mining regulations, progress is uneven, damages are still occurring at active facilities, and there is no evidence that States in general will adequately regulate processing wastes in the immediate future.

In June 1991, EPA determined that it would not regulate any Bevill processing wastes under Subtitle C and instead plans to address 18 of them under Subtitle D (see figure 2-2).[70] For the other two wastes, phosphogypsum and phosphoric acid process wastewater, EPA is considering developing regulations under TSCA (see figure 2-2), including addressing waste minimization in the production process and using existing authorities under RCRA Section 7003 or CERCLA Section 106 to address substantial and imminent hazards arising from their management.[71] Although the State of Florida (where most phosphogypsum production occurs) has drafted proposed regulations requiring, for example, that phosphogypsum stacks be constructed with composite liners and leachate collection systems (29), EPA believes that a more stringent regulatory approach is necessary. In the rulemaking, EPA also postponed considering a possible ban on the use of slag from elemental phosphorus production in construction or land reclamation.

Other EPA Statutory Authority

EPA implements other Federal laws that affect mining waste, such as the Safe Drinking Water Act (SDWA), Clean Water Act, Clean Air Act, and possibly the Toxic Substances Control Act (TSCA). Mining operations, especially those involving remining and cleanup of inactive and abandoned sites, are also affected by potential liabilities under CERCLA (see next section).

In comments to OTA, many industry representatives contend that the combined coverage of these statutes, along with programs of other Federal agencies such as BLM and of the States, is sufficient to address issues not strictly covered under RCRA. This appears to be true in terms of general statutory coverage, but with some major exceptions such as protection of groundwater, control of nonpoint source pollution, regulation of heap and dump leaching operations, and regulation of inactive and abandoned mine sites. Of course, the question of adequate Federal and State enforcement of existing regulations under these statutes always looms. In addition, EPA believes that existing programs for groundwater, surface water, air, and soil do not always provide the requisite authority to address specific risks associated with mining wastes (124). As a result, EPA's Strawman II approach for E&B wastes proposed that States incorporate site-specific multimedia requirements into mining permits (see box 2-B).

Clean Water Act

Under the Clean Water Act, effluent discharges of pollutants from a point source into navigable waters are legal only if the operator has obtained an NPDES permit.[72] These permits specify compliance conditions (such as applicable effluent guidelines, water quality-based effluent limitations, best management practices). Technology-based effluent guidelines have been established for 10 mining commodity sectors (of the 12 covered in the 1990 Report) for existing sources and for 9 sectors for new sources (127).[73] In general, the NPDES process is implemented by the States with Federal oversight, although in some cases EPA is the primary permitting authority. OTA is unaware of analyses of the scope of the guidelines or the enforcement of mining discharge permits.[74]

[70] 56 Federal Register 27300, June 13, 1991.

[71] EPA concluded that management of these wastes poses potential health and environmental problems and that more stringent regulation (including possible Subtitle C regulation) is both necessary and desirable. However, EPA also concluded that regulation under a modified Subtitle C or Subtitle D program would cause economic hardships for, and threaten the continued viability of, several facilities in the fertilizer industry.

[72] Discharges of solids may require a dredge and fill permit under Section 404 of the Clean Water Act.

[73] For new sources, the guidelines typically: 1) prohibit the discharge of process wastewater to navigable waters, and 2) specify allowable concentrations of substances (e.g., dissolved iron, total suspended solids, various metals depending on the category of mining) in mine drainage. In the absence of effluent guidelines, the permitting authority (EPA or the State) will establish technology-based effluent limitations based on "best professional judgment.' Water quality-based effluent limitations are established whenever technology-based limitations are insufficient to protect water quality.

[74] NPDES enforcement depends on the existence of appropriate Federal water quality criteria and subsequent State use of these criteria to develop water quality standards (92).

EPA also has promulgated regulations defining which entities must apply for a NPDES permit for stormwater discharges.[75] For mining operations, a permit application is required when discharges of stormwater runoff come in contact with any overburden, raw material, intermediate or finished product, byproduct, or waste product located on-site. This includes inactive mining sites that have an identifiable owner/operator.[76] Deadlines for the permitting process have not been reached, so it is too early to ascertain the effectiveness of the regulations.[77] DOI, however, has already concluded that the regulations cannot be effectively implemented, based on its concerns about the inclusion of abandoned mines and landfills; the complexity of the general permit process, particularly with respect to States with primacy to develop and implement regulations; the potentially higher costs being imposed on the affected community and on the Department's programs than those estimated by EPA; and apparent conflicts with DOI's obligations under the Historic Preservation Act (64).

Mineral processing facilities that discharge effluents into publicly owned treatment works are subject to "pretreatment" standards. For the mining industry, pretreatment standards have been developed for new sources in the bauxite, copper, lead, and zinc sectors and for existing sources in the lead and zinc sectors (127). However, although much success has been demonstrated in implementation and enforcement of the pretreatment program in general, major areas for improvement were delineated in a recent EPA report on pretreatment (133a).

Safe Drinking Water Act

The SDWA requires EPA to set drinking water regulations and Maximum Contaminant Levels for toxic water contaminants, to regulate underground injection of wastes to protect groundwater, and to protect sole source aquifers. SDWA regulates injection wells from the wellhead down but does not regulate surface activities associated with injection wells. In general, wells used for injection of hazardous wastes, including waste from in situ leaching, are regulated as Class I wells. RCRA does give EPA the authority to regulate Subtitle D disposal facilities and Subtitle C hazardous waste treatment, storage, or disposal facilities. However, EPA lacks authority under Subtitle D to prevent groundwater contamination from production facilities (unless a demonstrable hydrologic link exists between surface water, which EPA can regulate, and groundwater) and may lack authority to regulate impoundments used for storage of Subtitle D wastes at injection sites (see ''Current RCRA Status of Extraction and Beneficiation Wastes' above).

Clean Air Act

Under the Clean Air Act, EPA has issued National Ambient Air Quality Standards (NAAQS) for particulate matter and NESHAPS for radionuclide emissions from the stacks of elemental phosphorus plants and phosphogypsum stacks[78] and inorganic arsenic emissions from primary copper smelters. The Clean Air Act Amendments of 1990 expanded the list of hazardous air pollutants to be considered by EPA and required the Agency to develop emissions performance standards for major emitters of these pollutants. It is thus conceivable that some mining operations will be subject to additional regulations (e.g., for fine mineral fibers, or for beryllium compounds, asbestos, and radionuclides from sources other than those currently regulated). Whether these regulations will cover toxic pollutants in fugitive dust is unknown; EPA (124) noted that State Implementation Plans under the Clean Air Act typically do not address this source at mining sites.

Toxic Substances Control Act

Under TSCA (e.g., Section 6), EPA has authority to regulate the production, use, and disposal of specific chemical substances. The possible application of TSCA to the use of sodium cyanide in gold heap leaching operations is discussed in box 2-A. Application of TSCA to processing wastes, such as wastewater from phosphoric acid production and gypsum processing, is also being considered (see "Current RCRA Status of Mineral Processing Wastes" above).

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[75] 55 Federal Register 47990, Nov. 16, 1990; 56 *Federal Register 12098,* Mar. 21, 1991.

[76] The regulations exclude active or inactive coal mining operations that have been reclaimed under SMCRA, and active or inactive non-coal mining operations that have been reclaimed under similar applicable State or Federal laws.

[77] In addition, the American Mining Congress and other petitioners have challenged the stormwater regulations in the U.S. Court of Appeals fOr the Ninth Circuit (5).

[78] 54 Federal Register 51674, Dec. 15, 1989.

Inactive and Abandoned Mine Sites, CERCLA, and RCRA

Virtually all parties believe that remediation of problems at inactive and abandoned non-coal mines is a major issue. A study by the Western Interstate Energy Board (140) collated anecdotal evidence of environmental, public health, and safety problems associated with these mines, but noted that the nature of the problems and potential reclamation costs are largely unknown. Based on the study, the total number of sites is probably well over 140,000. For example, Arizona estimated 80,000 sites, and Colorado, Montana, and Texas each estimated more than 20,000 sites; however, definitions of abandoned sites differ among the States. The WGA, AMC, IMCC, and Western Interstate Energy Board are gathering additional data on these sites (140).[79]

These facilities generally are not subject to Federal regulations, except for the new stormwater requirements (see "Clean Water Act" above) or if a specific site is on the NPL for cleanup and remediation under CERCLA.[80] One related issue is what will happen to the many sites that may be having environmental impacts but are not on Federal or State Superfund lists.

Moreover, CERCLA may inhibit remining and cleaning up inactive and abandoned sites, contrary to the 'resource recovery' goal of RCRA. Technological advances in processing and increases in market prices have made remining and reprocessing of wastes at such sites more feasible. However, operators may not undertake such efforts because of potential liabilities under Superfund for past environmental problems at these sites and because of the costs of conducting remining in compliance with future Subtitle D regulations for new facilities (3,49, 101, 130, 139, 140). In addition, Federal land management agencies fear that they might be held liable for compliance with remedial action requirements under CERCLA.

EPA, WGA, and DOI are investigating policy options for encouraging remining of inactive and abandoned mines, including changes in existing CERCLA regulations.[81] AMC (3) recommended removing CERCLA liabilities for exploration activities, which are necessary to evaluate the feasibility of remining, if the activities do not exacerbate existing problems; one reviewer recommended that EPA expand its NPL deferral policy to cover mining waste sites and allow delisting from the NPL of mining sites that meet eventual Subtitle D design, operation, and corrective action requirements.[82]

EPA did not include these sites in Strawman II (see box 2-B) because it believes that RCRA does not provide the authority or funding mechanisms to adequately address cleanup problems at the sites, although the Agency can use RCRA Section 7003 and CERCLA authorities to deal with significant, imminent threats to human health and the environment. EPA also lacks sufficient data on the number, location, characteristics, and potential risks of these sites to implement and enforce technical criteria. WGA (139) and AMC (3) agreed that inactive abandoned mine sites should not be covered in Strawman II but did not suggest alternative approaches. WGA, however, agreed that remediation of these sites is important; it is sponsoring a study (through the grants described in "Current RCRA Status of Extraction and Beneficiation Wastes" above) on the scope of environmental, public health, and safety problems associated with them and on potential policy options for addressing the problems (140).[83] WGA also questioned whether RCRA is the appropriate statute for cleanup efforts at such sites.[84]

In contrast, environmental groups recommend that Strawman II include inactive units at active facilities and inactive facilities at which the owner/

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79 WGA, review comments, Jan. 23, 1991.

80 Authority exists under SMCRA for States that have completed work on lands mined for coal to use funds available under SMCRA's Abandoned Mine Lands Fund for cleanup and remediation of metal and industrial mineral mine sites, although the funding source is coal mining (funds derived from a tax on coal production are distributed to the States for reclamation projects) and priority generally is given to coal lands and coal mining States (R.D. Andrews, Boulder Innovative Technologies, personal communication, Apr. 16, 1991; J.P. Stone, BOM, personal communication, Apr. 12, 1991).

81 Also see box 5-B inch. 5 regarding recycling at smelters of sludges from manufacturing processes.

82 S. Crozier, Phelps Dodge Corp., personal communication, Mar. 6, 1991.

83 AMC (3) did not directly address how t. deal with such sites, other than to encourage modification of RCRA and CERCLA liability provisions to remove disincentives for remining.

84 As noted in footnote 57, legislation introduced in the 102d Congress to amend the Mining Law would authorize a fund for reclamation of abandoned hard-rock mining sites.

operator is known, and that EPA retain CERCLA liability for new contamination (23). They believe that inactive units at active sites might be appropriately included in a mining waste regulatory program to: 1) avoid the need to identify whether contamination at a site originated from an active or inactive unit, which can be an expensive and complex undertaking; and 2) ensure that owners/operators are not encouraged to close problem sites simply to avoid corrective action obligations.

ISSUES/QUESTIONS

Congress could consider several major issues and questions that are specific to mining wastes or that address the relationship between mining and other wastes, as part of oversight hearings or the RCRA reauthorization process. These include but are not necessarily limited to the following:

- Relationships Among Federal Statutes and Programs-What are the most appropriate Federal statutory vehicles for regulating mining wastes? How should relationships among statutes such as RCRA, TSCA, the Clean Water Act, the Mining Law, FLPMA, and others be coordinated? Are EPA, BLM, and U.S. Forest Service efforts to regulate mining wastes on Federal lands consistent with each other and coordinated with existing State regulatory programs? Should BLM and the Forest Service be given additional directions on the nature of surface mining waste regulations? Should EPA develop a multimedia approach within a RCRA Subtitle D mining program?
- Relationships Among Federal and State Agencies—what degree of primacy does Congress wish States to have in managing mining wastes? Within RCRA, for example, should EPA continue developing a State-implemented Subtitle D program (i.e., States develop their own regulations with Federal oversight and enforcement), focus instead on simply providing technical and financial assistance to individual State programs, or switch to developing a Federal Subtitle D program (i.e., EPA sets forth basic requirements that States must implement)? Does EPA need additional oversight and enforcement authority (and, if so, what types) to support an effective State-implemented Subtitle D program? How should EPA regulate existing, as opposed to new, units?
- Resources for Administration and Enforcement of Programs-Are existing resources sufficient to administer and enforce Federal and State mining waste regulatory programs? If not, what mechanisms are available to provide such resources? Should independent audits be conducted to assess how effectively various Federal and State regulations are being enforced?
- Regulation of Inactive and Abandoned Mining Sites-Should Congress establish new mechanisms and funding for cleanup of inactive and abandoned non-coal mining sites and if so, under the auspices of what agency or agencies? Should CERCLA be modified to allow the waiver of liability-related disincentives for remining old sites? Does EPA have sufficient authority to regulate new operations at such sites?
- Regulation of Mining Production Processes Should EPA be given authority under RCRA to regulate mining production processes (e.g., active heap and dump leaching operations, stockpiled ores) that exhibit some linkage with subsequent waste management? Would TSCA (Section 6) be a more appropriate statutory vehicle for regulating production processes? Should wastes from phosphoric acid production be regulated under TSCA in lieu of RCRA? How could EPA enhance the prospects of pollution prevention/waste reduction?
- Adequacy of Existing Toxicity Tests-Are existing toxicity tests such as the EP and TC adequate to determine the potential for long-term leaching and migration of contaminants from mining wastes?

Chapter 3

Coal Combustion Utility Wastes

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Chapter 3
Coal Combustion Utility Wastes

INTRODUCTION

As with mining and oil and gas wastes, the 1980 Bevill amendment to the Resource Conservation and Recovery Act (RCRA) exempted wastes resulting from the combustion of fossil fuels from regulation as hazardous wastes until the U.S. Environmental Protection Agency (EPA) submitted a Report to Congress on the adverse effects, if any, of these wastes and determined whether hazardous waste regulation was indeed warranted.[1] The amendment included utility wastes in this special category because of congressional concern that the imposition of unnecessary and costly regulation could reduce the use of coal as a fuel source and thereby increase the Nation's reliance on foreign energy sources (134). EPA's subsequent Report to Congress covered only wastes from the combustion of coal by the electric utility industry because these wastes were believed to account for 90 percent of all wastes generated by the combustion of fossil fuels (118).

Coal combustion utility wastes consist of "high-volume' wastes produced directly from coal combustion and "low-volume" wastes formed during equipment maintenance and water purification processes. The high-volume wastes include:

- fly ash—smaller ash particles entrained by the flue gas and generally captured in the air pollution control device;
- bottom ash—larger ash particles that settle on the bottom of the boiler;
- boiler slag—bottom ash that has melted and reformed into a solid; and
- flue gas desulfurization (FGD) sludge-sludge generated when sulfur dioxide is removed from other flue gases.

Low-volume wastes include boiler and cooling tower blowdown (i.e., boiler water removed from ash or sludge), coal pile runoff, demineralizer regenerants and rinses, boiler cleaning wastes, pyrites, and sump effluents. They are generated in smaller quantities than high-volume wastes, although some (e.g., cooling tower blowdown) can be generated in substantial amounts (118).2 In contrast to high-volume wastes, many low-volume wastes are also produced periodically at each plant rather than on a continuous basis (e.g., boilers may be cleaned, hence boiler cleaning waste produced, only once every 2 to 3 years).[3]

About 10 percent of the amount of coal burned remains in the form of ash.[4] More than 95 percent of all ash (i.e., fly ash, bottom ash, and bottom slag) produced by utilities is composed of oxides of silicon, aluminum, iron, and calcium (1 18). Ash also contains many other trace elements that vary by type and level depending on ash particle size, source of the coal, and other factors; these elements can include arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, and selenium, among others. Many are in the form of oxides tied up in complex silicates.

The composition of FGD sludge depends in part on the reagent used to absorb sulfur dioxide from the gas (e.g., lime or limestone, sodium hydroxide, or sodium sulfate). In addition, FGD sludge can contain oxides and trace elements derived from fly ash that is caught in air pollution control scrubbers; the type and concentration of trace elements would reflect their levels in the ash. FGD sludge maybe of more concern than ash because of higher concentrations of sulfur and other contaminants. Implementation of the 1990 Clean Air Act Amendments will significantly increase the amount of FGD sludge requiring disposal.

Low-volume cleaning wastes can contain significant levels of trace elements like lead and cleaning reagents such as chlorides, algicides, and phenols.

[1] RCRA Sec. 3001(b)(3)(A).

[2] The Utility Solid Waste Activities Group (USWAG), review comments, Feb. 22, 1991.

[3] K. Ladwig, Wisconsin Electric Power Co., personal communication, Feb. 28, 1991.

[4] USWAG (review comments, Feb. 22, 1991) indicates that ash content usually is between 8 and 10 percent, whereas EPA (119) indicated that ash content generally is more than 10 percent.

WASTE GENERATION

EPA estimated that coal-burning utilities account for 90 percent of the wastes produced by fossil fuel combustion in the industry (118). EPA provided two estimates for quantities of coal combustion wastes—85 million tons and 1 billion tons—that differ primarily in the inclusion of wastewater in the higher estimates The Utility Solid Waste Activities Group (USWAG), which represents most of the electric generation industry,[6] believes that the estimate of 85 million tons of high-volume wastes is more accurate. The industry explains that water is added simply to facilitate management of the wastes and should not be included in measurements of waste generation because it is either discharged to surface water under a National Pollutant Discharge Elimination System (NPDES) permit or recycled back to the electricity generating process; it is not disposed of in surface impoundments.[7] Furthermore, the industry has stated that the water does not add to the potential toxicity of the waste.[8] However, discharges to surface waters may contain trace elements derived from the ash or from FGD sludge.[9]

CURRENT MANAGEMENT PRACTICES

Coal combustion wastes can be treated, stored, or disposed of either in landfills or in surface impoundments (see figure 3-l). In general, coal ash and other wastes are sluiced into a surface impoundment where the solids settle out, leaving relatively clear water at the surface. The solids may accumulate in

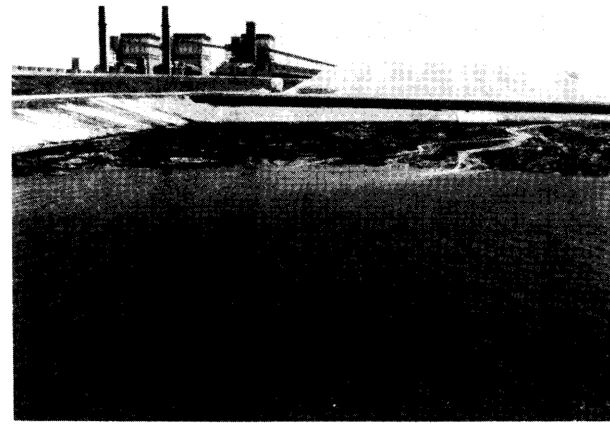


Photo credit: Electric Power Research Institute

Surface impoundment at coal-fired electric utility.

the surface impoundment until it is full, or they may be dredged periodically and taken to another disposal site such as a landfill (118). The water in the impoundment is often discharged to surface water, with or without treatment, under a NPDES permit; 95 percent of all coal combustion utilities have NPDES permits. Approximately 20 percent of all surface impoundments recirculate sluice water back to the combustion process.[10] Ash and flue gas desulfurization sludges are generally disposed of in landfills after they are generated or after they have been dredged from surface impoundments (118).

Most low-volume wastes are disposed of in landfills or surface impoundments. Some are codisposed with ash or FGD sludge, sometimes with treatment such as neutralization. USWAG believes

[5]First, EPA estimated in its Report to Congress that coal-fired powerplants generated 85 million tons of wastes in 1984-about 69 million tons of all types of ash and 16 million tons of FGD sludge (118). EPA expected the quantities of ash and FGD sludge to increase to 120 million tons and 50 million tons per year, respectively, by the year 2000, due to increased dependence on coal for electricity production. These quantities do not include the weight of wastewater used to sluice the ash and FGD sludge into surface impoundments. Also, EPA did not estimate the quantities of low-volume cleaning and maintenance wastes. Second, EPA conducted a screening survey of industrial Subtitle D facilities (116). For the electric power generation industry (Standard Industrial Classification Code 491 1), EPA estimated that almost 4,000 establishments produced nearly 1 billion tons of waste in 1985 (1 16). This quantity includes the weight of wastewater used to sluice ash into surface impoundments from the boilers and other wastewater involved in the coal combustion process. It also includes all electric power generating facilities, not just those burning coal. Although EPA is not certain how the data in the two studies are related, it appears that wastes from the approximately 500 coal-burning electric utilities included in the Report to Congress (1 18) would be included among the electric power generation industry wastes in the screening survey (R. Tonetti, U.S. EPA, personal communication, August 1990).

[6]USWAG is an informal consortium composed of the Edison Electric Institute, the American Public Power Association, the National Rural Electric Cooperative Association, and approximately 75 electric utility operating companies. Together, USWAG members represent more than 85 percent of the total electric generating capacity of the United States.

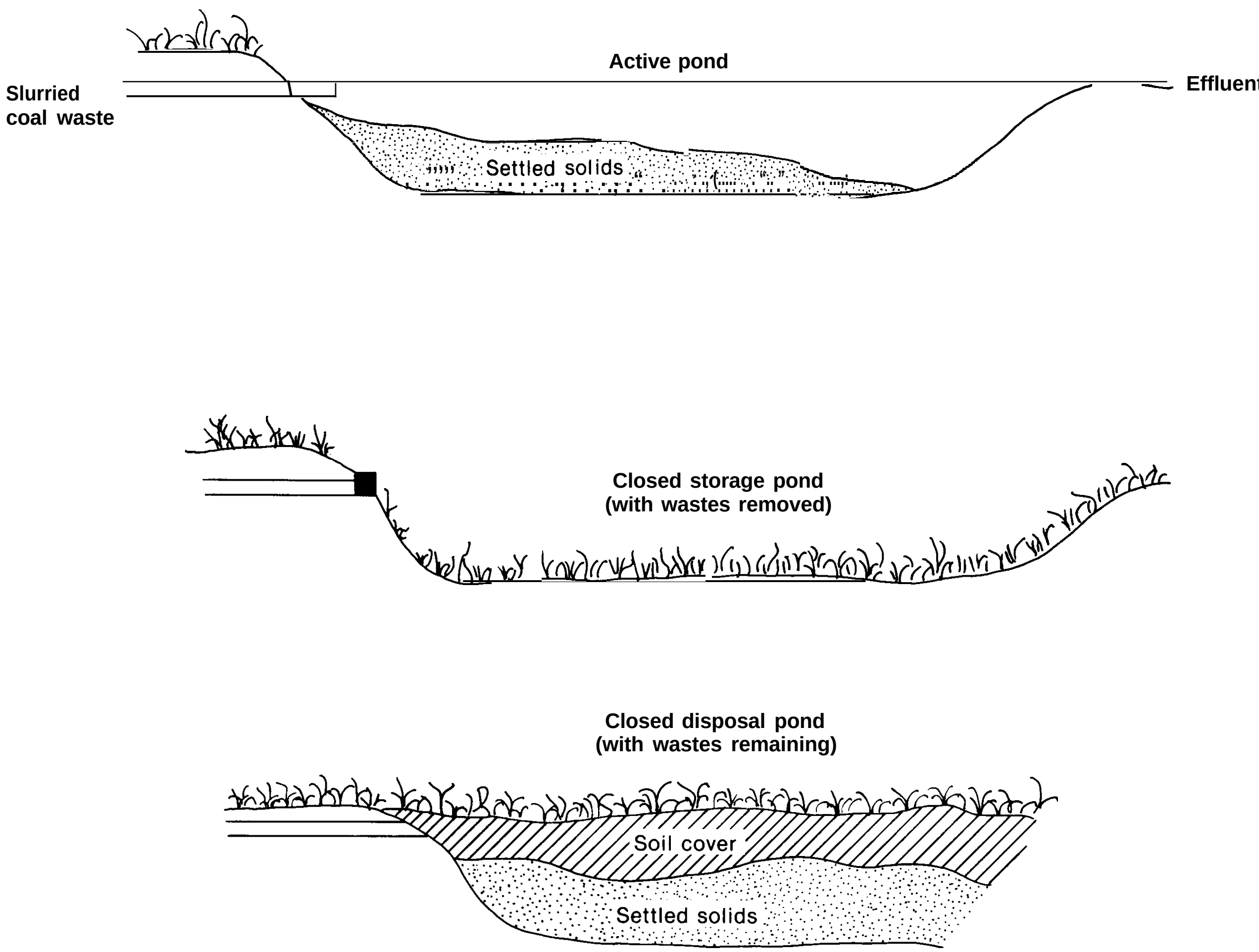
[7]Issues such as these draw into question the validity and comparability of generation estimates across different industries and studies. This may also mean that some RCRA-exempted wastes are included in the total volume of Subtitle D manufacturing wastes estimated by the screening survey.

[8]USWAG, review cements, Feb. 22, 1991.

[9]Additional FGD sludge will likely be generated as facilities comply with new emission standards required in the 1990 Clean Air Act (CAA) Amendments. The effects of the clean coal technologies and new emission standards in the CAA Amendments on the generation and management of coal combustion wastes have not been fully assessed.

[10]J. Roewer, Edison Electric Institute, personal communication, April 1991.

Figure 3-l-Typical Stages in the Life of a Surface Impoundment



SOURCE: U.S. Environmental Protection Agency, *Report to Congress: Wastes From the Combustion of Coal by Electric Utility Power Plants, EPA/530-SW-88-O02* (Washington, DC: February 1988).

that about 30 percent of utilities codispose high- and low-volume wastes; however, this does not indicate the volume of waste codisposed. Table 3-1 lists different management scenarios for typical low-volume wastes (118). No estimates are available on the amount of low-volume wastes that are handled as hazardous by the utilities and sent off-site for management.[11]

Clay or other liners may lower the rate at which leachate is released from impoundments. As of the mid-1980s, however, only 25 percent of all units—including about 40 percent of landfills and 13 percent of surface impoundments-for which information was available had some type of liner (118).[12] Of the generating units built since 1975,40 percent had liners; 60 percent of units built since 1975 that handled FGD sludge had liners. EPA estimated that only about 15 percent of all units had leachate collection systems and about 35 percent had groundwater monitoring systems. The extent to which liners, leachate controls, and groundwater monitoring occur at today's waste management units is unknown.

[11]K. Ladwig, Wisconsin Electric Power Co., personal communication, Feb. 28, 1991.

[12]Ch. 1 discusses a recent survey (33) of State requirements for liners at non-hazardous industrial waste landfills; the survey data do not distinguish landfills that accept only coal combustion wastes from landfills that accept a broader range of Subtitle D solid wastes.

Table 3-l—Methods of Handling, Treating, and Disposing of Low-Volume Wastes

Low-volume waste	Treatment	Predominant disposal method
Waterside cleaning waste	If organic chelating agents are used, waste can be incinerated. If acids are used, waste is often neutralized and metals are precipitated with lime and flocculants.	1. Codisposal with high-volume wastes in pond or landfill following treatment 2. Disposal by contractor
Fireside cleaning waste	Sometimes neutralized and precipitated. For coal-fired plants, most often diverted to ash ponds without treatment. If metal content is high, chemical coagulation and settling are used.	1. Codisposal with high-volume wastes in pond without treatment 2. Pending following treatment
Air preheater cleaning wastes	Settling in ash pond; neutralized and coagulated if combined with other streams before treatment.	1. Codisposal in pond without treatment 2, Pending with treatment
Coal pile runoff	Neutralized by diverting to alkaline ash pond. Fine coal material caught in perimeter ditch is often diverted back to coal pile.	1. Codisposal of sludge in landfill after treatment 2. Codisposal in ash pond
Wastewater treatment	Usually ponded with ash or as a separate waste. Sometimes solids redisposed with bottom ash.	1. Pending 2. Landfilling
Makeup water treatment	Usually codisposed in ash pond.	1. Codisposal in pond
Cooling tower basin sludge	Very little information; infrequent waste. Sludge commingled with wastewater treatment sludge.	1. Landfilling
Demineralize regenerants	Equalized in tanks, then commingled into ash ponds.	1. Pending
Pyrite wastes	Disposed in landfills with bottom ash or diverted to ash pond.	1. Pending 2. Landfilling

SOURCE: U.S. Environmental Protection Agency, *Report to Congress: Wastes From the Combustion of Coal by Electric Utility Power P/ants, EPA/530-SW-88-O02* (Washington, DC: February 1988).

Relative Use of Impoundments and Landfills

According to EPA, 80 percent of coal combustion waste from utilities in 1984 was treated, stored, or disposed of in land-based management units (1 18). The remaining 20 percent was reused in various ways. Disposed materials were most often managed in surface impoundments (also called ‘‘wet ponds’ and landfills. Based on data for 1,094 electricity generating units (including non-coal-burning units) for which management practices were known, 54 percent (578) disposed of their wastes in landfills and 44 percent (483) disposed of wastes in surface impoundments; the remaining facilities may have disposed of wastes in quarries, mines, or waste piles (118). The utility industry estimates that 49 percent of all units at coal combustion utilities currently manage coal ash in surface impoundments, temporarily or permanently .13

EPA estimated that almost 70 percent of all electric utility generating units managed coal combustion wastes on-site. Two-thirds of the on-site facilities were surface impoundments; most of the remaining on-site facilities were landfills. Landfills, however, accounted for about 95 percent of all off-site disposal. The trend in recent years is toward increasing use of on-site landfills (118).

EPA’s screening survey examined more than 4,000 facilities in the electric power generation industry, including about 3,500 non-coal-burning and 500 coal-burning plants (116). EPA estimated that on-site waste management units at these facilities in 1986 consisted of 1,220 surface impoundments, 155 landfills, 110 waste piles, and 43 land application units.

These data may indicate a greater reliance on surface impoundments for electric power generation as a whole than for the coal-burning portion of the industry. The coal combustion industry believes that EPA’s Report to Congress more accurately portrays management of coal combustion wastes. Furthermore, the industry believes that the screening survey

13 J. Roewer, Edison Electric Institute, personal communication April 1991.

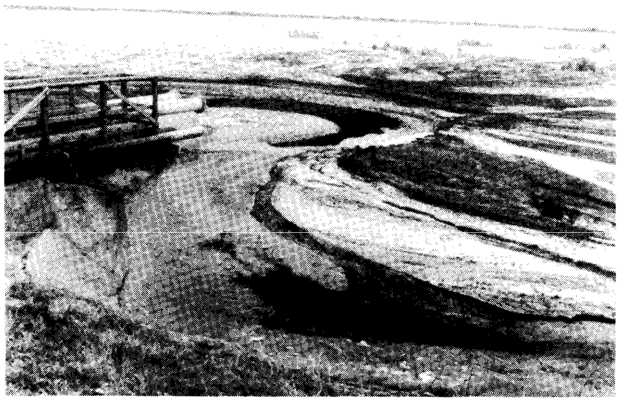


Photo credit: Electric Power Research Institute

Wastewater from coal-fired electric utility is stored or disposed in surface impoundment.

estimate of 1,220 surface impoundments must include wastewater treatment and storage impoundments in addition to disposal impoundments.[14] However, the generally continuous storage or treatment of wastewater in a surface impoundment results in wastewater being present in the impoundment for as long as it is active. The impoundment essentially becomes a disposal site, except for the wastewater in it, which is either recycled or discharged to surface waters under a permit.

Recycling and Waste Reduction

Although most coal-fired electric utility waste is land-disposed, about 20 percent (27 percent of all coal ash and less than 1 percent of FGD sludge) was recycled in 1985 (118). This percentage increased steadily between 1970 and 1985. The industry estimates that between 20 and 28 percent of coal ash being generated today is recycled annually.[15] Currently, about one-third of all bottom ash is recycled in products such as blasting grit or road and construction fill material. About 17 percent of fly ash is used as a concrete or cement additive, among other uses.

EPA's procurement rules under RCRA already promote the use of coal fly ash in cement and concrete.[16] Coal ash can also be used as structural fill, a soil substitute, or an antiskid material, and for mine subsidence control and other applications. Pemsylvania's proposed residual waste regulations would encourage such uses without requiring a permit, if the practices meet certain limitations and the Department of Environmental Resources is sent basic information about the use.[17] The rate of reuse varies among States, depending on market conditions and utility efforts. Wisconsin, for example, currently reuses about 50 percent of its coal ash.[18]

A logical question is whether any opportunities exist to reduce the amount of waste being generated. According to industry representatives, the ability to prevent generation of high-volume coal combustion wastes is minimal because of the composition of the coal itself. Moreover, the 1990 Clean Air Act Amendments and its provisions on increased sulfur dioxide pollution controls will result in the generation of even greater volumes of combustion wastes. The only way to lower these waste volumes significantly would be to use a fuel other than coal, although demand-side management (i.e., utility programs designed to encourage changes in energy use patterns to balance energy supply and demand) might also affect overall coal use. Reducing the use of coal in generating electricity would have detrimental effects on the U.S. coal industry; however, it also is one means of reducing emissions of carbon dioxide, which is the major gas contributing to potential global climate change *(98).* The industry and EPA see utilization, or recycling, of ash ash and FGD sludge as the most realistic way to lower the volume of waste requiring disposal.

RISKS FROM COAL COMBUSTION WASTE MANAGEMENT

According to EPA's Report to Congress (118), virtually no high-volume coal combustion wastes exhibited toxicity levels that would characterize them as hazardous, based on data using the Extraction Procedure (EP), Toxicity Characteristic (TC), and other tests. Cadmium, chromium, and arsenic were the only metals found in ash or FGD sludge at

[14] USWAG, review comments, Feb. 22, 1991.

[15] K. Ladwig, Wisconsin Electric Power Co., personal communication, Feb. 28, 1991.

[16] 48 Federal Register 4230, Jan. 28, 1983.

[17] 20 *Pennsylvania Bulletin, vol. 20, No. 8, 1160-1163,* Feb. 24, 1990.

[18] K. LadWig, Wisconsin Electric Power Co., personal communication% Feb. 28, 1991.

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potentially hazardous levels, but this occurred rarely and depended on the content of the coal.

Some low-volume cleaning wastes, however, were found to be potentially hazardous. Specifically, some samples of boiler cleaning wastes were found to be corrosive, and some had levels of cadmium, chromium, and lead that exceeded EP toxicity limits. However, these wastestreams do not always exhibit hazardous characteristics after disposal. For example, boiler cleaning wastes codisposed with coal ash showed no hazardous waste characteristics (118). EPA concluded that additional research on low-volume wastes was necessary before a clear decision on their risks could be determined.

Moreover, the industry believes that the EP and TC tests overestimate hazards associated with wastes. Both tests attempt to mimic conditions in a municipal solid waste landfill that the industry asserts is much more likely to leach constituents than a landfill used only for coal combustion wastes (134).

Some EPA and industry studies generally show only limited migration of leachate from coal combustion waste facilities, although the data are somewhat limited by the relatively low frequency of groundwater monitoring.

For example, EPA's Report to Congress contains data on the concentration of constituents (for which drinking water standards have been promulgated) in groundwater and surface water downgradient from coal combustion waste disposal sites which show some migration of trace elements from certain sites into surrounding water bodies. Elevated levels of cadmium, chromium, lead, fluoride, iron, manganese, sulfate, and boron were found downgradient in groundwater; cadmium, chromium, and fluoride were found downgradient in surface water. However, drinkig water standards were only exceeded infrequently, and only 3.7 percent of the sampling sites had downgradient concentrations of drinking water standard constituents higher than those measured in upgradient wells.[19] Furthermore, in some of these instances, the constituent was found in relatively equivalent concentrations upgradient as well as downgradient, which suggests that contamination was not necessarily caused by the waste disposal sites.

The Radian Corp. (67), at the request of the Electric Power Research Institute (EPRI), studied leaching potential from codisposal of low- and high-volume wastes in a coal ash pond (i.e., surface impoundment). Results from monitoring over a 2-year period showed that the majority of constituents analyzed were found in statistically equivalent concentrations in groundwater upgradient and downgradient of the ash pond or were not detected in either location. Only calcium, magnesium, strontium, and sulfate were found in significantly greater concentrations in the downgradient well, whereas other trace metals from the ash were not detected in downgradient groundwater. Constituents that might be most expected from low-volume wastes (ammonium, bromate, and hydrochloric acid from cleaning solutions; iron, copper, and other scale and metal deposits removed from equipment surfaces during cleaning) were not found in the downgradient samples. Radian concluded that the comanagement of low- and high-volume wastes had no impact on groundwater outside the ash pond. The reason given for this finding was that toxic metals in low-volume wastes are generally insoluble unless the pH of the solution is less than 1.5, which the investigators consider very rare. Furthermore, even if the metals did dissolve, they would be expected to be attenuated in the soil below, where the pH would likely exceed 5 (except in some coniferous and other forested areas). EPRI (21) obtained similar preliminary results from a second study site.

EPA (118) also concluded that the potential for exposure of human populations is likely to be limited, despite some migration of leachate off-site, because: only a limited number of contaminated sites were found; groundwater in the vicinity of utility waste disposal sites is not typically used for drinking water; and most management sites are not near populated areas.

However, these conclusions may be limited by several caveats:

1. 29 percent of the disposal sites in 1984 had people living within 1 kilometer, with popula-

[19] In contrast, data from 21 coal ash monofills in Pennsylvania indicate 17 sites with groundwater that exceeded drinking water standards for sulfates and occasionally exceeded drinkig water standards for iron, lead, arsenic, chromium, and zinc (J. Dernbach, Pennsylvania Department of Environmental Resources, review comments, July 23, 1991).

tions near these sites ranging between O and 3,708 people;
2. 34 percent of the sites had public drinking water systems downgradient from the site, half of which each served more than 5,000 people;
3. a high percentage of sites had populations of rare plant and animal species within 5 kilometers, and EPA found that a high potential existed for exposure of these species to some constituents of coal combustion wastes; and
4. the conclusion that potential exposure was limited did not account for the 'location of future utility sites.

In addition, EPA did not attempt to compile a complete census of damage cases by conducting extensive field studies (118). Even so, EPA was unable to identify any proven damage cases in the seven years prior to its report.

CURRENT REGULATORY PATHWAYS

Current RCRA Status of Coal Combustion Wastes

Based on findings from its report to Congress, EPA (118) made three preliminary recommendations, subject to change based on public comment, regarding the management of coal combustion wastes. RCRA (Sec. 3001 (b)(3)(C)) required EPA to make a regulatory determination on these wastes within 6 months of submitting the report to Congress. However, EPA has yet to do this and its activity on these wastestreams is currently on hold.[20]

EPA's three recommendations were as follows:

1. Because coal combustion wastestreams generally do not exhibit hazardous characteristics as defined under RCRA Subtitle C, high-volume wastes (e.g., fly ash, bottom ash, boiler slag, and FGD sludge) should not be regulated under Subtitle C.
2. The utilization of coal combustion wastes should be encouraged as one method for reducing the amount requiring disposal, to the extent this can be done in an environmentally protective manner.
3. Because some low-volume wastes may exhibit the hazardous waste characteristics of corrosivity and toxicity, EPA intends to further study and seek comment on these wastes and to consider whether they should be regulated under Subtitle C.

Although industry representatives concur with EPA's first two recommendations, they do not believe that low-volume wastes require further research or regulation. Instead, they interpret the Bevill amendment as requiring EPA to study, and base its findings on, the efficacy of "real-world" utility waste management practices and any environmental effects of these practices, not only on laboratory-generated characteristics (e.g., EP toxicity) of the wastes themselves. Furthermore, they contend that codisposal of low- and high-volume wastes is an environmentally sound way to manage the former. As noted above, EPRI is conducting field studies on the codisposal of low- and high-volume utility wastes.

Environmentalists contend that low-volume wastes should not have been included by EPA in the exemptions because they are not "high volume, low hazard" wastes within the Bevill exclusion as interpreted by the courts and that codisposal may encourage dilution as a management method for characteristic wastes.

State Coal Combustion Waste Programs

Coal combustion wastes are currently exempt from RCRA hazardous waste regulation (coal ash sites may still be addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) if necessary), and Federal Subtitle D regulations are generally incomplete (see ch. 1). These wastestreams are regulated primarily under State hazardous or solid waste laws. EPA's Report to Congress (118) listed disposal and management requirements promulgated under each State's solid waste regulations; these data were based on a 1983 USWAG report that was updated by EPA.

[20] According t. EPA's review comments on drafts of this paper, the delay is partly because of a July 1988 court riding that directed the Agency to undertake a series of rulemakings and issue a Report to Congress on exempt mineral processing wastes, under a schedule that contained very tight deadlines (*Environmental Defense Fund v. U.S. EPA, 852* F.2d 1316 (D.C. Cir. 1988)). This court order diverted a significant portion of staff and management attention away from utility-related activities, from 1988 through issuance of the mineral processing Report to Congress in July 1990 and the subsequent regulatory determination in May 1991. EPA has received a Notice of Intent to file a citizens' suit over the Agency's failure to issue a final regulatory determination for coal combustion wastes.

However, the EPA report was unclear as to what years the update included.

Based on EPA data, State regulations appear to vary widely, both in general requirements and in the specific details of each requirement. As such, it is difficult to generalize about the extent and quality of regulation of coal combustion disposal facilities. Moreover, no information on implementation and enforcement of these regulations is currently available. In addition, some regulations are likely to have changed since the report was issued.[21]

Forty-three States have exempted coal combustion wastes from hazardous waste regulation. Of the seven States that do not exempt them from such regulation, California burns little coal to produce electricity. The other six (Kentucky, Maine, New Jersey, Oklahoma, Tennessee, and Washington) require that coal combustion wastes be tested for toxicity; if they prove to be toxic, some or all hazardous waste regulations may apply. Classification by the States of a utility's waste as hazardous, however, apparently has been rare (118).

Solid waste regulations of every State require that off-site solid waste disposal facilities be permitted or have some form of approval. EPA has not updated its information on State regulatory programs since issuing its Report to Congress in 1988. Based on that report, a facility operator must meet the following requirements in different States:

- Permitting—Forty-one States required permits for both on-site and off-site facilities,[22] whereas eight States exempted on-site facilities.
- Site restrictions-Thirty States restricted placement of solid waste disposal facilities; these restrictions varied, but they may include banning placement in a 100-year" floodplain or requiring a minimum depth to groundwater.
- Liners-Only five States required all solid waste facilities to have a clay or synthetic liner; six other States could require a liner on a case-by-case basis.
- Leachate control systems-Twelve States required leachate control systems at all solid waste disposal facilities, and eight other States could require them on a case-by-case basis.
- Groundwater monitoring-Seventeen States required groundwater monitoring at all solid waste disposal facilities, and eleven other States could require groundwater monitoring on a case-by-case basis.
- Closure/postclosure—Twenty-six States required some closure or postclosure care, although the details of these requirements were not delineated.
- Financial assurance-Thirteen States required some financial assurance requirement, such as a bond or participation in a waste management fund, to ensure the long-term safety of closed facilities.

ISSUES/QUESTIONS

The previous sections suggest several issues specific to coal combustion utility wastes that Congress might address during the RCRA reauthorization process:

- Relationships Among Federal and State Agencies-Is there a need for regulations specific to coal combustion wastes, or can they be adequately managed under existing or future State and Federal programs for other manufacturing wastes? What degree of primacy does Congress wish States to have in managing coal combustion wastes? Should EPA develop uniform national guidelines for the management of coal combustion wastes and require States to submit detailed management plans for approval, or should EPA limit its efforts to technical and financial support of State-implemented Subtitle D programs?
- Efficacy and Enforcement of Existing Programs-How effective are existing State pro-

21 For example, in August 1988 Ohio established stricter design and siting requirements for "non-toxic" fly ash and bottom ash (i.e., constituent levels in extract from the EP toxicity test of the ash less than 30 times the Drinking Water Standards); however, these ashes remain exempt from solid waste, as well as hazardous waste, regulation (Ohio EPA, DWPC Policy 4.07, Aug. 1, 1988). Pennsylvania's proposed residual waste rules will increase requirements (e.g., liners, leachate control, groundwater monitoring) on all residual waste facilities, including those accepting coal combustion wastes. Facility requirements will vary depending on the concentration of certain hazardous constituents in each wastestream or in a leachate analysis (e.g., EP or TC test) of the wastestream (*Pennsylvania Bulletin*, vol. 20, No. 8, Feb. 24, 1990).

22 In Ohio, "non-toxic" fly ash and bottom ash (but not FGD sludge) are subject to design controls that are similar to non-exempted wastes, but they also are subject to more lenient permitting, siting and financial assurance requirements (E. Brdicka, Ohio Environmental Protection Agency, personal communication, Oct. 21, 1991).

grams? Should independent audits be conducted to assess how effectively various State and Federal programs and regulations are being enforced? Are existing resources sufficient to administer and enforce Federal or State coal combustion waste regulatory programs? If not, what mechanisms are available to provide such resources? What emphasis should be given to the enforcement of coal combustion waste programs relative to other Subtitle D wastes?

- **Regulation of Treatment and Storage Facilities** and Other Production Process Units—Does EPA have sufficient authority under RCRA Subtitle D to regulate production processes (which may include waste treatment and storage facilities) in addition to disposal practices? (Also see ch. 2).

- **Beneficial Use of Coal Combustion Wastes**-Should Congress encourage the beneficial reuse of coal ash? If so, what would constitute beneficial use? Should any limits be placed on such use?

- Regulation of Low- and High-Volume Wastes-Should codisposal in Subtitle D units of low- and high-volume wastes be allowed, or should high- and low-volume wastes be managed separately, given their different characteristics? In either case, what design features should be required for new and existing waste management facilities? Should Subtitle C regulation of low-volume wastes be required if they exhibit a hazardous characteristic?

Chapter 4

Oil and Gas Wastes

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Chapter 4
Oil and Gas Wastes

INTRODUCTION

In 1985, approximately 842,000 oil and gas wells in the United States produced 8.4 million barrels of oil, 1.6 million barrels of natural gas liquids, and 44 billion cubic feet of natural gas daily (117). Along with this high commodity production inevitably comes the generation of waste, most of which is disposed of through underground injection.

In searching for oil and gas, exploratory drilling usually results in "dry" wells that are plugged and abandoned. When an oil or gas reservoir is discovered, development wells are then drilled to extract the oil or gas. More than 70,000 exploration and development wells were drilled annually in the mid-1980s, although drilling activity decreased sharply in 1986 and has remained depressed (99, 117). These exploration and production (E&P) activities generate three types of "solid" wastes: produced waters, drilling fluids, and other "associated' wastes. Figure 4-1 illustrates the manner in which oil, gas, and water are separated in a typical production operation and the basic wastes that are generated. The U.S. Environmental Protection Agency (EPA) estimates that 3.7 billion tons of E&P waste was generated in 1985, whereas the American Petroleum Institute (API) estimates that about 2.9 billion tons was generated that year. The two estimates differ primarily in the amount of produced water generated, as well as in how much of the produced water is subject to jurisdiction under the Resource Conservation and Recovery Act (RCRA) (see "Waste Generation" below).

Produced waters are mixtures of the naturally occurring (and typically saline[1]) water in the geologic formation being drilled, naturally derived constituents such as benzene and radionuclides, and chemicals added for treatment (e.g., corrosion inhibitors). The produced waters must be separated from the oil and gas products before their entry into crude or natural gas pipelines. Produced waters account for 96 to 98 percent of all oil and gas wastes.

Drilling fluids include drill cuttings (i.e., rock removed during drilling) and drilling muds (water- or oil-based fluids with additives, pumped down the drilling pipe to offset formation pressure, provide lubrication, seal off the well bore to avoid contamination of various geologic layers, and remove cuttings) (117).[2] Drilling fluids account for about 2 to 4 percent of oil and gas wastes.

Much smaller quantities of associated wastes are produced. These include well completion, treatment, and stimulation fluids; sediment, water, and other tank bottoms; oily debris; contaminated soils; and produced sands.[3] They amount to about 0.1 percent of oil and gas wastes. In addition, naturally occurring radioactive material (NORM) such as radium may also be brought to the surface with crude oil (see box 4-A on page 77).

The exploration, development, and production of oil and gas reserves vary markedly from region to region. For example, wells range in depth from 30 feet in some areas to more than 30,000 feet in others, with an average depth of about 5,000 feet (7, 117). Production can range from fewer than 10 barrels per day for thousands of small 'stripper" wells to about 11,500 barrels per day for wells on the Alaskan North Slope. Only 14 percent of total U.S. production comes from stripper wells, yet they account for about 70 percent of all U.S. oil wells (117); because of their large numbers and potential environmental impacts, these wells pose significant regulatory challenges (e.g., concerns about enforcement and economic impacts).

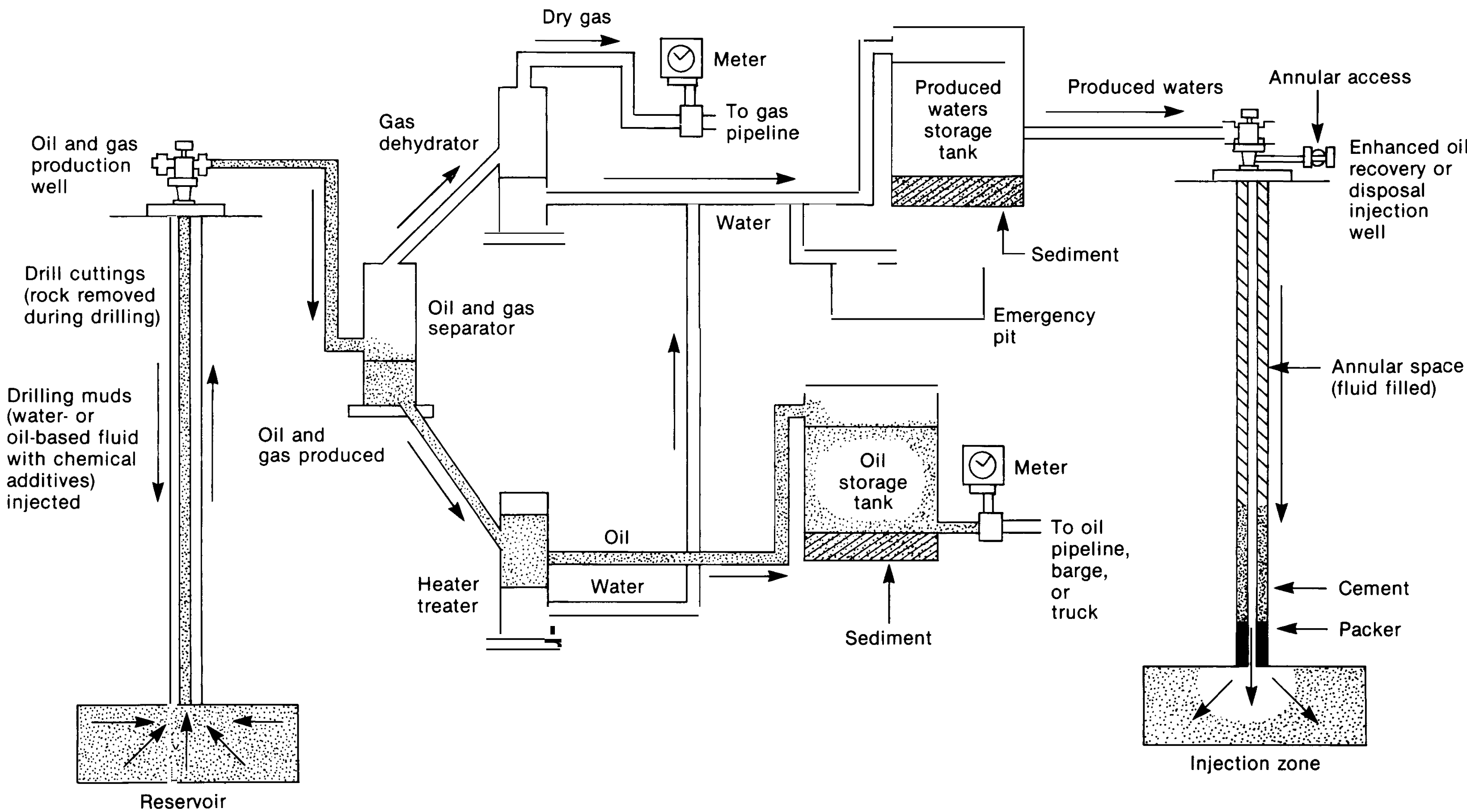
The 1980 Bentsen amendments to RCRA exempted drilling fluids, produced waters, and associated wastes from hazardous waste regulation pending further study and regulatory determinations by EPA. The amendments also directed EPA to distinguish between large-volume wastes (i.e., produced

[1] The concentration of chlorides in produced waters can range from 5,000 to 180,000 parts per million. In contrast, seawater is 35,000 parts total dissolved solids; a portion of the total dissolved solids are chlorides, typically about 19,000 parts per million (117).

[2] Chemicals added to drilling muds include acids and bases, salts, corrosion inhibitors, flocculants, surfactants, viscosifiers, dispersants, fluid loss reducers, lubricants, and biocides (117).

[3] 53 *Federal* Register 25453, July 6, 1988; also see ref. 25.

Figure 4-1—Typical Oil and Gas Production Operation



NOTE Se w was de ed se ra generally occurs at the well site or an adjacent tank battery. Produced waters are not ec ed nd ca ed

SO R E OTA based E ec ncy Of ce Solid Waste and Emergency Response, *Report to Congress: Management of Wa From Exploration Developmen and Production of Crude Oil, Natural Gas, and Geothermal Energy,* EPA/530-SW-88-003 Wa gt DC Decembe 7)

Photo credit: ARCO Alaska, Inc.

A 5-foot-thick gravel pad in the Prudhoe Bay field on the North Slope of Alaska supports drilling and production equipment and contains above-grade reserve pits.

waters and drilling fluids, including fluids from offshore operations that are disposed of onshore) and associated **wastes. In** 1988, EPA determined that Subtitle C regulation of these exempted wastes is not warranted (see "Current RCRA Status of Oil and Gas Wastes" below).[4] This means that the wastes are subject to existing State and Federal Subtitle D regulatory programs. Oil and gas wastes that are **not** exempt from Subtitle C regulation include refinery wastes, waste solvents from equipment maintenance, and spills from pipelines or other transport methods (117).

WASTE GENERATION

Oil and gas waste generation depends on the level of industry activity, which in turn varies with petroleum prices. Thus, oil and gas waste generation can vary considerably from year to year; it also varies geographically. Table 4-1 (based on data from API, cited in ref. 117) shows how the number of wells and the generation of drilling fluids and produced waters varied among States in 1985.

Based on data in its 1987 Report, EPA estimated that 3.7 billion tons of produced water was generated in 1985 (17). However, produced waters reinfected underground for enhanced oil recovery (EOR) operations are not subject to RCRA jurisdiction because this practice-at least from the point of the wellhead down-is regulated under the Safe Drinking Water

Table 4-l—Estimated Volumes of Produced Water and Drilling Wastes, 1985[a]

State	Number of wells drilled	Produced water (thousand barrels)	Drilling wastes (thousand barrels)[b]
Alabama	367	87,619	5,994
Alaska	242	97,740	1,816
Arizona	3	149	23
Arkansas	1,034	184,536	8,470
California	3,208	2,846,978	4,529
Colorado	1,578	388,661	8,226
Florida	21	64,738	1,068
Georgia	1	—	2
Idaho	3	—	94
Illinois	2,291	1,282,933	2,690
Indiana	961	—	1,105
Iowa	1	—	1
Kansas	5,560	999,143	17,425
Kentucky	2,482	90,754	4,874
Louisiana	4,908	1,346,675	46,726
Maryland	91	—	201
Michigan	870	76,440	3,866
Mississippi	594	318,666	14,653
Missouri	23	—	18
Montana	623	223,558	4,569
Nebraska	282	164,688	761
Nevada	36	—	335
New Mexico	1,780	445,265	13,908
New York	436	—	1,277
North Dakota	514	59,503	4,804
Ohio	3,818	—	8,139
Oklahoma	7,690	3,103,433	42,547
Oregon	5	—	5
Pennsylvania	2,836	—	8,130
South Dakota	49	5,155	289
Tennessee	228	—	795
Texas	23,915	7,838,783	133,014
Utah	364	260,661	4,412
Virginia	91	—	201
Washington	4	—	15
West Virginia	1,419	2,844	3,097
Wyoming	1,497	985,221'	13,528
TOTAL	69,734	20,873,24@	361.406

[a]Based on American Petroleum Institute survey reported in EPA (December 1987). EPA and API estimates for drilling waste and produced waters differed significantly in some cases (see text).
[b]Based on total volume of drilling muds, drill cuttings, completion fluids, circulated cement, formation testing fluids, and other water and solids.
[c]Wyoming estimated that 1.72 billion barrels of produced water were generated in the State in 1985.
[d]Includes only those States surveyed.

SOURCE: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy,* EPN530-SW-88-003 (Washington, DC: December 1987).

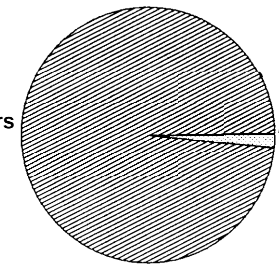
[4]Unlike the other "special" wastes, Congress in a seine reserved the ultimate regulatory decisions about oil and gas wastes to itself because EPA is prohibited from regulating these wastes as hazardous without approval by an act of Congress.

Act.[5] Since about 62 percent of produced waters are reinfected for EOR (6), this would leave about 1.4 billion tons to be managed as RCRA wastes. The API disagrees with these figures; based on data from its 1985 survey (6), industry analysts estimate that about 2.8 billion tons of produced water was generated in 1985, of which 2.5 billion tons was used for EOR operations.[6] In any event, produced waters clearly make up the largest portion of oil and gas E&P wastes (figure 4-2).

EPA and API estimates of the amount of drilling fluids generated in 1985 also differ by almost an order of magnitude (table 4-l). However, EPA concluded that API's method of predicting volumes was more reliable[7] and therefore used the API estimate of 361 million barrels (117).[8] EPA later used this volumetric estimate to calculate that the amount of drilling fluids generated in 1985 was 63 million tons, based on the assumption that the density of each waste type is equal to that of water (17).[9] About 65 percent of drilling mud is fresh water, 21 percent is salt water, 3 percent is oil, 2 percent is polymer, and the remainder is other materials (25); the specific type used in drilling depends on factors such as well depth and reservoir characteristics.

Associated wastes represent an estimated 0.1 percent (1 1.8 million barrels, or 2.0 million tons) of all oil and gas wastes.[10] The EPA/API estimate is based on the assumption that their densities are the same as the average density of water, which may result in underestimating the actual tonnage (17). However, it may be a reasonable estimate because much of the waste is oil-based and hence lighter than water. About half of the associated wastes are aqueous, and the remainder range from slurries to sludges and solids.

Figure 4-2-Relative Amounts,of Oil and Gas Exploration and Production Wastes, 1985



SOURCE: 53 *Federal Register 25448* (July 6, 1988).

CURRENT MANAGEMENT PRACTICES

Oil and gas exploration and production wastes can be stored in surface impoundments to recover the oil, injected underground, treated and applied to the land, or discharged into waterways. In some cases, percolation pits are used to allow wastes to seep into the soil, although this is not standard practice in most areas. Some recycling and source reduction options are also possible. API (7) estimated that in 1985 about 92 percent of oil and gas wastes was injected underground, 4 percent was discharged into waterways, and 2 percent was managed in surface impoundments.

Technical criteria and guidance documents on oil and gas waste management have been issued by API and the Interstate Oil and Gas Compact Commission (IOGCC) to supplement efforts by State and Federal agencies to improve such management (8, 44).[11] Both guidance documents recognize the applicability of a hierarchy for managing oil and gas wastes, similar to that often cited for managing other solid and hazardous wastes: 1) source reduction; 2)

[5] 53 *Federal Register* 25446, July 6, 1988. Reinfection of produced waters into the formation helps to maintain fluid pressure and to enhance oil and gas recovery.

[6] N. Thurber, Amoco, personal communication, Sept. 26, 1991.

[7] For example, EPA used estimates of reserve pit size as the basis for its calculation whereas API relied principally on survey data that it collected.

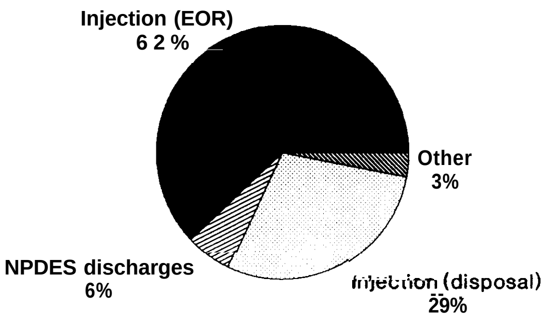
[8] Also see 53 *Federal Register 25448,* July 6, 1988.

[9] EPA considered it likely thatthis estimate is low (17). Similarly,industry analysts suggest that the amount might be in the range of 70 to 80 million tons (N. Thurber, Amoco, personal communication, Sept. 26, 1991).

[10] Based on ERT (25) and API (7) &@ about 48 percent are workover and completion fluids, including fluids used to stimulate the formation to produce additional oil; 32 percent are produced sand, tank bottoms, oily debris, and other production solid wastes; 15 percent are untreatable emulsions, used solvents and degreasers, cooling water, used oils, spent iron sponge, and other production liquid wastes; and 5 percent are dehydration and sweetening unit wastes used to remove sulfides from the oil or gas.

[11] The IOGCC, formed in 1935 (and formerly known as the Interstate Oil Compact Commission or IOCC), is an organization of Governors of 29 States that produce oil and gas. More than 99 percent of the oil and gas produced in the United States comes from member States.

Figure 4-3-Management Methods for Produced Waters



NOTE: Injection refers to underground injection; EOR refers to enhanced oil recovery.

SOURCES: Based on American Petroleum Institute, *API 7985 Production Waste Survey, Statistical Analysis and Survey Results, Final Report* (Washington, DC: October 1987); D. Derkics, "Revised Oil & Gas Statistics," memorandum, U.S. Environmental Protection Agency, Washington, DC, Jan. 28, 1991.

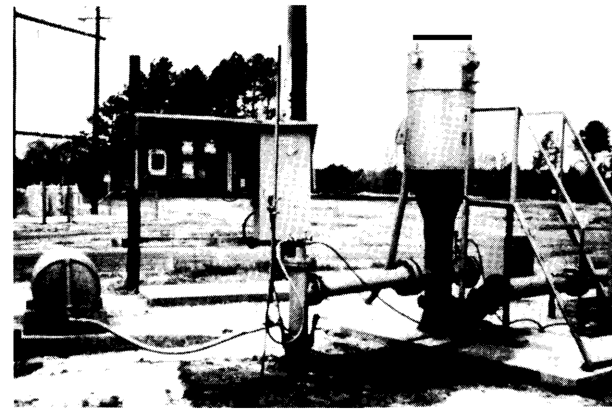


Photo credit: U.S. Environmental Protection Agency

This Class II injection well is equipped with corrosion inhibitors, constant pressure monitoring, automatic shut-off, and leak detection.

recycling and reuse; 3) treatment to reduce the volume or toxicity of waste; and 4) disposal of remaining wastes in ways that minimize adverse impacts to the environment and human health.

This section describes how each of the three basic waste types (drilling fluids, produced waters, and associated wastes) are managed. Because some management methods are used for more than one waste type, the section discusses each major method as well: surface impoundment; land application and landfilling; underground injection; discharge to surface waters; and source reduction and recycling. The management of naturally occurring radioactive material in oil and gas wastes is discussed below in box 4-A.

In general, most non-hazardous E&P wastes are managed and disposed of on-site, mainly through underground injection in Class II wells.[12] EPA concluded that many impacts can be minimized by improving housekeeping practices and using existing technologies to address design, operational, mixing (e.g., of associated wastes and produced waters), closure, and remediation problems (34). Many States restrict the types of wastes that can be stored in pits at Class II well sites, and require lining of these facilities (with either synthetic or clay liners, depending on site-specific conditions) and, where groundwater is present, groundwater monitoring systems (44). In addition, pumps can be built with features (e.g., their own containment sumps, alarm systems, automatic shutoff valves, and continuous pressure monitoring) that minimize releases, and tanks can be used as an alternative to liners. These practices generally afford more protection than systems that allow disposal of tank bottoms, produced waters, and other wastes in unlined pits or on the ground (34).

Management of Basic Waste Types

Produced Waters

Produced waters can be managed, with or without treatment, via injection in underground wells, evaporation and percolation from surface impoundments, application on roads, or discharges to surface water. Injection can take place on-site, off-site, or in centralized facilities. Most produced waters (about 90 percent) are reinfected underground, either in disposal wells (29 percent) or as part of EOR operations (62 percent) (figure 4-3).[13] Reinfection wells are regulated as part of the Underground Injection Control program (see "Other EPA Statutory Authority" below). The remainder are dis-

[12] Class II refers to three types of wells which inject fluids: 1) for enhanced recovery of oil or natural gas; 2) for storage of hydrocarbons which are liquid at standard temperature and pressure; and 3) for storage of liquids which are brought to the surface in connection with natural gas storage operations or conventional oil or natural gas production, and which may be commingled with waste waters from gas plants which are an integral part of production operations, unless those waste waters are classified as a hazardous waste at the time of injection (40 CFR 144.6(b)).

[13] As noted above (see "Waste Generation"), however, produced waters used in EOR systems are not considered solid wastes.

charged to surface waters (6 percent), under conditions specified in National Pollutant Discharge Elimination System (NPDES) permits, or are disposed of by other means such as evaporation and percolation (3 percent). Discharges to surface waters depend on the composition of the fluid and NPDES permit conditions.

Drilling Fluids

Drilling fluids can be disposed of on-site (either directly or after treatment) in reserve pits (which are essentially surface impoundments), in the annular space of injection wells, on land, or into surface waters (117). The choice of on-site methods depends on factors such as geologic formation, costs and regulatory conditions, composition of the drilling fluids, and type of well and surrounding conditions. The onshore discharge of untreated drilling fluids into surface waters is prohibited by effluent guidelines promulgated under the Clean Water Act. However, fluids may be discharged into the Gulf of Mexico if they pass specified bioassay tests (1 17).

Off-site management methods include disposal in centralized pits, land application at commercial landfarms (for adsorption or degradation by soil and organisms), and treatment and disposal in centralized treatment facilities (117). EPA does not have information on how frequently these off-site management methods are used.

API (6) reported that in 1985, 29 percent of drilling fluid was evaporated, 28 percent was sent off-site for some type of management, 13 percent was injected underground, 12 percent was buried on-site, 10 percent was discharged into surface waters, 7 percent was landspread, and less than 1 percent was solidified. Drilling muds, which constituted about two-thirds of drilling fluids in 1985, were typically disposed of by evaporation, followed by discharge into surface water and injection in the annular space of drilled wells (25).

Associated Wastes

Associated wastes may be stored, treated, landfarmed, landfilled, discharged under a NPDES permit, injected into a Class II well, or recycled. In 1985, about 48 percent of associated waste was reportedly transported off-site for centralized treatment or disposal at commercial waste management sites; 27 percent was disposed of on-site either in pits, by burial, or by roadspreading and landspreading; 4 percent was recycled; 1 percent was injected underground; and 19 percent was managed by other, unspecified methods (6).

Management Technologies and Practices

Surface Impoundments

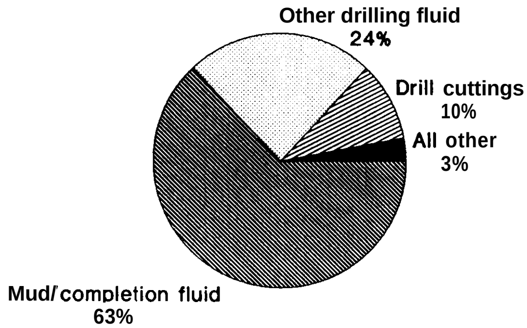
According to EPA (114), more than 125,000 oil and gas surface impoundments existed in 1984. Based on EPA data from themid-1980s(119), only 2.4 percent of the surface impoundments used for oil and gas wastes had synthetic liners, whereas another 27 percent had a natural liner of unknown composition quality. Furthermore, groundwater was monitored at only 0.1 percent, and surface water at 16 percent, of these impoundments. However, the data do not necessarily represent current practices in many States; moreover, not all impoundments are located near groundwater.

Reserve pits, a type of impoundment, are used to temporarily store drilling fluids for use in drilling operations or to dispose of wastes. Of all materials discharged to reserve pits, an estimated 90 percent are drilling fluids (mostly in the form of drilling muds and completion fluids) and cuttings (figure 4-4).

Some pits also are used for settling/skimmm g of solids and separation of residual oil; storage of produced waters prior to injection or off-site transport; percolation of liquids via drainage or seepage into surrounding soil; and evaporation (in lined pits) of produced waters into the atmosphere (44, 117). Other "special" pits are used for such purposes as flaring natural gas; collecting wastes from the emptying or depressurization of wells (or vessels); and, in emergencies, temporarily storing liquids resulting from process upsets (44, 117). These pits, however, may be in continuous use for many years before being closed or may at least be present on-site for use in emergencies. Many States now have-and IOGCC guidelines suggest—both reporting requirements and time limits for using such "temporary" pits, and long-term use can be a violation in those States.

Reserve pit size is largely a function of well depth (25); the average pit volume at depths less than 3,750 feet is about 3,600 barrels, whereas the average volume at depths greater than 15,000 feet is more than 65,000 barrels. Only 20 percent of reserve pits have a capacity greater than 15,000 barrels, whereas

Figure 4-4-Types of Drilling Fluids Discharged to Reserve Pits



SOURCES: ERT Co., *Oil and Gas Industry Exploration and Production Wastes,* prepared for Ameriean Petroleum Institute, No. 471-01-09 (Washington, DC: July 1987); U.S. Environmental Protection Agency, Office of Solid Waste and Emergeney Response, *Report to Congress: Management of Wastes From the Exploration, Development,* and *Production of Crude Oii, Natural Gas, and Geothermal Energy,* EPA/530-SW-88-003 (Washington, DC: December 1987).

44 percent have a capacity of 5,000 barrels or less (25).

Reserve pits are usually closed after drilling activity has been completed. After a reserve pit is closed, solids in the pit can be spread on land or buried on-site; liquids can be evaporated, discharged to land or surface waters, or reinfected in underground wells.[14] Although most States have established regulations for siting, operation, and closure of pits[15], the proper closure of reserve pits and the disposition of their contents are still matters of concern in environmentally sensitive areas such as wetlands (25).

One potential alternative is solidification of pit contents—adding solidifiers (e.g., commercial cement, fly ash, or lime kiln dust) to help immobilize pollutants and minimize leaching of toxic constituents. The Pennsylvania Department of Environmental Resources, among others, has conducted some demonstration solidification projects (32). One problem, however, is that after removal of the free liquid fraction of pit wastes, the remaining pit contents still contain about 30 percent water. In addition, the use of cement kiln dust, and possibly other solidifiers, increases the volume of solid waste to be managed (117). Other areas of concern include finding a better mixing method, identifying and minimizing groundwater and leachate impacts, and ensuring the use of the method in winter (32). EPA was unaware of data indicating whether the use of kiln dust adds harmful constituents to the reserve pit wastes (117).

Landfilling and Land Application

Landfilling basically consists of placing wastes in the ground and covering them with a layer of soil. Currently, most landfills used for oil and gas wastes are unlined. However, the IOGCC recommends that a protective bottom liner or a solidification, fixation, or encapsulation method be required when the salt or hydrocarbon content in the wastes exceeds applicable standards, unless the site has no underlying groundwater or is naturally protected from the risk of contamination (44). The IOGCC considers landfilling appropriate for drilling muds and cuttings, spent iron sponge, pipe scale with low levels of naturally occurring radioactive material (see below), gas plant catalysts, and molecular sieve materials.

The IOGCC also believes that roadspreading—using tank bottom sediments, emulsions, or heavy hydrocarbon and crude oil-contaminated soils as part of road oil, road mix, or asphalt-is acceptable if the waste materials are not ignitable and have a density and metal content consistent with approved road oils or mixes (44, 117). However, the Hazardous and Solid Waste Amendments of 1984 (RCRA Sec. 3004(1)) prohibited the use of material that is contaminated or mixed with a hazardous waste (other than a waste identified solely on the basis of ignitability) for dust suppression or road treatment.

Land application, known in the industry as landspreading or landfarming, consists of spreading or mixing wastes into soils to promote the natural biodegradation of organic constituents and the dilution and attenuation of metals. Nitrogen and other nutrients can be added to the soil to enhance biodegradation (44). The IOGCC recommends that the waste-soil mixture not contain more than 1 percent by weight of oil and grease; any free oil can be removed by skimming or filtration before landspreading. Liquid wastes may also have to be

[14] In 1985 the oil and gas industry reportedly spent more than $118 million on construction of reserve pits (35 percent Of which had artificial liners, at a cost of $99 million), more than $187 million to close pits on-site, and $480 million to dispose of pit wastes off-site (25),

[15] J. Simmons, IOGCC, personal communication, July 9, 1991.

neutralized and should be applied so as to avoid pooling or runoff of the wastes.

Land application of drilling muds and cuttings has been used for years. Some studies conclude that it is a relatively low-cost method (which accounts for its increasing popularity) that does not adversely affect receiving soils (e.g., 75, 143). One of these studies concluded that landfarming could benefit certain sandy soils in Oklahoma by increasing their water-holding capacity and reducing fertilizer losses (75). These studies also suggest that the technique can be used in conjunction with cleanup and remedial processes for saltwater or hydrocarbon spills and pipeline breaks (75, 143).

Whether land application is appropriate for all mud is not clear. Some muds contain substantial quantities of oil and various additives, raising questions about the potential adverse effects on parts of the food chain or in areas with high water tables. EPA (117) suggested that land application might work best for treating organic chemicals that are susceptible to biodegradation, if the appropriate microorganisms are present in the soil. However, the ability of most soils to accept chlorides and other salts, which generally are highly soluble in water, and maintain beneficial use is limited (117). Whether heavy metals are attenuated by soil particles or taken up by plants depends on many factors, including the clay content and cation-exchange capacity. In addition, volatile organic compounds (VOCS) may evaporate from sites (117, 143).

Underground Injection Wells

About 90 percent of produced waters from onshore oil and gas operations are disposed of in more than 166,000 underground injection wells, for either EOR or final disposal purposes (117, 121). When used for disposal, produced waters are injected (via gravity flow or pumps) into saltwater formations, the original formation, or older (depleted) formations. Figure 4-1 shows a typical injection well for produced waters. Steps generally taken before wastes are reinfected into wells include: 1) separation of free oil and grease from produced waters; 2) storage of wastes in tanks or reserve pits; 3) filtration; and 4) chemical treatment (e.g., coagulation, flocculation, and possibly pH adjustment) (117).

Again, one concern regarding this method is its potential for contaminating groundwater (117). For example, injection wells used for disposal are often older wells that require more maintenance (EPA regulations require periodic testing of the mechanical integrity of injection wells; see “Other EPA Statutory Authority” below). Well failure also can occur because of design and construction problems, the corrosivity of the injected fluid, and excess injection pressure. Concerns over the adequacy of injection well regulations are discussed below (see “Other EPA Statutory Authority”).

Discharges to Surface Waters

Discharges to surface waters are permitted under the NPDES program: 1) into coastal or tidally influenced waters; 2) for agricultural and wildlife beneficial use; and 3) for produced waters from stripper oil wells to surface streams. Treatment to control pH and to minimize oil and grease, total dissolved solids, sulfates, and other pollutants often occurs before discharge. The presence of radiation and benzene or other organic chemicals, however, is typically not addressed in discharge regulations.

Pollution Prevention/Waste Reduction

Pollution prevention (i.e., reducing the volume and toxicity of wastes) and recycling are possible for all three types of oil and gas wastes. As the prospects for Superfund liability from past disposal practices become apparent (see “Other EPA Statutory Authority” below), the incentives for reducing and recycling oil and gas wastes increase (79, 117). As with other source reduction and recycling efforts, success depends on support from top management, a complete inventory and characterization of the wastestreams and chemical additives used in an operation, and the flexibility to address site-specific variations in formations and production activities (44, 79). EPA discourages some types of “recycling,” specifically those involving the mixing of hazardous wastes with non-hazardous or exempt oil and gas wastes (117).

The greatest opportunities may involve drilling fluids. According to an analysis by Amoco Corp., basic waste minimization methods can potentially reduce the volume of drilling fluids, including cuttings, by more than 60 percent (79). EPA estimated that “closed-loop systems” can reduce the volume of drilling fluids by as much as 90 percent.[16] The high cost of formulating drilling mud has led to more reuse and reconditioning of spent muds (117).17 Closed-loop systems use mechanical solids control equipment (e.g., screen shakers, hydroclones, centrifuges) and collection equipment (e.g., vacuum trucks, shale barges) to minimize drilling waste muds and cuttings that require disposal and to maximize the volume of drilling fluid returned to the drilling mud system. These systems are increasingly being used (e.g., in California), because of the reduction in overall drilling costs and in the volume of waste needing disposal (79, 117, 141).[18] Without proper wastewater management, however, the volume reduction gains from using closed-loop systems can be negated (79). In addition to these methods, drilling wastes maybe used in the well-plugging process, depending on site location and conditions (117).

Reducing the toxicity of drilling fluids is also possible.[19] EPA and API survey data indicate that fluids in some reserve pits contain chromium, lead, and pentachlorophenol at hazardous levels, and oil-based fluids may contain benzene. These components, however, can potentially be reduced or eliminated by product substitution (79). In addition, the hydrocarbon content of drill cuttings might be reduced by using thermal and solvent extraction processes; these appear promising but have not yet been used extensively or evaluated (69).

For produced waters, volume reduction efforts are driven more by the direct costs of waste management than by regulatory incentives or liability. Horizontal drilling (an exploration technology designed to increase the exposure of fractured or productive zones to the borehole) can reduce the generation of produced waters, but this may be related more to the character of the producing formation than to the technology itself.[20] Reducing the toxicity of produced waters also may be possible by using less toxic or hazardous additives during drilling and completion or during stimulation of the well bore (79). In some cases, wastewaters can be physically or chemically treated and then reused in other parts of oil and gas production processes; solid residues can be separated during treatment and used in cement block or asphalt manufacturing (71).

Associated wastes may contain constituents similar to those in produced waters and other wastes, but often at higher concentrations. The toxicity of cooling tower blowdown, for example, can be reduced by replacing chromate corrosion inhibitors and pentachlorophenol biocides with less hazardous or toxic products (e.g., organic phosphonates or bisulfites; and isothiazolin, carbamates, amines, and glutaraldehydes, respectively) (79).[21] Oil recovery can also lead to reductions in tank and vessel sludges, emulsions, and other wastes (79).

RISKS FROM OIL AND GAS WASTES

In its 1987 Report to Congress and subsequent 1988 regulatory determination (see "Current RCRA Status of Oil and Gas Wastes" below), EPA concluded that oil and gas exploration and production wastes should remain exempt from regulation under Subtitle C. The oil and gas industry, as represented by the IOGCC, agrees with this and contends that the regulatory framework needed to prevent adverse impacts from the management of E&P wastes already exists in State programs (44).

Some of the general public, though, is still concerned about the environmental impacts and, in certain areas, the possible human health impacts of some oil and gas waste sites (e.g., 45, 63, 72). In addition, EPA also concluded that adverse impacts have resulted from mismanagement of oil and gas wastes and that some improvements in waste management are necessary (34, 117).

16 55 Federal Register 23355, June 7, 1991.

17 EPA also suggested that greater potential for increased recycling appears possible through more efficient management of mud handling systems (117).

18 J. Murphy, Amoco Oil Co., personal communication, Jan. 14>19910

19 EPA concluded that drilling fluids are usually not characteristic hazardous wastes. However, the Extraction Procedure (EP) or Toxicity Characteristic (TC) tests are not considered appropriate for oily wastes, and the TC is not legally applicable to exempt oil and gas wastes *(55 Federal Register 11835, Mar. 29, 1990; also see* ch. 5).

20 D. Nielson, Utah Department of Natural Resources, review comments, Aug. 2, 1991.

21 N. Thurber, Amoco, personal communication, Sept. 16, 1991.

Hazardous Characteristics and Health Risk Assessments

Both EPA and API analyzed samples of E&P wastes from drilling and production sites, waste treatment facilities, and commercial waste storage and disposal facilities. In summarizing these data, EPA (117) concluded that chemicals such as benzene, phenanthrene, lead, and barium were present in some samples at "levels of primary concern" (i.e., in amounts greater than EPA health-based limits multiplied by 1,000). EPA also noted that chemicals such as arsenic, fluoride, and antimony were found in some samples at "levels of secondary concern" (i.e., in amounts greater than health-based limits multiplied by 100).

In its 1988 rulemaking,[22] EPA estimated that from 10 to 70 percent of large-volume oil and gas wastes (i.e., drilling fluids and produced waters) and 40 to 60 percent of associated wastes (as defined in ''Introduction' above) could potentially exhibit RCRA hazardous waste characteristics.[23]

EPA conducted some risk assessments for oil and gas wastes, based on a relatively small sample data set on waste constituent concentrations (117). In general, it found that only negligible risks would be expected to occur for most of the model scenarios evaluated. However, EPA also noted that:

- It did not analyze all release modes, including releases from unlined pits;
- There were realistic combinations of measured chemical concentrations and release scenarios that could be of substantial concern;
- A few of the hundreds of chemical constituents detected in reserve pits and produced waters appeared to be of 'primary concern relative to health or environmental damage" (e.g., benzene, chlorides); and
- Wide variation (five or more orders of magnitude) existed in estimated health risks across the model scenarios, reflecting the great variation in the nature, location, and management of oil and gas sites.

Another potential exposure pathway involves consumption of contaminated seafood. Two studies in Louisiana suggested that potential human health risks exist from the bioaccumulation of radionuclides, metals, and hydrocarbons in benthic invertebrates, including edible species such as oysters (66, 78). In laboratory studies, oysters released accumulated hydrocarbons after being exposed to contaminant-free water; this may be particularly important because oysters are usually eaten directly after harvest and are not depurated (78). EPA (117) also concluded that potential endangerment of human health was associated with consumption of contaminated fish and shellfish.

Risks associated with naturally occurring radioactive materials are discussed in box 4-A.

Environmental Damages

EPA documented 62 actual or potential damage cases resulting from the management of E&P wastes, many of which were in violation of existing State and Federal requirements (117). These cases included: 1) damage to agricultural land, crops, streams, aquatic life, and other resources from produced water and drilling fluids (including potential contamination of aquatic and bird life in marine ecosystems by metals and polycyclic aromatic hydrocarbons from discharges of these wastes); 2) degradation of soil and groundwater from runoff and leachate from treatment and disposal facilities, reserve pits, and unlined disposal pits; 3) salt damage to groundwater, agricultural land, and domestic and irrigation water caused by seepage of native brines from improperly plugged or unplugged abandoned wells; 4) groundwater degradation from improper functioning of injection wells; and 5) damage to vegetation (including potential damage to tundra on the Alaska North Slope) from roadspreading of high-chloride drilling muds and seepage or discharges from reserve pits.

For example, activities such as drilling, EOR operations, and underground injection of produced waters have been associated with migration to nearby wells of various liquids and chemicals (e.g., brine, fracturing fluid, produced waters, hydrocarbons from oil or gas; ref. 117). According to the U.S. General Accounting Office (82), EPA data indicate 23 cases of drinking water contamination associated with Class II wells; EPA, however, noted that these incidents occurred prior to implementation of EPA's

[22] 53 *Federal Register 25455*, July 6, 1988.

[23] This estimate was made before the new TC test was promulgated. However, the TC *test* does not apply to exempt wastes *(55 Federal Register* 11835, Mar. 29, 1990).

Box 4-A—Risks and Management of Naturally Occurring Radioactive Materials

Naturally occurring radioactive material (NORM) is present in many industrial process residues, including produced waters and equipment from oil and gas production, sludges from drinking water treatment, fly ash from electricity generation, phosphogypsum from phosphate production (see ch. 2), and tailings from rare-earth and uranium mill processing.[1] The oil and gas industry has known about NORM since the 1930s (65), but concerns increased in the mid-1980s as the extent of NORM-enhanced pipi scale, sludges, and sediments became known (68).

For the oil and gas industry, the principal constituents of concern in NORM are radium-226 (a decay product of uranium-238), radium-228 (a decay product of thorium-232) and its daughter products radon-222 and lead-210.[2] The volume and concentration of these constituents in the material brought to the surface at a production site depend on the concentrations of the original uranium and thorium in the formations encountered during exploration and production, the temperatures and pressures at the production reservoir depth, the amount of water and natural gas produced, the duration of production, and the water chemistry.

Most radium remains in the produced waters, which typically are injected in Class II underground wells back into the original formation from which the waters were derived or into other saline formations below underground sources of drinking water. However, some radium precipitates on the inside of oil and gas production equipment in the form of barium/radium sulfate scales, which are difficult to remove because they are highly insoluble.[3] In addition, lead-210 also tends to precipitate on the inside of gas production equipment, primarily as a film in propane and ethane pumps (65). Because older production fields handle more produced water than newer fields, equipment at older fields is exposed to more water and thus tends to have higher concentrations of NORM.

The radiation exposure pathway of most concern in oil and gas operations is ingestion and inhalation by workers during cleaning of NORM-contaminated equipment. Internal exposure to radium and radon can cause bone and lung cancer, respectively, whereas lead-210 can attach to respirable particles and cause necrologic abnormalities and other problems. As a result, the industry has developed procedures for cleaning equipment containing NORM to prevent inhalation or ingestion by workers (7, 68); these include minimizing exposure by purging vessels (e.g., tanks) prior to entry, using respirators and other breathing gear while inside vessels, using masks while performing grinding and chipping operations, and other industrial hygiene practices.

An API-sponsored survey of major petroleum companies operating in 20 States and 2 offshore areas (Gulf of Mexico, California) obtained more than 36,000 measurements of NORM activity (i.e., gamma radiation) at background levels and on contact with equipment (65).[4] About 20 percent of the sites had readings above background levels, with the highest reported measurement being 4.49 Millirems/hour. Even so, more than 95 percent of all measurements, whether background or of equipment, were less than 0.11 millirem per hour.[5] However, these readings suggest that relatively insensitive measuring instruments were used, since normal background readings in uncontaminated areas should be 5 to 15 microroentgens per hour. Another, preliminary field study by the Michigan Departments of Natural Resources and Public Health found maximum readings of 3.2 microroentgens per hour, with the highest concentrations of NORM being found in sediment from the bottom of tanks (56).

Furthermore, since the principal source of any adverse health impacts due to exposure to NORM would be due to inhalation or ingestion of alpha radiation, not gamma dose, the relevance of the measurements in these studies is limited. Determination of the alpha radiation dose expected from contamination of NORM would require laboratory analyses of the types and amounts of specific radionuclides present in samples, in addition to estimates of the internal dose received by persons handling the contaminated equipment and at risk for ingesting or inhaling the materials. The Occupational Safety and Health Administration general industry standard for worker exposure

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[1]For further information on the management of commercial low-level radioactive waste, see ref. 96.

[2]Radium-226 and radium-228 have half-lives of more than 1,600 and 5,7 years, respectively. Radon-222@ a half-life of o@'3.8 days, whereas lead-210, one of its decay products, has a half-life of 22 years.

[3]The industry is trying t. develop scale inhibitors to keep radium in the produced waters and inhibit its precipitation into scale. Although some short-term inhibitors do exist, effective longer-term inhibitors have yet to be developed.

[4]The decay products of uranium and thorium emit alpha, beta, and gamma radiations; alpha and beta radiations normally do not penetrate through vessel or pipe walls, but gamma radiation can do so and thus can be measured outside a vessel or pipe.

[5]The survey did not obtain measurements of NORM concentrations in tank sediments, soil, or groundwater—parameters that could be necessary if regulations are developed on design requirements for management and disposal operations. The API, the Department of Energy, and the Gas Research Institute are currently studying oilfield NORM concentrations (B. Steingraber, Mobil Exploration& Producing U.S., personal communication, Aug. 21, 1991).

Continued on next page

Box 4-A—Risks and Management of Naturally Occurring Radioactive Materials-Continued

is for the total of external (i.e., gamma) and internal (i.e., principally alpha) radiation-a maximum permissible dose for total body exposure of 5 reins per year (29 CFR 1910.96).[6]

Another health-related issue is the extent to which old equipment sent off-site for reuse or disposal results in the exposure of nonindustry workers to NORM. Although NORM-enhanced scale can be cleaned out of pipes and other equipment mechanically, the industry has usually found it cheaper to buy new equipment and send the old equipment off-site for smelting, cleaning, use in other ways (e.g., fencing or cattle guards), or disposal via land burial.[7] Most equipment with relatively low levels of radioactivity is sent to scrap yards and smelted. Past practices also included landspreading, landfilling, disposal along with scrap tanks, and on-site shallow burial (e.g., 56), although major petroleum companies no longer use these methods. Louisiana is the only State that presently regulates this material (cited in ref. 56).

How to handle equipment that exhibits higher levels of NORM is more problematic. Currently, equipment containing NORM with estimated exposure levels higher than 50 microrems per hour is stored, at least by major petroleum companies, until disposal alternatives are approved.[8] EPA, the Nuclear Regulatory Commission, and the States (except for Louisiana) have not issued regulations on land-based disposal and management of NORM. However, the industry is developing guidelines for disposal of NORM (7, 68).

Rogers and Associates (68) calculated radiation exposures via seven environmental pathways[9] for 12 different disposal methods and compared them with existing exposure limits developed for other, related radiation sources. They concluded that many methods could be used to manage NORM without exceeding the exposure limits, including some forms of landspreading, injection into inactive wells, burial at various sites (e.g., commercial oilfield waste sites, licensed NORM disposal sites, low-level radioactive waste disposal sites, surface mines, salt domes), and use of wells destined to be plugged and abandoned. Another study (57) also suggested that injecting NORM into wells is acceptable because it would allow for disposal at levels below groundwater standards[10] and because it is one of the least costly alternatives. However, improperly plugged wells and correctly plugged wells that later leak under some conditions are still of concern (see “Underground Injection Wells” in this chapter, and ref. 117). Methods such as shallow burial in humid environments or landspreading would also require consideration of the potential for groundwater contamination and human access.

In general, the industry feels that the relatively small volumes of NORM, especially compared with those from mill tailings, fly ash, phosphate fertilizer tailings, and other sources, can be adequately and carefully handled under State regulation. With the exception of Louisiana, however, no State has thus far adopted NORM regulations. However, at least a dozen other States are considering adopting such regulations in the next few years.[11] Abandoned NORM sites (e.g., old pipe cleaning operations or defunct wrap operations that handled pipe) are just beginning to be assessed in terms of potential exposures and risks and potential corrective actions.

6The International Commission on Radiation Protection recently lowered its guidelines to a total of 2 rems per year (T. O’Toole, O’IA, personal communication, Nov. 8, 1991).

7The Petroleum Environmental Research Forum is currently studying the fate of NORM during smelting operations to analyze potential exposures (B. Steingraber, personal communication, Aug. 21, 1991).

8B. Steingraber, personal communication, Aug. 21, 1991.

9The pathways were radon inhalation, external gamma exposure, groundwater ingestion, surface water ingestion, dust inhalation, food ingestion, and skin beta exposure.

10Based on models using a criterion of 100-millirem total dose from all routes, including radon, to ensure safety.

11B. Steingraber, review comments, Oct. 9, 1991.

Class II well regulations (see “Other EPA Statutory Authority” below) .24 All Class 11 wells are subject to these regulations. Although many injection wells now used for disposing produced waters were in existence prior to implementation of the regulations and did not need to be repermitted, they must still comply with construction, operating, testing, monitoring, and plugging requirements. EPA has formed a Class II Advisory Committee to consider potential improvements to the program, through guidance or regulation.

About 4 percent of drilling muds and produced waters are discharged to surface waters. Although

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24F. Brasier, U.S. EPA, review comments, Sept. 26, 1991.

these discharges may meet State and Federal permit standards, large volumes of discharges containing low levels of certain pollutants may cause damage to aquatic communities (117). Discharges into Gulf Coast bays and estuaries have resulted in the bioaccumulation of metals, hydrocarbons, and radionuclides in shellfish and other organisms. For example, the Louisiana Department of Environmental Quality (78) found that benthic invertebrates (including edible species such as oysters) growing near discharges of produced waters may accumulate radionuclides and organic chemicals (e.g., hydrocarbons) whose potential risks to humans are discussed above. Preliminary findings from another study in Louisiana, funded by the Louisiana Division of the Mid-Continent Oil and Gas Association, appear to corroborate the main findings, namely, that organic compounds and metals in produced waters can contaminate benthic communities, depending in part on the volume of discharges and on the hydrologic and sedimentary features of the sites (66).

In general, most cases of environmental impacts result from violations of existing State standards, but some do not. In Ohio and New Mexico, for example, oil and gas operators are allowed to dispose of produced waters in unlined surface impoundments in areas where there is no groundwater. Chronic, low-level discharges of produced waters into streams are often allowed legally under NPDES permit conditions.

Another problem may be surface water contamination from abandoned pits. As of August 1991, for example, Louisiana had identified 71 abandoned pits (31 with inactive operators, 28 with no operator of record, and 12 for which closure was in noncompliance) and 180 unclosed pits requiring remediation or closure.[25] However, Louisiana also considers groundwater contamination from numerous plugged and abandoned wells to be of more importance.

The Superfund National Priorities List (NPL) contains four sites that received oil and gas E&P wastes. Three are in Louisiana: two received oil drilling muds, salt water, and other drilling fluids; the third received sludges from oil field production. The fourth site is a landfill located in New Mexico, on Federal land managed by the U.S. Bureau of Land Management; this site received produced water, waste oil, spent acids, chlorinated organic solvents, and sewage. However, these sites were not necessarily listed on the NPL because of E&P wastes. In addition, some Potentially Responsible Parties (PRPs) at the Louisiana sites have contested their designation as PRPs because of perceived statutory exclusions in CERCLA, although as of November 1991, EPA is proceeding with initial site investigations.[26]

Two other issues of concern involve wetland losses and wildlife mortality.

Wetland Losses

Degradation or loss of some wetland areas has been linked with the physical nature of oil and gas exploration and production activities. For example, one study (80) estimated that canals accounted for 6 percent of total net wetland loss from 1955 to 1978. The Louisiana Mid-Continent Oil and Gas Association (cited in ref. 36) estimated that less than 10 percent of the land lost in coastal Louisiana since 1900 can be attributed to dredging of navigational channels and oil and gas access canals.

Wetland losses have also been associated with discharges of E&P wastes. One review of Louisiana's coastal wetlands concluded that a correlation exists between large numbers of brine discharge points and adjacent areas with rapidly deteriorating marsh (135). At one oil field, these investigators estimated that more than 13 million barrels of brine had been discharged into surface waters annually, and that roughly 30 percent of the wetlands within a 6-mile radius of the field had disappeared between 1956 and 1978. They concluded that the salinity associated with brine discharges can accelerate natural marsh loss rates and initiate vegetation loss in more stable, healthy marshes. In March 1991, the Louisiana Department of Environmental Quality issued new water quality regulations on discharges associated with oil and gas exploration and production activities (see "State Oil and Gas Programs" below).

Wildlife Mortality

Another problem concerns birds and other wildlife that are killed after landing at oily waste pits, whose reflection is apparently viewed as a sign of flesh water. The U.S. Fish and Wildlife Service (F&WS) surveyed New Mexico, Texas, and Okla-

[25] S. McCarty, Louisiana Office of conservation personal communication, Aug. 29, 1991.

[26] J. Vanbuskirk, U.S. EPA, personal communication, Nov. 14, 1991.

homa in 1987 and estimated that about 225,000 migratory birds had been killed in eastern New Mexico alone (109). This problem is not limited to the Southwest. During 1990 and 1991, for example, another study (26) found more than 600 dead animals at 88 pits in Wyoming; two-thirds were birds and one-third were mammals.

Several methods can be used to prevent animals from getting into pits, including plastic flagging, metal reflectors, strobes, complete covering with hardware cloth, and fencing; many States require fencing and other methods (26). The most effective measure is probably a cover of screening or netting, which can cost from a hundred to several thousand dollars. Many major oil companies have invested in such measures.

New Mexico's Oil Conservation Division enacted regulations in September 1989 that require screening or netting of all open pits; other States have been slower to adopt such requirements. Under the Migratory Bird Treaty Act, the F&WS can impose a $10,OOO fine for operations that result in the death of a migratory bird. In the fall of 1988, the F&WS suspended enforcement of this provision until October 1989, to provide industry with time to voluntarily clean up the problem (109). Although many industries responded, particularly in New Mexico, the F&WS felt that the situation might still be severe in areas such as Texas. As a warning to oil pit operators, the F&WS investigated mortality at oil pits operated by Union Pacific Railroad, which pleaded guilty in March 1990 to killing migratory birds. In addition, the Texas Railroad Commission revised its rules, effective November 1, 1991, to require that open-top tanks that are 8 feet or more in diameter be netted or screened.

CURRENT REGULATORY PROGRAMS

As with other solid wastes, the management of exploration and production wastes illustrates the multimedia dimension inherent in waste management decisionmaking. For example, when E&P wastes are stored in surface impoundments, some organic chemicals may volatilize into the air and other chemicals may seep into groundwater if the impoundment is improperly sited and managed. In addition, other air emissions are associated with exploration and production activities (117).[27] Similarly, some E&P wastes are discharged into surface waters, whereas others reach groundwater via leaks from underground injection wells.

Currently, oil and gas E&P wastes are regulated primarily at the State level. EPA has not developed a regulatory program under Subtitle D for these wastes. However, the Agency does regulate underground injection of produced waters under the Safe Drinking Water Act (SDWA), surface discharges of oil and gas wastes under the Clean Water Act (CWA), and air emissions under the Clean Air Act (CAA).[28] In all of these statutes, States generally have primacy in actually implementing the Federal regulations. The U.S. Bureau of Land Management (BLM) also has authority over the management of E&P wastes on Federal lands (but not over the State primacy programs under the Clean Air Act, Clean Water Act, or Safe Drinking Water Act).

Enforcement issues ace of great concern to Federal and State authorities, because there are large numbers,of oil and gas wells and sites, and relatively few government inspectors (see table 4-2). However, a U.S. District Court recently returned the frost-ever indictment under the Safe Drinking Water Act, against a Kentucky oil and gas company and its president for injecting fluids into an underground drinking water source without a permit.[29] EPA hopes the case will set an example for other small operators. Whether such targeted enforcement efforts will have a comprehensive effect remains to be seen.

[27]These include particulate matter and sulfur and nitrogen oxides from diesel engines that run drilling processes; sulfur dioxide released when hydrogen sulfide is removed from natural gas; and volatile organic compounds released from leaks in production equipment. In addition, hydrogen sulfide produced at thewellhead in gaseous form poses occupational risks from leaks or blowouts, although it poses no danger when dissolved in crude oil.

[28]Section 112(n)(5) of the Clean Air Act Amendments of 1990 requires EPA to assess the hazards to public health and the environment resulting from emissions of hydrogen sulfide that are associated with the extraction of oil and natural gas resources and to submit a report to Congress containing findings and recommendations within 24 months. The section also authorizes EPA to develop and implement a control strategy under this section and Section 111 for such emissions, based on the findings of the study.

[29]*United States* v. *Glen Weatherbee*, CR 90-00019-01BG(M), U.S. District Court, Western District of Kentucky, filed Nov. 5, 1990.

Table 4-2-Oil and Gas Wells, Injection Wells, Regulatory Agencies, and Enforcement Personnel, by State

State	Gas wells	Oil wells	Injection wells[a]	New wells completed in 1985	Agency	Number of Enforcement Positions[b]
Alaska	104	1,191	472 Class II 425 EOR 47 disposal	100 new onshore wells	Oil and Gas Conservation Commission; Department of Environmental Conservation	[illegible] each
Arkansas	2,492	9,490	1,211 Class II 239 EOR 972 disposal	1,055 new wells	Arkansas Oil and Gas Commission; Department of Polliution Control and Ecology	7 and 2, respectively
California	1,566	55,079	11,066 Class II 10,047 EOR 1,019 disposal	3,413 new wells	Department of Conservation; Department of Fish and Game	31
Kansas	12,680	57,633	14,902 Class II 9,366 EOR 5,536 disposal	6,025 new wells	Kansas Corporation Commission	30
Louisiana	14,436	25,823	4,436 Class II 1,283 EOR 3,153 disposal	5,447 new onshore wells	Department of Environmental Quality; Office of Conservation	32 and 36, respectively
New Mexico	18,308	21,986	3,871 Class II 3,508 EOR 363 disposal	1,747 new wells	Energy and Minerals Department	10
Ohio	31,343	29,210	3,956 Class II 127 EOR 3,829 disposal	6,297 new wells	Department of Natural Resources	66
Oklahoma	23,647	99,030	22,803 Class II 14,901 EOR 7,902 disposal	9,176 new wells	OklahomaCorporation Commission	52
Pennsylvania . . .	24,050	20,739	6,183 Class II 4,315 EOR 1,868 disposal	4,627 new wells	Department of Environmental Resources	34
Texas	68,811	210,000	53,141 Class II 45,223 EOR 7,918 disposal	25,721 new wells	Texas Railroad Commission	120
West Virginia . . .	32,500	15,895	761 Class ii 687 EOR 74 disposal	1,839 new wells	Department of Energy	15
Wyoming	2,220	12,218	5,880 Class II 5,257 EOR 623 disposal	1,735 new wells	Oil and Gas Conservation Commission; Department of Environmental Quality	7 and 4.5, respectively

[a] Class II = underground injection well; EOR = enhanced oil recovery wells.
[b] Only field staff are included in total enforcement positions.

SOURCE: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy, EPA/530-SW-88-003* (Washington, DC: December 1987).

State Oil and Gas Programs

State regulation of oil and gas E&P wastes may vary, depending on differences in climate, hydrology, geology, and economics (44, 117). Additional differences are attributable, in some locations, to the complexity of exploration and production processes and to the variety of waste management options. For example, the number of wells and the volume and types of waste generated vary dramatically from one State to another (see table 4-l). Regulations often differ for wastes managed on-site and those managed off-site at commercial or centralized facilities.

Most produced waters are injected in underground wells, which are regulated under the Underground Injection Control (UIC) program. Landspreading, evaporation, and storage in pits may also be regulated by States. Since the mid-1980s, for example, several States have enacted regulations for land application of oil and gas wastes (75).[30] Similar options, except for underground injection, exist for drilling fluids and low-volume associated wastes. Most States regulate pits and, thereby, at least indirectly regulate drilling fluids and associated wastes; however, few States single out associated wastes for special regulatory attention.

Discharges to surface waters generally are regulated by the States under the Clean Water Act. Given the concern about wetland losses in Louisiana (see "Environmental Damages" above), it is noteworthy that the Louisiana Department of Environmental Quality issued new water quality regulations in March 1991, on discharges and stormwater runoff associated with oil and gas exploration and production activities (Louisiana Title 33, Part IX, ch. 7, Sec. 708). The regulations set forth general guidelines requiring permits and spill prevention and control plans for all discharges. They prohibit discharges of produced waters to water bodies located in intermediate, brackish, or saline marsh areas after January 1, 1995, unless the discharge is authorized in an approved schedule for elimination or for effluent limitation compliance.[31]

All oil and gas producing States permit and therefore identify drilling sites (44). The permits may or may not cover waste management (whether on- or off-site) associated with drilling, but they usually require some financial assurance to cover closure or remediation of a well or disposal facility; the amounts required vary tremendously. A State's overall regulations, however, generally include requirements for using certain management methods, with varying levels of detail and site-specific flexibility.[32] All States have some enforcement program, but actual enforcement mechanisms and resources differ. As with regulatory programs for mining wastes (see ch. 2), often two or more State agencies are involved in regulating oil and gas wastes.

The IOGCC has issued administrative and technical criteria that it recommends States include in their oil and gas regulatory programs.[33] The criteria emphasize that States should retain control over implementation of the recommendations (because of their knowledge of local management practices, waste characteristics, climate, and hydrogeology) and suggest that States establish and implement site-specific performance standards and design specifications (44). The criteria cover the following:

- **Permitting:** States should have a recordkeeping mechanism (e.g., individual permits, permits by rule, registration of facilities, or notification of certain activities) to track waste management facilities.
- Compliance evaluation: States should be capable of evaluating compliance by facilities managing wastes. Capabilities should include a requirement for periodic reporting by facilities and evaluation of these reports by regulatory agencies; inspection and surveillance procedures independent of the self-reporting requirement; procedures to process complaints reported by the public; authority to enter any regulated site; and guidelines for investigations in support of enforcement proceedings.
- Enforcement: States should have the authority to take enforcement actions such as giving notice of violation and establishing a compliance schedule; restraining continued activity by an operator; identifying emergency conditions that warrant corrective action by a State agency; bringing suit in court for continuing violation; issuing administrative orders or bringing suit to correct past harm to public health and the environment; and revoking, modifying, or suspending a permit.

[30] Oklahoma and Kansas, for example, prohibit the use of reserve pit wastes for commercial landfarming (117).

[31] The regulations also prohibit discharges of produced waters to: 1) freshwater lakes, rivers, streams, bayous, and canals; and 2) freshwater swamps or marshes unless these are authorized in accordance with an approved termination schedule or under a permit allowing discharge to portions of the Mississippi River or the Atchafalaya River. Numerical effluent limitations are set for benzene, ethylbenzene, toluene, oil and gas, total organic carbon, pH, temperature, total suspended solids, chlorides, dissolved oxygen, acute and chronic toxicity, soluble radium, and visible sheen.

[32] For example, the State of Pennsylvania adopted regulations in 1989 that require oil and gas pits (and tanks) to be constructed according to standards to protect groundwater, with additional standards applicable if pits are also to be used for disposal (25 *Pennsylvania Code, Sections 78.51-78.63).* Alternative practices to the use of pits, such as solidification, can be approved by the Pennsylvania Department of Environmental Resources.

[33] The criteria do not address discharges t. surface waters or injection in underground wells because these are regulated by EPA or the States under the authority of the CWA or SDWA, respectively.

- **Additional program requirements:** States should include provisions for public participation; contingency planning by operators in the event of a waste release; financial assurance (e.g., for closure and postclosure); waste hauler certification; waste tracking mechanisms; the ability to identify the location of closed disposal sites; and effective data management.

The criteria also included general recommendations for managing wastes in pits, land application units, and centralized and commercial facilities (44). In most cases these criteria are presented as goals that States should attempt to meet in establishing their own technical standards.[34]

API also issued guidelines for managing solid waste from oil and gas operations, to support EPA's activities and provide guidance to industry and State regulatory agencies (8).[35] API recently initiated a training program geared to small oil and gas operators to teach them how to implement the guidance.

No systematic, comparative information exists, however, on the overall quality of State oil and gas regulations and programs. Given the great variety in State regulations and in the level of State implementation and enforcement, the quality of the programs is difficult to assess without an extensive field survey, which is beyond the scope of this background paper. In its 1987 Report to Congress (117), EPA recommended that it work with State regulatory agencies to improve oil and gas programs where necessary. The IOGCC, under a grant from EPA and the U.S. Department of Energy, is in the process of evaluating individual State regulatory programs, and comparing them with IOGCC's criteria.[36] This peer review process includes environmental, industry, and State representatives; the first review-of Wyoming's program-was completed in June 1991.

However, some data are available to indicate the general problems and challenges facing State regulatory programs. A major constraint is that State programs often do not have adequate resources to address, for example, an estimated 1.2 million abandoned wells; Texas and Oklahoma have many more wells to plug than they have money to pay for the plugging.[37] EPA's 1987 Report to congress (117) included information on the number of active production and injection wells and field inspectors in 1985 (table 4-2). The number of field enforcement positions varied from 16 personnel for approximately 1,300 oil and gas wells in Alaska to 120 personnel for almost 300,000 wells in Texas. These data could argue that many States need more inspectors, although the exact number would still vary greatly with factors such as age of wells (older wells generate more produced water and require more maintenance) and compliance history of the companies involved. GAO (82) reviewed the underground injection programs of several States and concluded that program safeguards were far from complete or adequate. For example, the files for 41 percent of the wells with permits contained no evidence that pressure tests had ever been performed.

Current RCRA Status of Oil and Gas Wastes

Except for the general Subtitle D criteria (ch. 1), RCRA does not explicitly authorize EPA to control Subtitle D oil and gas wastes. The 1980 Bentsen amendments to RCRA exempted certain wastes unique to the exploration and production of oil and gas from regulation as hazardous wastes under Subtitle C (see table 4-3), pending further study and a determination by EPA of the appropriate level of regulatory action (and a subsequent act of Congress should EPA determine that Subtitle C regulation was warranted).

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[34] For example, the technical criteria for construction of pits recommended t&t "talcs or liners should be required in certain instances based on type of fluid and site-specific characteristics. . . . Liners can be natural or constructed of natural or synthetic materials, provided they are installed according to accepted engineering practices and are compatible with expected pit contents" (44).

[35] The API plans to up&k this Environmental Guidance Document in 1991 to address in more detail issues such as waste minimization, guidelines for field sampling and analysis of oil field wastes, NORM guidelines, and land disposal criteria for metals; it also plans to review the consistency of its guidelines with the IOGCC criteria for exploration and production wastemanagement programs (142).

[36] J. Simmons, IOGCC, personal communication% March 1991.

[37] GAO (82) expected the number of such wells t. increase, because the economic downturn of the oil industry in the late 1980s might have led to more improperly plugged wells.

Table 4-3-Examples of RCRA Exempt and Nonexempt Oil and Gas Wastes

Exempt wastes	Nonexempt wastes
Produced waters	Unused fracturing fluids/acids
Drilling fluids	Painting wastes
Drill cuttings	Service company wastes
Rigwash	Refinery wastes
Well completion fluids	Used equipment lubrication oil
Workover wastes	Used hydraulic oil
Gas plant dehydration wastes	Waste solvents
Gas plant sweetening wastes	Waste compressor oil
Spent filters and backwash	Sanitary wastes
Packing fluids	Boiler cleaning wastes
Produced sand	Incinerator ash
Production tank bottoms	Laboratory wastes
Gathering line pigging wastes	Transportation pipeline wastes
Hydrocarbon-bearing soil	Pesticide wastes
Waste crude oil from primary field sites	Drums, insulation, and miscellaneous solids

SOURCE: M. Fitzpatrick, "Common Misconceptions About the RCRA subtitle C Exemption for Wastes From Crude Oil and Natural Gas Exploration, Development and Production," in *Proceedings of the First International Symposium on* Oil and Gas *Exploration and Production Waste Management Practices (New* Orleans, LA: U.S. Environmental Protection Agency, Sept. 1-13, 1990).

On the basis of its Report to Congress (117), EPA published its regulatory determination in July 1988.[38] EPA determined that Subtitle C regulation for oil and gas E&P wastes is not warranted and that the Agency instead would develop a Subtitle D program tailored to these wastes.[39] EPA reasoned that operators would be freed from prescriptive Subtitle C requirements, but that the combination of future Subtitle D requirements, other Federal and State regulatory requirements, and potential Superfund liability (from mismanagement of oil and gas wastes) would be sufficient incentives for prudent management and would encourage waste minimization and recycling; at the same time, although EPA hopes to promote greater national consistency in managing these wastes, it also stated a desire to maximize State authority. The Agency indicated that development of a Subtitle D program would consider requirements such as engineering and operating practices to manage releases to surface water and groundwater; procedures for closure; monitoring that accommodates site-specific variability; and cleanup provisions.

EPA further stated that it planed to develop "a three-pronged approach toward filling the gaps in existing State and Federal regulatory programs." This approach would aim to:

1. improve existing Federal programs in Subtitle D of RCRA, the Clean Water Act, and the Safe Drinking Water Act;
2. work with States to encourage improvement and changes in their regulation and enforcement of oil and gas wastes; and
3. work with Congress to determine any additional statutory authority that might be necessary.

To date, however, EPA has made little direct progress toward the goal of establishing a Subtitle D oil and gas program. Not surprisingly, environmental groups and the industry disagree about the need for such a program. Environmental groups contend that a Subtitle D program, along with possible Subtitle C regulation for some wastes, is necessary. The oil and gas industry believes that most wastes can be managed adequately with existing State and Federal programs (e.g., the UIC program under the Safe Drinking Water Act, the NPDES program under the Clean Water Act), provided the programs are adequately financed and enforced.

Other EPA Statutory Authority

EPA has additional statutory authority, other than RCRA, to issue regulations regarding oil and gas waste management. The most important areas are under the Clean Water Act, the Safe Drinking Water Act, and Superfund. In addition, the Clean Air Act regulates air emissions associated with oil and gas activities.

Clean Water Act

The Clean Water Act established a permitting program for wastewater discharges-the National Pollutant Discharge Elimination System. EPA grants primacy to most States to administer State NPDES programs that are equivalent to or more stringent than Federal requirements. NPDES per-

[38] 53 *Federal Register 25446,* July 6, 1988.

[39] EPA determined that Subtitle C regulation was not warranted because: 1) Subtitle C is extremely costly and unnecessary for safe management of these wastes; 2) Congress indicated that such regulations are unwarranted where existing programs can be used to address problems; 3) Subtitle C permit processing times are typically lengthy, which would cause disruptive delays for oil and gas operations; 4) inclusion of these wastes in Subtitle C would severely strain existing hazardous wastemanagement capacity; 5) such regulation would disrupt and duplicate State authorities; and 6) implementation would be impractical and inefficient.

mits are required for discharges to surface waters and to public sewer systems that lead to publicly owned treatment works.

To date, however, most States have not issued NPDES permits for discharges of produced waters to coastal areas and wetlands or for discharges from stripper wells to surface waters in general.[40] As of 1990, for example, EPA's Office of Inspector General noted that no general permits had been issued for discharges into coastal wetlands in Louisiana (125). One reason for the lack of such permits is that in the initial phases of implementing the Clean Water Act, EPA's Region VI concentrated on establishing control over single major dischargers.[41] As the NPDES program matured, emphasis shifted to controlling aggregate impacts from multiple minor dischargers, including coastal oil and gas exploration and development facilities. On February 25, 1991, Region VI issued a final NPDES general permit for "onshore" oil and gas production facilities, which allows for zero discharge of drilling fluids and produced water. The Region's final NPDES general permit for "coastal" oil and gas drilling activities, which also will establish a zero discharge limitation for drilling muds and cuttings, was expected to be published in late 1991.

EPA, GAO, and others have noted the need for national guidelines to underlie such permitting efforts (82, 125). Part of the problem is that EPA has not yet promulgated effluent limitation guidelines for discharges from the "offshore" crude oil and natural gas industry, nor has it revised guidelines for the "coastal" oil and gas subcategory so that they are based on best available technology economically achievable (BAT).[42] EPA is developing guidelines for the offshore subcategory, due to be finalized in 1992, and for the coastal subcategory, due to be finalized in 1995. EPA also has not decided whether or how to include stripper oil wells and marginal gas wells in these regulations, although it is considering this issue.[43] A related issue that may also warrant more attention concerns the impacts of nontoxic pollutants, such as chlorides, in effluents discharged from oil and gas operations.

Safe Drinking Water Act

The Safe Drinking Water Act established the Underground Injection Control program to regulate injection wells. The statute established a special class (Class II in EPA terminology) of injection wells in the UIC program for oilfield-related fluids, and stipulated that regulation of Class II wells should not impede oil and gas production unless necessary to prevent endangerment of underground sources of drinking water.

The UIC program regulates only the injection of fluids related to oil and gas production and hydrocarbon storage. These include produced waters and other fluids used for enhanced recovery, as well as disposal of brines.[44] UIC regulations require that injection of such fluids into Class II wells (for disposal or for enhanced oil recovery) must take place below all formations containing underground sources of drinking water (117, 121). They also require that periodic tests (at least every 5 years) be conducted of the mechanical integrity of the wells and that a one-quarter-mile radius around a well be reviewed (i.e., the area of review) for potential migration of injected fluids or brines from the site. EPA has noted, however, that produced waters stored in surface impoundments prior to injection may be subject to RCRA Subtitle D regulations[45]; whether this would extend to management in storage tanks prior to injection is unclear.

The UIC program is largely administered by the States, with EPA approval and oversight. EPA has granted primacy for administering the program to 25 of the 32 oil and gas producing States. EPA is responsible for management on tribal lands.

[40] Exceptions to this general statement exist. For stripper wells, for example, Pennsylvania issued a general permit that was scheduled to finalized in October 1991, and Louisiana and Texas issue individual State water discharge permits without distinguishing between stripper and onshore wells. For coastal areas and wetlands, Louisiana issues individual State permits for discharges to State waters; these are not the same as NPDES permits because Louisiana is not a "delegated" State, but they do require monitoring and include discharge limitations and some best management practices.

[41] U.S. EPA, Office of Water, review comments, Oct. 3, 1991.

[42] EPA promulgated effluent limitations guidelines in 1979 for discharges in the coastal subcategory (44 *Federal Register* 22069, Apr. 13, 1979); these were based on best practicable control technology currently available (BPT), which provides a less stringent level of control than BAT.

[43] 54 Federal *Register 46919, Nov. 8,* 1989.

[44] Produced water injected for enhanced oil recovery is considered t. be beneficially recycled as an integral part of some crude oil and natural gas production processes and, as such, is not a waste for purposes of regulation under RCRA (53 *Federal Register 25454,* July 6, 1988).

[45] 53 *Federal Register* 25454, July 6, 1988.

Several concerns have been raised about the effectiveness of injection well regulations, and EPA continues to evaluate the UIC program (82, 121, 122). EPA's most recent evaluation of the Class II UIC program (122) indicated a need for: 1) further study of risks associated with abandoned oil and gas wells; 2) additional evaluation of State area of review programs for existing wells, which vary widely among States; and 3) possible changes in Class II well construction requirements. According to EPA (117), economic incentives for operators to comply with requirements may be lower for disposal wells than for EOR wells.[46]

CERCLA/Superfund

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), passed in 1980 and commonly known as Superfund, excludes petroleum (including crude oil) from its liability provisions. However, oil and gas operators are not exempt from CERCLA liability, for several reasons.[47] First, other nonpetroleum ''special wastes" (see "Introduction" and table 4-3) from oil and gas exploration and production activities may still result in CERCLA liability if the waste constituents are hazardous substances as otherwise defined by CERCLA. Second, the petroleum exclusion does not apply to any constituents of oil and gas wastes that are hazardous substances added to the oil (and not normally found in petroleum at the levels added). Third, codisposal of exempt and nonexempt wastes can result in liability under the "mixture' rule of RCRA (see ch. 5). As noted above, oil field waste disposal sites have been designated as Super-fund sites because oil and gas wastes that are exempt from Subtitle C, along with other wastes at some sites, were not managed so as to avoid the release of hazardous substances (27).

Other Federal Agency and General Statutory Authority

Other Federal agencies also regulate certain aspects of oil and gas waste management, and several general Federal statutes contain provisions that affect oil and gas operations.

The National Environmental Policy Act (NEPA) requires Federal agencies to assess the potential environmental impacts of "major federal actions" undertaken or permitted by Federal agencies. If the assessment indicates that the environment will be significantly affected, then a more detailed Environmental Impact Statement must be prepared. In addition, the Endangered Species Act requires Federal agencies to ensure that their actions do not jeopardize endangered or threatened species or destroy critical habitats of endangered species.

The Federal Land Policy Management Act of 1976 (FLPMA) requires the U.S. Department of the Interior to develop land use plans for resources on Federal lands. With respect to regulating oil and gas E&P wastes, the Department generally favors continuing the existing approach of working relationships among the Federal Government, States, and industry. Within the Department, the U.S. Bureau of Land Management (BLM) is responsible for oil and gas production and waste management on many Federal lands, although not for the primacy programs of the Clean Water Act, Clean Air Act, or Safe Drinking Water Act. BLM manages public lands under its jurisdiction according to the comprehensive land use guidelines established by FLPMA and other acts. For example, BLM has issued orders that instruct onshore operators about how to conduct their operations in an environmentally safe manner.[48]

The U.S. Forest Service, within the Department of Agriculture, is responsible for administering oil and gas activities in the National Forests. It develops land use plans under the guidelines of the National Forest Management Act of 1976 and the Forest and Rangeland Renewable Resources Planning Act of 1974.

GAO (84) evaluated land use plans and related environmental impact statements in four resource areas administered by BLM and four national forests administered by the Forest Service, on the basis of five elements that it considered essential for assessing environmental impacts of oil and gas leasing and development decisions.[49] It concluded that most

[46] For EOR wells, oil recovery depends on maintaining the pressure within the producing zone and avoiding communication between that zone and the reservoir where wastes are injected.

[47] The precedent for Superfund liability b, oil and gas companies was set by *Eagle-Picher Industries, Inc.* v. Us. *Environmental Protection Agency, 83-2259,* U.S. Court of Appeals for District of Columbia, 822 F.2d 132, June 30, 1987.

[48] BLM, review comments, Aug. 9, 1991.

[49] The elements W... il and gas potential, reasonably foreseeable development scenarios, indirect impacts, cumulative impacts, and lease stipulations.

plans and impact statements for lands with high oil and gas potential did not contain adequate information on one or more of the five elements. GAO also found that leases and permits had been approved without including appropriate mitigation measures. In written comments to GAO, BLM and the Forest Service essentially agreed with its two major recommendations regarding the establishment of management controls to ensure that NEPA requirements are adequately addressed and that appropriate stipulations and conditions of approval are attached to leases and permits.

FLPMA also requires BLM and the Secretary of the Interior to review all public land roadless areas of 5,000 or more acres with wilderness characteristics to determine their suitability for wilderness designation by October 21, 1991. This is significant because it could potentially protector open up large areas of public lands (e.g., on the North Slope of Alaska) to potential oil and gas exploration and production (as well as other uses). If more oil and gas development occurs on Federal lands, the relationships among BLM, EPA, and the States will be even more important.

The Federal Oil and Gas Royalty Management Act of 1982, which is administered by the Department of the Interior (specifically by BLM and the Minerals Management Service) requires oil and gas operators on Federal lands to construct and operate wells in such a manner as to protect the environment and conserve Federal resources.[50] It also requires the Department to establish a comprehensive system, including inspections, for accurately determining oil and gas royalties.

The U.S. Department of Energy (DOE) charter is to ensure the Nation's energy security and, as such, includes research on waste management. DOE's concerns about oil and gas operations focus on production aspects (e.g., economic impacts of regulatory changes on the industry and on domestic production), in line with concerns of the oil and gas industry, rather than on environmental concerns, which are generally of secondary importance (100).

ISSUES AND QUESTIONS

Concerns over future liability may be encouraging oil and gas operators to improve waste management methods, but efforts on the parts of Federal and State agencies may still be needed in some areas. At the same time, the sheer number of oil and gas operators and sites and the variation in site-specific conditions pose many challenges for any waste management regulatory program, whether at the Federal or the State level. Some issues and questions related to oil and gas waste management that Congress might address include, but are not necessarily limited to, the following:

- **Relationships Among Federal Agencies and Programs-Is an** adequate mechanism available to ensure that EPA and Department of Interior regulations are consistent with each other and nonduplicative? How do Department of Interior regulations for managing oil and gas wastes on Federal lands compare with those of EPA's RCRA, UIC, and NPDES programs, which usually are implemented by the States? Does EPA need to better coordinate its own programs, which are authorized by multiple statutes (e.g., RCRA, SDWA, CWA)? Should EPA develop a multimedia approach within a RCRA Subtitle D oil and gas program? Are existing CVLA regulations on discharges of oil and gas waste to surface waters adequate, particularly for coastal discharges of produced waters and for discharges from stripper wells?
- Relationships Among Federal and State Agencies-should the Federal government specify requirements to be adopted by State programs? If so, does EPA need additional oversight, monitoring, and enforcement authority under RCRA to support an effective State-implemented Subtitle D program for oil and gas waste, or are existing State and Federal regulatory programs adequate? Should existing relationships among the Federal Government (including the Department of the Interior), States, and industry be maintained and strengthened? Can consistent environmental protection and flexibility to address variable conditions at oil and gas operations both be incorporated into a Federal waste management program?
- Scope of a Federal Regulatory Program—Should EPA or another agency develop a Federal regulatory program for the disposal of

[50] In addition, some oil and gas lease agreements may impose obligations on operatorsfor waste management tbat are different from or more stringent than State or Federal requirements.

naturally occurring radioactive material, particularly off-site? Should a Federal regulatory program be developed for abandoned oil and gas wells? What components should such programs include? Should EPA regulate produced water in storage pits or tanks prior to injection into Class II wells, whether or not the water is used for enhanced oil recovery? Should stripper wells be included in any Federal regulatory program for E&P wastes (i.e., is the current distinction for small quantity generators warranted)? Are standards needed for land treatment and land application?

- **Resources for Administration and Enforcement of Programs-Are existing** resources sufficient to administer and enforce Federal and State oil and gas waste regulatory programs? If not, what mechanisms are available to provide such resources? What emphasis should be given to enforcement of such programs relative to other Subtitle D programs and, in turn, relative to other environmental protection programs? Should independent audits be conducted to assess how effectively various Federal and State regulations are being enforced?
- Pollution Prevention/Waste Reduction—How can pollution prevention and waste reduction efforts be encouraged, especially for drilling fluids?
- Adequacy of Existing Toxicity Tests-Do existing toxicity tests such as the Extraction Procedure and the Toxicity Characteristic adequately determine the potential for long-term leaching and migration of contaminants from oil and gas wastes (i.e., is a testing scenario based on mismanagement of wastes in municipal landfills appropriate for oil and gas wastes)? Should any oil and gas exploration and production wastes be regulated as hazardous?

Chapter 5

Manufacturing Wastes

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Manufacturing Wastes

INTRODUCTION

Subtitle D manufacturing wastes include a wide range of process residues—including sludges, oily wastes, paint wastes, ashes and slags, inorganic chemical residues, food processing residues, solvents, plastics, and off-specitfication products (119).[1] The U.S. Environmental Protection Agency (EPA) estimated that about 6.5 billion tons of such waste was managed on-site (i.e., at the point of generation) in 1985; this excludes waste from electric power and generation (see ch. 3). The new Toxicity Characteristic (TC) might result in more than 800 million tons of waste yearly being identified as hazardous, but much of this is managed in units exempt from Subtitle C.[2] This chapter also discusses kiln dust from cement manufacturing, a Bevill waste that is exempt from Subtitle C pending further study and a regulatory determination by EPA. Although EPA does not consider these dusts to be Subtitle D non-hazardous manufacturing waste, they are included in this chapter for convenience.

Almost 97 percent of the Subtitle D manufacturing wastes managed on-site in 1985 were managed in surface impoundments (119). Most of the wastes were probably wastewaters, some of which may have been treated before disposal. As of 1984, approximately 29 percent of surface impoundments had Clean Water Act permits to discharge wastewater into surface water (119). EPA was unable to estimate the amount of manufacturing wastes managed off-site.

In general, few nationwide data are available on the design and operation-including the frequency of different pollution controls and groundwater monitoring-of current management units for Subtitle D manufacturing wastes. Furthermore, potential risks to human health and the environment posed by management of such wastes are relatively unstudied by EPA, compared to risks associated with other Subtitle D wastes.

Unlike the special wastes (see chs. 2 through 4), Congress did not exempt manufacturing wastes from regulation as hazardous. As a result, many manufacturing wastestreams are indeed listed hazardous wastes, and others are subject to the TC test for hazardous characteristics. However, EPA has not developed a Subtitle D program for regulation and management of non-hazardous manufacturing solid wastes, other than the general landfill criteria that were revised in 1991 (which focus on municipal solid waste landfills). The States bear primary responsibility for developing and implementing any regulatory programs for these wastes.

WASTE GENERATION

Based on data in its 1987 telephone survey of selected industrial establishments (as reported in ref. 119), EPA estimated that the manufacturing sector produced and managed approximately 6.5 billion tons of Subtitle D wastes in 1985 (table 5-1).[3] This estimate includes only wastes managed or disposed of in on-site, land-based units (i.e., landfills, surface impoundments, land application units, and waste piles).[4] EPA did not estimate how much of the total consisted of wastewaters. However, since the vast majority of the wastes were initially managed in surface impoundments (see ‘‘Current Management Practices” below), it is likely that most were wastewaters with small amounts of solids. EPA has not estimated the amount of wastes disposed of off-site or recycled (116), nor does it have figures on the amount that is injected underground.

Of the wastes managed in on-site, land-based units, the pulp and paper industry accounted for the largest quantity-about 35 percent of the total. The primary iron and steel and the inorganic chemicals

[1] Wastes contaminated with polychlorinated biphenyls (PCBs) and some pesticide residues are also included. The Toxic Substances Control Act (TSCA), for example, allows small capacitors containing less than 3 pounds of PCB dielectric to be disposed of in Subtitle D landfills. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) also allows pesticide containers that have been rinsed in accordance with label instructions to be disposed of in Subtitle Dlandfiis(119).

[2] 55 Federal *Register* *11855,-.29,* 1990.

[3] This excludes an estimated 1 billion tom of electric power generation wastes from the coal combustion utility industry (See chs. 1 and 3).

[4] Data were derived from a telephone survey of the 17 industries believed by EPA to produce more than 99 percent of all manufacturing Subtitle D “waste. EPA asked industries to estimate the quantity of waste and the quantity of water within which it was dissolved.

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Table 5-l—Estimated Amounts of Subtitle D Manufacturing Waste Managed in Land-based Units, by Industry, 1985

Industry[a]	Amount[b] (million tons)	EPA assessment of relative levels of heavy metals or organics in wastes[c]
Pulp and paper	2,250	Moderate. Organic pollutants from wood fibers may be significant. Coal and bark ash maycontain metals. Sulfates and metals high in some pulping wastes; dioxins present from some bleaching processes.
Primary iron and steel	1,300	High. Many wastes low in pH, may release significant quantities of heavy metals.
Inorganic chemicals	920	High for organics. Some small quantity generators may dispose of hazardous wastes in on-site, land-based facilities.
Stone, clay, glass, and concrete	622	Low. Most wastes are inert, Earth-type materials. However, significant quantities of pollution control sludges are generated, and some may contain heavy metals.
Food and kindred products	374	Low. Most wastes are biodegradable, although they can cause taste and odor problems.
Textile manufacturing	254	Low. Waste descriptions indicate low organics and heavy metals, but virtually no analytical data are available for confirmation.
Plastics and resins	181	High. Many wastes contain organic solvents and unreacted monomers, which are frequently toxic.
Petroleum refining	169[d]	High. Wastes generally contain high levels of sulfides, ammonia, phenols, and oils; some also contain benzo[a]pyrene and other toxic organics. Some small quantity generators may dispose of hazardous wastes in on-site, land-based facilities.
Fertilizer and agricultural chemicals	166	High. Waste gypsum piles may cause local pH and metal contamination problems. Pesticide residues may release organics and heavy metals
Primary nonferrous metals	67	High. Several waste streams contain high levels of heavy metals.
Organic chemicals	59	High. Many waste streams contain high levels of toxic organic chemicals. Some small quantity generators also may dispose of hazardous wastes in on-site, land-based facilities.
Water treatment	59	Low. Wastes are composed mainly of alum and lime, but may contain some heavy metals.
Rubber and miscellaneous products	24	High. Sketchy data indicate possibly significant levels of elastomers, carbon black, plastic resins, plasticizers, and pigments.
Transportation equipment	13	High. Wastewater treatment sludges, oils, and other wastes expected to have potential to release heavy metals and organics. Some small quantity generators also may dispose of hazardous wastes in on-site, land-based facilities.
Leather and leather products	3	Moderate. Wastes generally contain chromium, although usually in the trivalent state.
Miscellaneous	63	
TOTAL	6,524	

[a]Excludes wastes from coal combustion by utilities (see ch. 3).
[b]Based on telephone survey. Includes only wastes from on-site, land-based facilities; indudes weight of wastewater.
[c]Based on literature search; unclear how much wastewater is included. Quality and age of sources varied widely.
[d]This EPA estimate is 10 times greater than that of the American Petroleum Institute (see text).

SOURCE: Based on EPA reports cited in U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: Solid Waste Disposal in the United States*, vols. 1-2, EPA/530-SW-88-OI 1 (Washington, DC: October 1988).

industries accounted for an additional 20 and 14 percent, respectively.

The American Petroleum Institute (API) (10) recently published data on waste generation and management in the petroleum refining industry.[5] Based on responses from refineries representing 80 percent of domestic crude refining capacity, API estimated that 16 million wet tons of waste was generated in 1987 and 1988. About three-fourths of this was aqueous; the remainder included contaminated soils, oily sludges, chemicals, spent catalysts,

[5]API defined waste broadly to include hazardous and non-hazardous wastes, as well as secondary materials that might be considered byproducts or recyclable materials.

Photo credit: Union Carbide Chemicals and Plastics

The Union Carbide Chemical and Plastics plant in Seadrift, Texas. In the foreground are two Subtitle D wastewater impoundments; in the background are the plant production areas surrounded by cooling water impoundments.

and" other substances. Note that API's estimate is one-tenth of EPA's (see table 5-l); the discrepancy may result from differences in the degree of wetness reported, with many respondents in the API survey reporting dewatered waste.[6]

OTA is unaware of more recent information on total Subtitle D waste generation rates. The Chemical Manufacturers Association collects data on hazardous waste generation by its member companies, but it has not obtained systematic data on Subtitle D waste generation (14).

Effects of the New Toxicity Characteristic

Regardless of the exact amount of waste generated, recent regulatory developments regarding hazardous waste determinations will change the way in which some manufacturing wastes are classified. In particular, in 1990, EPA promulgated the new TC, which expands the criteria for determining whether a wastestream exhibits a hazardous characteristic (i.e., toxicity) and should therefore be regulated under Subtitle C.[7] EPA estimated that approximately 800 million tons of wastewater and between 1 to 2 million tons of sludges and solids currently managed as Subtitle D manufacturing wastes would be characterized as hazardous under the TC. By using the 1985 estimates of total manufacturing waste and the estimates regarding the effect of the TC, approximately 5.7 billion tons per year of manufacturing wastes would theoretically be subject to Subtitle D.

Some of the major chemical constituents included in the new TC are benzene, chloroform, vinyl chloride, and trichloroethylene.[8] EPA estimated that

[6] A. O'Hare, API, personal communication, Sept. 5, 1991.

[7] 55 *Federal Register* 11798, Mar. 29, 1990; also see "Hazardous and Solid Waste Amendments" below.

[8] EPA published a complete list in 55 *Federal Register* 11804, Mar. 29, 1990.

the industries most likely to be affected by the TC were:

1. **for wastewater-petroleum refining,** organic chemicals, synthetic rubber, and synthetic fibers; and
2. for non-wastewater sludges and solids-pulp and paper, synthetic fibers, organic chemicals, pharmaceuticals, petroleum refining, and wholesale petroleum marketing.

Certain factors limit the scope of the TC.[9] For example, EPA identified three major problems in relying on the TC to characterize treatment sludges from petroleum refining. First, the sludges can contain significant levels of hazardous constituents that are not covered by the TC (e.g., benzo[a]pyrene, chrysene). Second, EPA studies have shown that both the Extraction Procedure (EP) and the TC tend to underestimate the leachability of hazardous constituents from oily wastes (also see ch. 4).[10] Third, an oily matrix interferes with analytical methods for determining what portion of chromium is present in the hexavalent form. These limitations led EPA to list several petroleum refining primary treatment sludges as hazardous wastes (i.e., F037, F038, K048, and K051).

Hazardous Wastes Currently Exempt From Subtitle C

Determiningg a waste's regulatory status is complex, not least because Resource Conservation and Recovery Act (RCRA) regulations contain many exemptions and partial exemptions (e.g., depending on whether some wastes are recycled or not). Conditionally Exempt Small Quantity Generator (CESQG) hazardous wastes (i.e., hazardous wastes generated at a rate of less than 100 kilograms per month per generator) are generally exempt from Subtitle C regulations. Although they are not considered Subtitle D manufacturing wastes, they still can be disposed of in Subtitle D facilities.[11] They account for a relatively small amount of Subtitle D wastes (120,000 tons annually), but their toxicity, corrosivity, ignitability, or reactivity might be higher than other Subtitle D wastes because they exhibit one or more hazardous characteristics; some CESQG wastes also are listed hazardous wastes. EPA (119) estimated that most (over 75 percent) CESQG waste consists of used lead-acid batteries and spent solvents and is codisposed with municipal solid waste.

The Domestic Sewage Exclusion in RCRA[12] allows industries to discharge hazardous wastes to municipal sewers that lead to publicly owned treatment works (POTWs), without meeting Subtitle C generator requirements. Because POTWs are not designed to handle hazardous wastes, the industries are generally required to have their discharges meet pretreatment standards imposed by the local POTW under the Clean Water Act (see "Clean Water Act" below).[13] EPA (113) studied 47 industrial categories and estimated that they discharged 3,200 million gallons of process wastewater per day into municipal sewers, accounting for about 12 percent of total POTW flow. EPA estimated that in the mid-1980s this wastewater may have contained between 12,000 and 200,000 tons of hazardous metals and organic chemicals (depending, respectively, on whether pretreatment standards were fully implemented or no pretreatment occurred). Industrial users are now required to notify POTWs, States, and EPA Regions about such discharges of hazardous waste (see "Clean Water Act" below).

In addition, kiln dusts from the cement manufacturing industry are currently exempt from regulation under Subtitle C. EPA does not consider these to be Subtitle D non-hazardous manufacturing wastes, but it does regulate cement kilns that burn hazardous waste. Box 5-A provides additional information on cement kiln dusts.

MANAGEMENT PRACTICES

EPA conducted two surveys of Subtitle D programs and waste management facilities in the mid-1980s-a census of State and territorial programs in 1985 (114) and a screening survey of

[9] 55 *Federal Register* 46370, NOV. 2, 1990.

[10] As a result, EPA developed an oily waste extraction procedure (OWEP) to evaluate delisting petitions for wastes containing more than 1 percent oil or grease; however, the OWEP is not used to initially determine whether a waste should be characterized as hazardous (50 *Federal Register* 48908, Nov. 27, 1985).

[11] CESQGs are distinguished from Small Quantity Generators (SQGs), which produce waste at a rate of 100 to 1,000 kilograms Per month. SQGs were exempt from hazardous waste regulations, but the exemption ended on Sept. 22, 1987. CESQG wastes remain exempt.

[12] 40 CFR 261.4(a)(l).

[13] Some States, such as Wisconsin, require that an industry obtain specific approval from the POTW to discharge its wastes into municipal sewers.

Box 5-A-Cement Kiln Dust

The 1980 Bevill-Bentsen amendments exempted cement kiln dusts from regulation as hazardous wastes under Subtitle C, pending further study by EPA of their environmental and human health effects. EPA has not yet addressed cement kiln dust in a Report to Congress, but it did contract for a report on the cement industry (73) and it made a regulatory determination in 1991 on burning hazardous waste in boilers and industrial furnaces that also addressed cement kiln dust.[1] EPA plans to finish the required Report to Congress by April 30, 1993.[2]

Cement is produced by combining oxides of calcium, silicon, aluminum, and iron and small amounts of other ingredients at high temperatures in a rotary kiln or oven. In 1990,213 kilns operated at 112 plants,[3] Historically, cement manufacturers have used fossil fuels (coal, natural gas, petroleum products) and electricity (which is derived primarily from fossil fuels) to meet their energy needs. In the last 10 years, to lower energy costs and remain competitive, they have begun to burn certain hazardous and non-hazardous wastes (e.g., liquid organic waste solvents and waste oils) either as primary or as supplementary fuels. Currently, waste fuels (including both hazardous and non-hazardous) substitute for about 15 percent by Btu value of the cement industry's fuel requirements.[4] Some companies also selectively use a portion of an appropriate hazardous waste as a feed material for the cement itself.

Waste from cement production includes gaseous emissions and cement kiln dust. Gaseous emissions generally consist of nitrogen, carbon dioxide, and water, as well as smaller quantities of oxygen, sulfur, and nitrogen oxides; trace amounts of heavy metals with low boiling points and of organic pollutants may also be present. Cement kiln dust is generally captured by air pollution controls (e.g., electrostatic precipitators) downstream of the rotary kiln (where combustion occurs). It is composed predominantly of substances present in the feed material and products of combustion, along with trace amounts of high-boiling point heavy metals that were not exhuasted with gaseous emissions.

Cement kiln dust can be reused in cement kilns ("insufflation"), blended with sewage sludge for subsequent land application, used to produce lime products for agricultural applications, or landfilled (generally on-site). SAIC (73) estimated that approximately 160,000 tons of dust must be disposed of annually per facility, usually in on-site, land-based units.[5]

Some testing of cement kiln dust has been conducted to ascertain whether or not it exhibits hazardous characteristics.[6] The Bureau of Mines tested 113 cement kiln dust samples from 102 plants in the early 1980s (37):

1 56 *Federal Register* 7134, Feb. 21, 1991.

2 Under the terms of a proposed consent decree between EPA and the Environmental Defense Fund (see ch. 1), EPA is required to issue a Report to Congress on cement kiln dust by Apr. 30, 1993.

3 U.S. EEA, review comments, October 1991.

4 U.S. EPA, review comments based on Portland Cement Association plant information summary for 1990, October 1991.

5 This estimate is based on the assumption that 98 percent of the dust is recycled back into the process as a feed material. However, this assumption may be too high by a factor of 2 to 5 (H.P. Hackett, Holnam, Inc., personal communication, May 24 and 31, 1991); if so, then larger quantities would require disposal or other management.

6 The Portland Cement Association is finalizing a study on TC testing of dozens of cement kiln dust samples from facilities across the United States (D.L. Singletary, Cement Kiln Recycling Coalition, personal communication, May 21, 1991).

Continued on next page

industrial establishments in late 1985 and early 1986 (116). The screening survey in particular was very limited in scope, and EPA also considered the data provided by industry in response to the survey to be poor.[14] However, no national data are available on current features (e.g., design, operation, site characteristics) of these waste management units, so the two surveys provide the only national glimpse of management practices for Subtitle D manufacturing wastes. The screening survey, for example, estimated that more thi"- 72,006 industrial establishments generated Subtitle D wastes in 1985.

On-site, Land-based Units

EPA (116) estimated that only 17 percent of the establishments generating Subtitle D wastes in 1985 (i.e., 12,000 establishments) managed these wastes

14 U.S. EPA, review comments, Aug. 22, 1991.

Box 5-A-Cement Kiln Dust-Continued

only 1 sample failed the EP test; the report did not indicate, however, whether any of the sampled kilns used hazardous wastes. Although EPA has no evidence that cement kiln dusts are causing widespread environmental damage, it is concerned about: 1) the industry's growing use of hazardous wastes as fuel and the potential impact of this on the character of the dust; and 2) potential problems from land disposal of cement kiln dust (partly because three cement kiln dust disposal sites are on the Superfund National Priorities List).

Regulatory Framework

Cement kilns are subject to RCRA regulations regarding the storage of hazardous waste. Kilns that burn hazardous waste are also subject to the hazardous waste combustion requirements recently promulgated by EPA for boilers and industrial furnaces.[7] According to a recent survey (77), there were 23 cement facilities in the United States in 1990 that together burned over 0.8 million ton of hazardous waste fuels; under the new rule, as many as 45 facilities may achieve interim status, which will add to the capacity to burn hazardous waste fuels.

Under the new regulations, a cement kiln burning hazardous waste solely "as an ingredient" will not be subject to emissions controls. There are limits, however, on the concentrations of toxic constituents in such "ingredients," so the process is not completely unregulated. Also, some special restrictions apply if a waste is burned even partially for energy recovery.[8] These restrictions address minimum operating temperatures, oxygen levels, hydrocarbon monitoring, and input of the hazardous waste directly into the kiln (rather than, for example, into a precalciner). Cement kiln operators, however, generally oppose these energy recovery-related restrictions.

In addition, the applicability of the Bevill exclusion to cement kilns processing primarily raw materials must also be considered.[9] First, to be eligible for the Bevill exclusion, at least 50 percent of the feedstock to a cement kiln must consist of normal raw materials. Second, to determine whether the exclusion continues to apply when a kiln burns hazardous waste, the 1991 rule promulgated a two-part test to determine, on a case-by-case basis, whether combustion of the hazardous waste would significantly affect the character of the cement kiln dust. Cement kiln dust is considered to be significantly affected if both:

1. concentrations of toxic compounds (listed in App. VIII, 40 CFR Part 261) in the dust are significantly higher than normal (i.e., compared with cement kiln dust from a facility where hazardous waste was not burned as a fuel); and
2. toxic compounds are present in the dust at levels that could pose significant risks to human health.

Even if cement kiln dust remains exempt from regulation under Subtitle C after the case-by-case determination, emissions from the facility itself are still regulated. Moreover, the facility itself becomes subject to the corrective action provisions of RCRA Sections 3008(h) and 3004(u). These require that potential problems relating to the mismanagement of any waste (including cement kiln dust) must be evaluated before completion of the permitting process. The corrective action provisions do not apply, however, if the cement kiln is not burning hazardous waste.

[7] 56 *Federal Register* 7134, Feb. 21, 1991.

[8] EPA considers a waste t. be burned at least partially fo, energy recovery if it has a heating value of 5,000 Btu (British thermal ids) or more per pound.

[9] In this context, the Bevill amendment also applies to boilers burning p- ly coal or other fossil fuels and to industrial furnaces processing primarily ores or minerals.

on-site in land-based units (surface impoundments, landfills, land application units, or waste piles). Furthermore, EPA estimated that about 25,000 on-site, land-based units were active in the mid-1980s (table 5-2). Table 5-3 shows, by industry, the number of active on-site, land-based units and the percentage of waste disposed of in them in 1985 (based on the screening survey).[15]

Almost 97 percent of the wastes managed in on-site, land-based units were initially disposed of in surface impoundments (figure 5-l), indicating that most of them were probably wastewaters.[16] In 1984,

15 The 1985 census, unlike the screening survey, was not limited to on-site units; this may explain why the census found somewhat larger numbers of landfills, surface impoundments, and land application units than did the screening survey.

16 Again, the effect of the new TC on the manner in which these wastes are characterized is unknown.

Photo credit: Union Carbide Chemicals and *Plastics*

A Subtitle D wastewater impoundment at the Union Carbide Chemical and Plastics plant in Seadrift, Texas.

Table 5-2—Estimated Number of Subtitle D Manufacturing Waste Management Units, Mid-1980s

Type of Unit	EPA census[a]	EPA screening survey[b]
Landfill	3,511	2,602
Land application unit	5,605	4,266
Surface impoundment	16,232	14,033
Waste pile	N/A[c]	5,225
TOTAL 0	25,346	26,126

[a]Survey of 55 State and territorial solid waste management programs.
[b]Survey of 17 industry categories contributing an estimated 99 percent of manufacturing Subtitle D wastes; includes only on-site facilities. OTA subtracted facilities managing electric power generating wastes, which are covered in ch. 3.
[c]Not applicable.

SOURCES: U.S. Environmental Protection Agency, Census *of State* and *Territorial Subtitle D Nonhazardous Waste Programs*, EPA/530-SW-86-039 (Washington, DC: October 1986); U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Screening Survey of Industrial Subtitle D Establishments," unpublished draft final report, December 1987.

approximately 29 percent of these impoundments had discharge permits issued under the National Pollutant Discharge Elimination System (NPDES) program (119); the permits specify conditions under which effluent discharges into surface waters are allowed (see "Federal Regulations" below). The portion of all manufacturing waste that is managed in surface impoundments with discharge permits, as well as the volume of actual discharges to surface waters, is unknown. Manufacturing wastes do not appear to be injected underground in general, other than the 1 percent indicated below for alternative on-site practices; however, the extent of this practice warrants additional study.

Among industrial sectors, the pulp and paper, primary iron and steel, and inorganic chemicals industries accounted for 70 percent by weight of the wastes managed in surface impoundments. However, nearly half of the total number of impoundments were operated by the food and kindred products industry and the stone, clay, glass, and concrete industry.

About 1 percent of the total manufacturing Subtitle D wastestream was managed in landfills, 1 percent in land application units, and 1 percent in waste piles (figure 5-1).[17] In landfills, most of the wastes by weight were generated by the stone, clay, glass, and concrete; pulp and paper; fertilizer and agricultural chemicals; and primary iron and steel industries. Most of the landfills were operated by the stone, clay, glass, and concrete; pulp and paper; primary iron and steel; and food and kindred products industries. The food and kindred products industry accounted for 77 percent of the waste going to land application units and operated 73 percent of the units. The inorganic chemicals industry was responsible for more than half of the waste going to waste piles, whereas the stone, clay, glass, and concrete industry operated almost half of the piles. Based on 1985 data, the types of waste disposed of in waste piles include sludges and "off-specification" products from the organic chemicals industry, and slag from the metals manufacturing industry (119).

According to EPA's screening survey, some manufacturing establishments reported managing halogenated solvents, nonhalogenated solvents, and metals in on-site, land-based units. All of these wastes reportedly passed EP toxicity tests and thus were not characterized as hazardous. The effect of the newly promulgated TC on characterizing these wastes is unknown, but more will certainly be classified as hazardous.[18] For the petroleum refining industry, the API (10) indicated that most aqueous

[17]About 55 percent of establishments with waste piles eventually send these wastes off-site, However, some wastes are probably always being stored in the on-site piles at these establishments. This may mean that the area in which the on-site waste piles are located is a de facto permanent waste disposal site.

[18]55 Federal Register 11798, Mar. 29, 1990; also see "Federal Regulations" below.

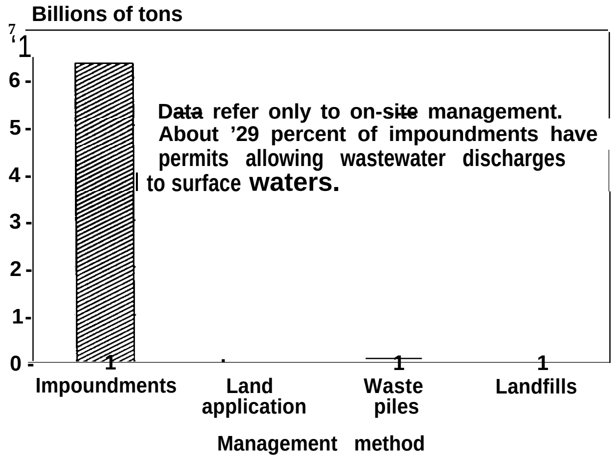
Table 5-3—Number-of On-site Subtitle D Facilities and Percentage of Waste Handled at Different Waste Management Facilities, by Industry, 1985

Industry	Type of unit: Landfill	Surface impoundment	Land application unit	Waste pile	Total
Organic chemicals					
Units	17	262	27	79	385
Waste (%)	0.4	96.3	3.1	0.08	
Primary iron and steel					
Units	201	383	76	464	1,124
Waste (%)	0.3	99.2	0.01	0.5	
Fertilizer and agricultural chemicals					
Units	31	274	160	50	515
Waste (%)	3.5	93.1	0.5	2.9	
Plastics and resins					
Units	32	292	17	32	373
Waste	0.05	98.2	0.02	1.7	
Inorganic chemicals					
Units	120	1,039	24	98	1,281
Waste (Ye)	0.4	95.1	0.01	4.5	
Stone, clay, glass and concrete					
Units	1,257	3,152	309	2,528	7,247
Waste(%)	1.2	97.3	0.01	1.5	
Pulp and paper					
Units	259	918	139	232	1,548
Waste (Ye)	0.3	99.3	0.4	0.07	
Primary nonferrous metals					
Units	111	448	9	312	880
Waste(%)	2.1	84.3	0.6	13	
Food and kindred products					
Units	194	4,166	3,128	540	8,029
Waste(%)	1.0	78.6	20	0.1	
Water treatment					
Units	121	659	147	48	974
Waste(%)	0.3	84.5	15	0.1	
Petroleum refining					
Units	61	915	114	158	1,248
Waste(%)	0.2	99.6	0.2	0.05	
Rubber and miscellaneous products					
Units	77	176	16	123	392
Waste(%)	2.2	97.4	0.2	0.2	
Transportation equipment					
Units	63	287	11	362	723
Waste(%)	1.4	93.1	0.01	4.6	
Selected chemicals and allied products					
Units	21	219	17	41	298
Waste(%)	0.2	99.1	0.7	0.01	
Textile manufacturing					
Units	28	741	72	103	944
Waste(%)	0.03	99.7	0.3	0.01	
bather and leather products					
Units	9	102	0	54	165
Waste(%)	0.3	99.4	0	0.3	
TOTAL[a]					
Units	2,602	14,033	4,266	5,225	26,126
Waste (%)	0.5	96.8	1.5	1.2	

[a]Table entries may not add up to their respective totals because of rounding.

SOURCES: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Screening Survey of Industrial Subtitle D Establishments," unpublished draft final report, December 1987; U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: So/id Waste Disposal in the United States,* vols. 1-2, EPA/530-SW-88-011 (Washington, DC: October 1988).

Figure 5-l—Land-Based Management of Subtitle D Manufacturing Wastes, 1985



SOURCE: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report* to *Congress: Solid Waste Disposal in the United States,* vols. *1-2,* EPA/530-SW-88-011 (Washington, DC: October 1988).

wastes are injected underground in wells. Management methods for nonaqueous wastes varied: 23 percent recycling; 28 percent treatment (e.g., dewatering, wastewater treatment, chemical/physical treatment, incineration); 16 percent land treatment; and 33 percent disposal (landfill, impoundment, landspread).

Other On-site Units and Off-site Management

The other 60,000 manufacturing establishments identified in the survey must manage their Subtitle D wastes either off-site, or on-site via processes such as underground well injection, recycling, incineration, or treatment in tanks. EPA estimated that about 11 percent used on-site alternatives, 90 percent used off-site practices, and 13 percent employed practices that were either unknown or for which the site was unknown (the total is more than 100 percent because a given establishment can use several practices). Of the establishments that used on-site alternatives, 68 percent recycled, reclaimed, or reused some waste; 25 percent used tank treatment; 7 percent used incineration; and less than 1 percent used underground injection or boilers (1 16). EPA was unable to estimate the amounts of waste managed on-site in these other ways.

EPA was unable to depict off-site facilities in any detail or to estimate the quantities of waste disposed of in them or recycled through them. Qualitatively, however, EPA found off-site disposal to be the predominant practice in 1985 for the following industries: electrical machinery and components; food and kindred products; leather and leather tarming; machinery (except electrical); pharmaceutical preparations; and soaps, other detergents, and polishing, cleaning, or sanitation goods (1 19). Some of these off-site facilities are municipal landfills; others are for manufacturing wastes only. No national estimates exist on the amount of manufacturing solid waste disposed of at municipal solid waste landfills.

Some manufacturing wastes are sent off-site for disposal at commercial manufacturing waste landfills, which often are operated by large waste management companies. One company, for example, said that it operates special programs for these wastes to ensure compliance with relevant Federal and State regulations and keeps records of the wastes managed at its facilities.[19]

EPA is exploring information-gathering strategies, including statistical surveys, to address the gap in knowledge of off-site management practices, to update and complete its knowledge of on-site **practices,** and to obtain more detailed information that will enable it to better assess the need for development of guidelines for manufacturing wastes.[20]

Recycling

Many industries recycle some wastes on-site in the manufacturing process or sell them for off-site reuse (112). On-site recycling and reuse of spent solvents and other organic compounds (which also may be burned on-site as a fuel source) are common in the organic chemicals, plastics, and resins industries. The primary iron and steel, primary nonferrous metals, fabricated metals, and electronic component industries recover most scrap metal and often sell it to off-site scrap metal recyclers. Many organic

[19]E. Skernolis, Waste Management, Inc., review comments, Aug. 6, 1991.

[20]56 *Federal Register 50978,* Oct. 9, 1991.

wastes from the food industry are used in byproducts such as animal feed or are otherwise recycled.[21]

The State of Ohio estimated that 32 percent by weight of the manufacturing wastestream generated in that State is recycled (55). Industries reporting the highest recycling rates included furniture and fixtures, machinery (except electrical), food and kindred products, fabricated metals, and transportation equipment.

The rate of recycling generally depends on the economic value of the wastes, the technical ease of recycling, and the fear of future liability associated with disposing of the waste (1 12). In the Ohio study, the most common reasons given by companies for not recycling were increased handling and transportation costs, liability concerns, the difficulty of recycling certain waste mixtures (i.e., mixtures of different solid waste types or wastestreams), and regulatory barriers. (See discussion of "mixture' and "derived-from" rules in chs. 1 and 2.)

The presence of regulatory barriers that inhibit off-site recycling of manufacturing wastes is an important issue in the RCRA reauthorization process. Many industries and commercial recyclers believe that regulating recycling under Subtitle C will discourage the development of collection and processing systems and lead to less recycling (1 1).[22] They are concerned, for example, about the increased costs of meeting permitting and reporting requirements and about the increased liabilities likely to be associated with recycling if it or the recyclable materials are regulated under Subtitle C. In contrast, others consider such regulation a means of promoting more responsible recycling (e.g., see ref. 70 regarding used oil). Environmental groups such as the Natural Resources Defense Council (NRDC) also believe that recycling of any hazardous wastes should be regulated as a treatment activity under Subtitle C, because of potential releases of toxic constituents to the environment, and that recyclable wastes themselves should be regulated as hazardous when, for example, they fail the TC test.[23]

An additional issue is how the regulatory status of recycling facilities might affect efforts to reduce the generation of solid wastes in the first place. In one sense, the higher costs likely to be associated with recycling if it were regulated under Subtitle C might provide an incentive for companies to look for additional means of reducing their wastes, rather than sending them off-site for recycling. According to industry representatives, however, recycling of Subtitle D processing wastes and efforts to reduce their generation already are becoming more common in some industries,[24] partly because of lessons learned from-and direct linkages with-hazardous waste prevention efforts (93). If this continues, regulating recycling under Subtitle C might lead to less recycling and to more recyclable wastes being sent to treatment and disposal facilities, depending on the costs of these various options.

The issue of recycling manufacturing wastes also affects primary smelters in the mining industry, as explained in box 5-B.

Pollution Prevention/Waste Reduction

Relatively little is known on a nationwide scale about the extent and success of efforts to reduce the generation of Subtitle D manufacturing wastes or the use of toxic substances in processes that generate these wastes. For example, only 10 percent of the industrial facilities that filed Toxics Release Inventory (TRI) forms for 1988 reported attempts to minimize TRI chemicals (reporting of such efforts was optional, though; ref. 128). However, the extent to which this applies to Subtitle D manufacturing wastes in general is unknown.

As noted above, regulating the recycling of manufacturing wastes under Subtitle C might provide some incentive for companies to explore pollution prevention opportunities, although it could also lead to more recyclable wastes being sent to treatment and disposal facilities. Alternative, nonregulatory approaches such as waste audits and technical assistance-mechanisms used with success in pollution prevention programs for hazardous waste-might provide more positive incentives.

[21] They can also be processed and used as fuel sources; e.g., one thermochemical system devised by Battelle Pacific Northwest Laboratory reportedly can transform 1 ton of wet organic wastes (e.g., cheese whey, coffee grounds, spent brewery grains) into a fuel source with less than 20 pounds of ash residue (20).

[22] A. O'Hare, API, review comments, July 26, 1991.

[23] L. Greer, NRDC, review comments, July 1991.

[24] E. Males, Chemical Manufacturers Association review comments, Aug. 7, 1991.

Box 5-B—Recycling of Manufacturing Wastes by Smelters

One issue affecting both manufacturing and mining is the regulatory status of the recovery or recycling, by primary metal smelters, of metals contained in manufacturing residuals. Smelting, one of the last steps in the mining process, involves using a high temperature to separate the pure, desired metal from other compounds in concentrated ore. It can also be used to separate and recover metals from residuals such as wastewater treatment sludge and air pollution control sludge; these are generated, for example, in electroplating processes common in the electronics, automotive, aerospace, and other industries.[1]

Some primary metal smelting companies are currently recovering significant amounts of copper, zinc, and precious metals from metal-bearing wastes. Many mining industry representatives claim that this offers several advantages: 1) the metals are recovered and returned to commerce, rather than being landfilled, thereby conserving nonrenewable domestic resources; 2) the volume of incoming waste material is substantially reduced; and 3) the incoming hazardous waste material is transformed into a chemically inert slag that generally passes EPA leaching tests.[2] However, they believe that conflicts in the interpretation of RCRA, particularly whether or not recyclable materials should be defined as "solid wastes" and therefore be subject to RCRA, hinder full development of such recovery activities (including on-site closed-loop and other recovery processes; ref. 11).

EPA does not generally have authority under RCRA to regulate primary manufacturing production processes (see ch. 2). However, it does have authority to include reclamation (i.e., recovery) and residuals from such reclamation in the scope of solid waste management under RCRA and to regulate some aspects of production under the Toxic Substances Control Act (TSCA); it may also have authority under RCRA when hazardous wastes are introduced into primary processes. A reclamation process is subject to Subtitle C regulation if the residuals being treated are listed hazardous wastes (unless the process is a closed loop). Moreover, any subsequent residuals from the reclamation process may be regulated as hazardous under the "mixture" and "derived-from" rules (see ch. 1), whether or not the residuals exhibit hazardous waste characteristics.

The American Mining Congress (AMC) challenged inclusion of these manufacturing residuals in the definition of solid waste. In 1987, the court agreed with the AMC and ruled that the definition of solid waste was limited to materials that are discarded by virtue of being disposed of, abandoned, or thrown away.[3] The court also ruled that EPA had specifically exceeded its authority insofar as it classified certain in-process streams in the petroleum refining and primary smelting industries as RCRA solid wastes. Some representatives of the mining industry contend that EPA has ignored the ruling and that metal recycling by smelters is still unnecessarily constrained (e.g., 30).

EPA expressed its own view on the ruling in 1988.[4] The Agency stated it would amend its rules so that they do not extend to ongoing manufacturing operations characterized by continuous extraction of material values from an original raw material. It specifically proposed changing the rules to state that recycled oil-bearing secondary

[1] Recycling of similar wastes generated from the mining and mineral processing industry itself also occurs. For example, metal-bearing dusts and sludges generated during the smelting of ores maybe reintroduced into smelters. Materials from one mining sector may be used by other sectors (e.g., dust or sludges from zinc smelters may have high lead values recoverable in a lead smelter) (Crozier, Phelps Dodge Corp., personal communication, Mar. 6, 1991).

[2] Multinational Business Services, Inc., review comments, July 30, 1991.

[3] *American* Mining *Congress v. EPA, 824* F.2d 1177 (D.C. Cir. 1987).

[4] 53 *Federal Register* 520, Jan. 8, 1988.

Continued on next page

Some States have developed programs-which vary in scope and funding-to promote pollution prevention efforts for manufacturing wastes, particularly those considered hazardous or toxic. As of 1991, for example, over one dozen States had some legislation dealing with pollution prevention; these laws generally target hazardous waste and toxic releases as defined by or listed under RCRA, the Superfund Amendments and Reauthorization Act, and various State statutes and regulations (45a). Furthermore, as many as 46 States, regardless of legislative mandate, have developed or initiated some form of pollution prevention program (or support for such a program). These typically consist of activities relating to promotion (e.g., technical assistance), regulatory integration (e.g., multimedia permitting), or facility planning; a few provide incentives (e.g., tax breaks, Governors' awards) to companies to work toward pollution prevention (45a). While no State is known to have a program

Box 5-B—Recycling of Manufacturing Wastes by Smelters-Continued

materials from petroleum refining are not solid wastes, provided there is no other element of discard or disposal.[5] For recycling by the primary smelting industry, however, EPA noted that whereas some operations are ongoing manufacturing processes, others involve sludges and byproducts that are not part of ongoing processes and contain elements of discard. The Agency proposed to revise its rule to state that the ultimate jurisdictional testis whether the materials are being used in an ongoing continuous manufacturing process.

Two other major treatment options exist for these metal-bearing industrial residuals. They can be incinerated at **a** hazardous waste treatment facility, with subsequent landfilling of ash residues (which may or may not test as hazardous, depending on the specific residues), or they can be stabilized with cement and then landfilled Each option has several drawbacks: neither recovers the metals; stabilization substantially increases the volume of the waste; and both require final land disposal.

In February 1991, EPA issued a Rule on Burning of Hazardous Wastes in Boilers and Industrial Furnaces.[6] A portion of the rule defers regulation of those primary metal smelters that accept hazardous metallic sludges solely for metal recovery. EPA intends to study whether regulation of these smelters under the Clean Air Act would be more appropriate.

In the rule, EPA also stated its intent to discourage "sham" recycling operations, in which operators seek to remove conventional treatment operations from regulation as hazardous waste management facilities by claiming that they actually are processing materials for recycling. EPA defined conditions to be met before such operations would be considered eligible for deferred regulatory status: 1) hazardous waste must be burned solely to recover metals (as opposed to burning for treatment or for energy recovery); 2) wastes must contain economically viable amounts of recoverable metals; and 3) operators must be in the business of producing metals for public sale.

Primary metal smelters contend that their metal recovery operations represent a legitimate and environmentally sound activity. Thus, they would like to see Congress encourage such recovery (while discouraging "sham" metal recycling) by requiring that: 1) facilities engaged in legitimate metal recovery not be treated as waste management facilities under RCRA; 2) secondary materials that are processed for metal recovery purposes not be defined as solid wastes; and 3) residuals from legitimate metal recovery operations be regulated based on their actual characteristics, not on the derived-from and mixture rules.[7] Amoco (11), for example, suggested that EPA either develop a special "recycling category" or support a new RCRA subtitle on recycling, with different regulatory treatment for consumer recyclable materials (e.g., used oil), commercial recycling facilities, and industrial recycling activities.[8]

As noted in this chapter, many of these suggestions run counter to the position taken by certain environmental groups and the Hazardous Waste Treatment Council regarding recycling of manufacturing wastes in general.

[5] EPA also viewed the court's opinion as not affecting any of its rules (with the exception of in-house recycling activities in petroleum refining) on burning of hazardous secondary materials for energy recovery or using such materials to produce fuels.

[6] 56 *Federal Register* 7134, Feb. 21, 1991.

[7] How the international Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, adopted in 1989 but not yet in force, might affect such recycling is unclear. Annex IV of the convention includes recycling of hazardous waste as a form of disposal.

[8] In a more general context, mining companies believe that any secondary materials generated in the industry and reused in normal primary production processes should not be regulated under Subtitle C (S. Crozier, Phelps Dodge Corp., personal communication, Mar, 6, 1991). They suggest, however, that EPA should ensure these materials are properly conveyed or transported to the recycling site and properly handled while there.

specifically aimed at Subtitle D manufacturing wastes, some State programs do include activities devoted to Subtitle D wastes. Several States also are conducting "roundtables" on pollution prevention; these focus primarily on hazardous wastes but some include efforts to address Subtitle D wastes (141a). In addition, EPA is examining several State programs to get a better perspective on their scope and is considering holding workshops in which States would exchange infomation and ideas about regulating Subtitle D manufacturing wastes.[25]

Some municipalities, in attempts to ease local landfill capacity shortfalls, have actively promoted the reduction of Subtitle D manufacturing wastes by passing laws and implementing cooperative efforts

[25] K. Sandler, U.S. EPA, personal communication Nov. 6, 1991.

with industrial generators. These efforts, though, are generally aimed only at the portion of Subtitle D manufacturing wastes that is managed at municipal landfills.

RISKS FROM MANUFACTURING WASTES

Land-based waste management units in general can release some contaminants, which may or may not approach levels of concern for human health and the environment. Constituents can leach from landfills, surface impoundments, or waste piles into nearby soil and groundwater; runoff can contaminate surface water; and volatile organic chemicals can be released to the air. Several factors suggest that land-based management of Subtitle D manufacturing wastes may pose some risks to human health and the environrnent-large quantities of wastes are generated (see above); a variety of toxic constituents are present in them; their management relies heavily on numerous land-based units (most of which probably lacked pollution controls in the mid- 1980s; see above); and some exempted hazardous wastes are disposed of in Subtitle D waste management units. Sites on the National Priorities List (NPL) are linked with poor management practices in the past for Subtitle D non-hazardous manufacturing wastes.

Even so, although problems do exist, it is difficult to be more precise about the overall hazards posed by these wastes. Few risk assessments have been performed, and few data are available on specific environmental and human health impacts resulting from the management of Subtitle D manufacturing wastes. It is also difficult to determine how many Superfund sites resulted primarily from contamination by non-hazardous manufacturing wastes.[26] Municipal landfills comprise about 20 percent of the NPL, and most of them received manufacturing waste at some time, but even in these cases it is difficult to pinpoint exact sources of contamination (see ref. 95).

Toxicity

A crude, qualitative idea of the level of toxicity of Subtitle D manufacturing wastes, and how these levels might vary among industries, is conveyed in table 5-1. These data were compiled in 1985, from diverse studies which varied in age and quality, for 22 industries expected to generate more than 99 percent of the Subtitle D manufacturing wastes managed on-site. They compare estimated waste generation with **qualitative estimates** of the levels of heavy metals or organic chemicals in the wastes. EPA estimated that wastes contained relatively high levels of heavy metals and organic chemicals in 12 industries, relatively moderate levels in 4 industries, and low levels in 6 industries.

This information was compiled by EPA prior to promulgation of the new TC (see "Effects of the New Toxicity Characteristic" above). Some manufacturing wastes now handled at Subtitle D landfills and surface impoundments would probably be classified as hazardous by using the new TC.[27] The extent to which this would change relative amounts and toxicity levels is unkown.

EPA's screening survey (116) found that 16 percent of CESQGs managed their hazardous wastes in on-site surface impoundments, waste piles, landfills, and land application units.

Some reviewers suggested that the TRI might provide information on where some of the potentially greatest risks from manufacturing solid wastes might be found.[28] EPA conducted a preliminary analysis of the TRI database, in the belief that the data might give some hint of where some of the potentially greatest risks from manufacturing solid

[26] At many sites, very little is known about the origin or character of wastes present, partly because such sites frequently contain wastes generated before RCRA was passed. Furthermore, whether a waste found at a Superfund site currently exhibits a hazardous characteristic may not be sufficient information to determine ifit exhibited that characteristic when generated. Hence, although information on specific cases of conlamination caused by known Subtitle D non-hazardous manufacturing waste generators is attainable, EPA suggests that the aggregate number of sites on the Superfund NPL resulting primarily from non-hazardous manufacturing waste conlamination is probably indeterminable (U.S. EPA, review comments, Aug. 22, 1991).

[27] The TC rule will not apply to the special wastes that are currently exempt from Subtitle C regulation (i.e., mining and some mineral processing wastes, oil and gas exploration and production wastes, and cement kiln dust), unless EPA determines on a case-by-case basis that some of these wastes warrant such regulation (55 *Federal Register* 11835, Mar. 29, 1990). If such a determination is made, EPA would then make a separate determination concerning the applicability of the TC to the wastes.

[28] Title III (the Emergency Planning and Community Right-to-Know Act) of the 1986 Superfund Amendments and Reauthorization Act requires certain companies manufacturing or processing certain amounts of 302 individual toxic chemicals and 20 categories of chemical compounds to file an annual TRI report with EPA and the appropriate State agency. Companies with Standard Industrial Classification (SIC) codes 20 to 39, having 10 or more employees, are required to report. The threshold for reporting in 1988 was 25 tons; the threshold in subsequent years is 12.5 tons. Companies using 10 tons or more of a chemical annually (as of 1988; 5 tons or more subsequently) also are required to report.

Table 5-4-Number (and percentage) of On-site Subtitle D Manufacturing Waste Management Facilities With Different Design and Operating Controls, 1985

	Type of waste management facility		
Design and operating controls	Landfill	Surface impoundment	Land application unit
Synthetic liners	45(1 %)	756 (5%)	N/A
Natural liners, including slurry walls	392 (ll%)	2,818 (17%)	N/A
Leachate collection systems	112 (3%)	Unknown	N/A
Leak detection systems	Unknown	896 (65%)	N/A
Runon/runoff controls	1,150 (33%)	Unknown	3,837 (69%)
Overtopping controls	N/A	3,672 (23%)	N/A
Methane controls	98 (3%)	N/A	N/A
Ban on certain Subtitle D waste types (e.g., bulk liquid)	1,200 (34%)	2,685 (17%)	3,633 (65%)
Discharge permits	Unknown	4,738 (29%)	Unknown
Waste application rate limits	N/A	N/A	4,085 (73%)
Restrictions on growing food chain crops	N/A	N/A	2,395 (43%

NOTE: N/A = not applicable.

SOURCE: U.S. Environmental Protection Agency, Census *of State and Territorial Subtitle D* Nonhazardous *Waste* Programs, EPA/530-SW-86-039 (Washington, DC: October 1986).

wastes might be found.[29] EPA believes that TRI provides a sense for the intrinsic hazard of wastes, but because the data are reported in pounds of chemicals released, not as concentrations of chemicals in wastestreams, they are not directly comparable to data on the quantities of wastes produced by manufacturing facilities. EPA views this information as a starting point for future studies, not as a definitive indicator of risk; it therefore does not intend to release this information to the public.[30]

Frequency of Pollution Controls

According to data in EPA (119), the presence of pollution controls and monitoring at management facilities for manufacturing waste was minimal in the mid-1980s, in part because they often were not required prior to that time. Some States have adopted liner and leachate requirements for Subtitle D units since then, but OTA is unaware of aggregate data on the presence of controls at facilities for manufacturing waste that have been constructed or retrofitted since that time.[31]

Design and operating controls such as liners and emissions controls were rare in the mid-1980s, especially at landfills and surface impoundments (table 5-4). Because 97 percent of Subtitle D manufacturing wastes which were disposed on-site were disposed of in surface impoundments, and **because wastes generally are in** mobile form, the deficiency of controls at impoundments seems particularly significant, especially if the same situation exists today. In the mid- 1980s, only 4.7 percent had synthetic liners, 17.4 percent had natural liners such as existing clay, 5.5 percent had leak detection systems, 23 percent had overtopping controls, and 17 percent had any restrictions on receipt of liquids. No information was available on the fkequency of leachate collection systems or runon/runoff controls at the impoundments. Designs for waste piles occasionally included runon/runoff controls, but liner systems were generally not used (119).

Available information on the frequency of monitoring and violations at these facilities showed that very few Subtitle D landfills, surface impoundments, and land application units were monitoring potential or actual releases to the environment as of 1984 (table 5-5). Of the facilities that were conducting monitoring, many were violating State standards. Because more than one violation may have been detected at a single facility, the actual percentage of facilities with monitoring that also experienced a violation may be lower than indicated in table 5-5.

29U.S. EPA, review comments, Aug. 22, 1991.

30U.S. EPA, review comments, Nov. 8, 1991.

31Ch. 1 discusses a recent survey (33) of State requirements for liners at non-hazardous industrial waste landfills; the survey data, however, do not distinguish between landfills that accept only manufacturing wastes and those that accept a broader range of non-hazardous solid wastes.

Table 5-&Violations of State Standards Detected at Subtitle D Manufacturing Waste Management Facilities in 1984

	Landfills				Surface impoundments				Land application units			
Medium of concern	Facilities with monitoring	Percentage of total facilities	Violations detected	Percentage of facilities with monitoring also with violation[a]	Facilities with monitoring	Percentage of total facilities	Violations detected	Percentage of facilities with monitoring also with violations[a]	Facilities with monitoring	Percentage of total facilities	Volations detected	Percentage of facilities with monitoring also with violation@
Groundwater	626	18	111	18	1,396	9	416	30	592	11	45	8
Surface water	230	7	50	22	3,151	19	279	9	137	2	60	44
Air	80	2	18	23	73	Lees than 1	145	100	31	bee than 1	10	32
Methane (subsurface gas)	63	2	8	13								
Soil	204	4	N/A	N/A								
Total active facilities	3,511				16,232				5,605			

NOTE: N/A = not applicable.

[a]Because more than one violation may have occurred at the same facility, this is the maximum percentage of facilities with monitoring that may have had a violation.

SOURCE: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Report to Congress: So/id Waste Disposal in the United States*, vols. *1-2*, EPA/530-SW-88-01 1 (Washington, DC: October 1988).

In 1990, the General Accounting Office (83) interviewed State regulatory officials about non-hazardous waste facilities in six States (Alabama, Ohio, Pennsylvania, Tennessee, Texas, and Washington). Officials in all six States were concerned about groundwater contamination at these facilities for several reasons. First, the same facilities had been responsible for groundwater contamination in the past. Second, some unpermitted facilities did not have proper controls. Finally, the States lacked resources to complete all required inspections. Based on data supplied by California and New Jersey, GAO reported that groundwater contamination had been detected at 68 (61 percent) of 112 manufacturing waste management facilities that monitored groundwater in these two States. At 32 facilities (29 percent of the total), the known or suspected source of contamination was a Subtitle D non-hazardous industrial landfill, surface impoundment, or construction/demolition debris landfill.[32] State officials believed that 18 of these 32 facilities posed a "moderate" to "great" threat to groundwater.

Some Subtitle D non-hazardous manufacturing waste is managed at on-site facilities that are also Subtitle C treatment, storage, or disposal facilities (TSDFs). All Subtitle D management units located at Subtitle C TSDFs are subject to RCRA Subpart S corrective action requirements, even if the units receive only Subtitle D wastes. These wastes may pose lower risks than wastes that are otherwise regulated. ICF (40) estimated that 780 million tons of wastes included in EPA's manufacturing waste telephone survey were managed at facilities with TSDF status.

CURRENT REGULATORY PATHWAYS

Subtitle D manufacturing wastes are primarily controlled at the State level, under programs developed by each State. EPA believes that much more information on waste types and characteristics, management facility design, exposure routes, and State regulation must be obtained before a Federal Subtitle D program for manufacturing wastes can be developed.[33]

State Programs

In many States, relatively few regulatory requirements exist beyond those contained in the Federal Subtitle D landfill criteria, which are applied in most instances to municipal landfills (see ch. 1). Several States, however, have promulgated more comprehensive regulations.[34] As of 1991, for example, Pennsylvania was finalizing extensive amendments to its regulations for "residual" wastes (i.e., non-hazardous solid waste from industrial, mining, and agricultural operations) .35 The amended regulations set forth requirements for permits, permit review procedures, bonding and insurance, civil penalties and enforcement, and beneficial use; they also require generators to prepare a source reduction strategy. In addition, they establish standards for the design, construction, and operation of impoundments that store or dispose of residual waste.

In GAO's study (83), all six States varied in their requirements for permits, liners, and groundwater monitoring for manufacturing waste facilities. Five of the States also exempt some categories of facilities from permit requirements. For example, Alabama exempts all industrial surface impoundments established before 1979 (when the State instituted a permit requirement) unless they are associated with wastewater treatment plants that discharge to surface water. Texas exempts all on-site landfills and on-site surface impoundments that are not apart of a wastewater treatment plant. According to EPA (as cited in the GAO study), facilities exempted from permits could threaten groundwater because they may handle harmful substances but not be required to have environmental controls.

Furthermore, permitted facilities in the States varied greatly in the percentage of facilities having liners and groundwater monitoring controls (see

[32] At the other facilities with detectable groundwater contamination, either different sources (e.g., a hazardous waste management unit, underground storage tank, or adjacent facility) were known or suspected, or the source of contamination was unknown.

[33] 53 Federal Register 33327, Aug. 30, 1988.

[34] ICF (41) prepared a study for API and CMA on the status of State Subtitle D regulatory programs for manufacturing wastes; the study attempts to evaluate the quality of current programs and their level of implementation and enforcement. OTA did not receive this document in time to summarize its findings or to discuss it with representatives from environmental groups, EPA, and other interested parties.

[35] These regulations were proposed under the State's Solid Wrote Management Act. Mining wastes from non-coal surface mining activities and oil and gas residual wastes are regulated under different State statutes.

table 5-6). All six States require liners and ground-water monitoring at some permitted facilities. However, the requirements for particular units are determined on a site-specific basis.[36] In addition, the States varied in the type of material required for liners. Not all permitted facilities had required controls in place, because States either have not fully implemented requirements or have exempted older facilities.

No systematic summmary is available on the overall efficacy and enforcement of current State regulations. As of 1985, according to EPA's State census, more than half of all industrial surface impoundments, 84 percent of land application units, and almost 20 percent of industrial landfills were being inspected by State agencies once every 2 years or less frequently in the mid-1980s (119).

Federal Regulations

In theory, waste management facilities for non-hazardous manufacturing wastes are regulated under Subtitle D of RCRA. However, the only extant major Federal regulations are the criteria for solid waste disposal facilities, which have been applied primarily to municipal solid waste (MSW) landfills and which were revised in 1991 (see below and ch. 1). The 1984 Hazardous and Solid Waste Amendments (HSWA) attempted to rectify this situation (see below), and other Federal statutes such as the Clean Water Act and Clean Air Act also regulate some aspects of manufacturing wastes.

Hazardous and Solid Waste Amendments

HSWA included several provisions that greatly affect the design and operation of Subtitle D waste management units, as well as those manufacturing wastes that are to be regulated under Subtitle C rather than Subtitle D.

First, HSWA required EPA to revise the Subtitle D criteria for facilities that may receive hazardous waste from households and small quantity generators, by March 31, 1988. EPA focused initially on MSW landfills and issued new criteria for them in October 1991.[37] While MSW landfills represent only a small portion of Subtitle D waste management facilities, they probably receive the bulk of household hazardous waste and CESQG waste. EPA plans to explore information-gathering strategies to learn more about facilities that handle Subtitle D manufacturing wastes to determine if revised criteria are necessary for these facilities.[38]

Although some States (e.g., California, New York, Pennsylvania) have revised their Subtitle D programs, including aspects applicable to manufacturing waste, other States probably will not amend their regulations unless EPA issues new criteria for Subtitle D waste management facilities. Because only one-third to one-half of the landfills and one-half of the surface impoundments used for Subtitle D manufacturing waste in the mid-1980s had permits (based on data in ref. 119), it seems important that EPA evaluate the extent of risks associated with such facilities and whether new criteria are needed for them.

Second, HSWA directed EPA to promulgate additional characteristics to replace the EP toxicity characteristic. EPA issued regulations on a new Toxicity Characteristic in 1990, under court order.[39] The TC covers 39 substances, including 25 organic chemicals. On a case-by-case basis, this characteristic effectively removes some wastes from Subtitle D regulation and includes them in the Subtitle C universe. This could affect about 800 million tons of wastewater and 1 to 2 million tons of sludges and solids, except that many of these are managed in units exempt from Subtitle C (see "Waste Generation" above). However, environmental groups believe that the TC inadequately predicts the toxicity of the 39 substances, does not cover enough substances, and does not address exposure pathways such as ingestion and inhalation (e.g., see ref. 76). In contrast, industry groups believe that in some instances the model upon which the TC testis based (i.e., continuous waste input to a municipal landfill) overestimates the risks posed by disposing of many wastestreams.[40] Whether the TC satisfies the HSWA

36Application on a site-specific basis may be considered appropriate by some, depending, for example, on exposure of humans and other species to releases from given sites.

37 56 *Federal Register 50978,* Oct. 9, 1991.

38 56 *Federal Register 50978,* Oct. 9, 1991.

39 55 *Federal Register* 11798, Mar. 29, 1990.

40 A. O'Hare, API, review comments, July 26, 1991.

Table 5-6-Estimated Number and Percentage of Permitted Surface Impoundments and Landfills With Liners or Groundwater Monitoring for Six States

	Surface impoundment						Landfills					
	Liners			Monitoring			Liners			Monitoring		
State	Requirement	Number	Percentage	Requirement	Number	Percentage	Requirement	Number	Percentage	Requirement	Number	Percentage
Alabama	All[a]	500	83	Site specific	30		Site specific	7	9	Site specific	13	16
Ohio	All'	674	50	Certain Categories	674	50	All	b	b	All	10	50d
Pennsylvania	Site specific	109	38c	Site specific	144	50	Site specific	11	10	All	98	90
Tennessee	Site specific	10	11	Site specific		12	Site specific		5	Site specific	33	58
Texas	Site specific	350	50	Site specific	11	20	Certain categories	:	57	Certain categories	2	29
Washington	All	b	b	Allld	d	d	All	b	b	All	d	d

NOTE: Based on data submitted by six States in telephone interviews with the U.S. General Accounting Office.

[a]The liner requirement applies to all units built after the requirement was established. As a result, less than 100 percent of all permitted units have liners.

[b]The State was implementing this control at all units at the time of the phone interviews. As a result, the number of permitted units with liners is not available.

[c]Estimate based on 1980 data.

[d]The State was implementing this control at all units at the time of the phone interviews. As a result, the percentage of units with groundwater monitoring was less than 100, or data were not available.

[e]The groundwater monitoring requirement applied to all units that were built after the equipment was established. As a result, less than 100 percent of all Permitted units have groundwater monitoring.

SOURCE: U.S. Congress, General Accounting Office, *Nonhazardous Waste: Environmental Safeguards for Industrial Facilities Need To Be Developed,* GAO/RCED-90-92 (Washington, DC: April 1990).

mandate is the subject of continuing litigation by the Environmental Defense Fund.[41]

Because the TC will identify additional wastes as hazardous, Subtitle D surface impoundments that continue to accept wastes newly classified as hazardous either must be retrofitted (in most instances by March 29, 1994) to meet certain minimum technological standards under Subtitle C or must cease operation.[42] In effect, EPA expected this to cause many surface impoundments to be closed and many aqueous hazardous wastes to be treated or stored in tanks rather than impoundments.

Third, HSWA (Sec. 3004 of RCRA) restricted the land disposal of hazardous wastes according to prescribed deadlines and required EPA to set levels or methods of treatment for hazardous wastes by each of the deadlines.[43] The treatment standards were to be based on performance of the best demonstrated available treatment (BDAT) to treat the waste.[44] A listed hazardous waste, even if treated to BDAT levels, cannot be disposed of in a Subtitle D facility unless it has been delisted (see derived-from rule in 40 CFR 261.3). Only characteristic hazardous wastes from which the characteristic has been removed may be disposed of at Subtitle D facilities (40 CFR 268.9). However, EPA has not yet issued treatment standards for wastes exhibiting the TC, even though RCRA (Sec. 3004(g)(4)) required the Agency to make a determination on land disposal restrictions and treatment standards for all TC wastes within 6 months of the March 29, 1990 rulemaking.

Fourth, HSWA mandated that EPA determine, in most cases by February 8, 1986, whether or not to list 24 additional wastes as hazardous. The Agency has not made determinations yet for 17 of the wastestreams and, as a result, was sued by the Environmental Defense Fund to comply with the HSWA mandate.[45] The two litigants recently proposed a consent decree that establishes a schedule for making these determinations. (See ch. 1 for more information on the consent decree.) When made, the determinations will likely expand the universe of wastes managed under Subtitle C.

Finally, HSWA directed EPA to review the domestic sewage exemption (see following section).

Clean Water Act

Although surface impoundments themselves are regulated under RCRA, discharges of wastewater from impoundments (or directly from manufacturing processes, for that matter) into surface waters are regulated under the Clean Water Act. This act established the National Pollutant Discharge Elimination System (NPDES), which is implemented primarily by the States. Dischargers must receive a NPDES permit that specifies conditions under which discharges are allowed. (See ch. 2 for additional details.) In general, permit writers base conditions on various Federal and State guidelines, including EPA's effluent limitations guidelines, which themselves are usually based on best available technology economically achievable (BAT). OTA is unaware of aggregate nationwide information on the range of conditions contained in permits for discharges from surface impoundments.

RCRA's Domestic Sewage Exclusion also allows industries to discharge hazardous wastes into sewers

[41] *Environmental Defense Fund* v. *U.S. EPA et al.*, U.S. District Court for D.C., Civ. No. 89-0598. A consent decree proposed in June 1991 addresses many of EDF's claims (see ch. 1), but not the claim that EPA has not adequately met HSWA's mandate to promulgate regulations identifying additional characteristics of hazardous waste; the court has been has been fully briefed on this latter claim and a decision is pending (K. Florini, EDF, personal communication, Oct. 1, 1991).

[42] 55 *Federal* Register 11835, Mar. 29, 1990. HSWA allows hazardous wastes to be stored or treated in surface impoundments that meet certain minimum technological requirements under Subtitle C. For already permitted landfills snd impoundments, owners/operators of new units or extensions of existing units must install two or more liners and a leachate collection system. For interim status facilities, owners/operators must install liners and a leachate collection system or equivalent protection.

[43] 55 *Federal Register 22520,* June 1, 1990. The land disposal restrictions are required unless EPA determines "to a reasonable degree of certainty, tbat there will be no migration of hazardous constituents from the disposal unit. . . for as long as the wastes remain hazardous." The schedule, based on a ranking of listed wastes that considers intrinsic hazard and volume, was designed to ensure that prohibitions and treatment standards are promulgated first for high-volume hazardous wastes with high intrinsic hazards. It required EPA to make these determinations for at least one-third of all listed hazardous wastes by Aug. 8, 1988; at least two-thirds by June 8, 1989; and all remaining listed hazardous wastes and all characteristic hazardous wastes by May 8, 1990.

[44] They could be in t& form of performance standards (e.g., maximum concentration of a constituent allowed in the waste) or specified technologies. In its final rule on land disposal restrictions (51 *Federal Register 40572, Nov. 7, 1986),* EPA promulgated an approach to establishing treatment standards based entirely on technology-based standards expressed as BDAT.

[45] This suit also included the claim mentioned above regarding the adequacy of the TC (*Environmental Defense Fund* v. *U.S. Environmental Protection Agency et al.*, U.S. District Court for D.C., Civ. No. 89-0598).

that lead to publicly owned treatment works (POTWs). The Clean Water Act regulates discharges from POTWs and also established a ''pretreatment' program for industrial discharges into sewers. As a result, some industrial wastewaters are 'pretreated' prior to their discharge into sewers, in accordance with Federal pretreatment regulations and limits developed by local POTWs. However, POTWs generally are not designed to handle metals and certain organic chemicals. Pretreatment programs also had not been widely implemented as of 1987 (81, 92), although EPA has attempted to rectify this situation. In 1990, for example, EPA issued a rule that substantially strengthened legal control over all non-domestic sources.[46] It also required industrial users (with certain exemptions for generators of less than 15 kilograms of hazardous waste per month) to notify the POTW, State, and EPA Region of any discharge into the POTW of a substance which, if otherwise disposed of, would be a hazardous solid waste.[47] In 1989, however, the Natural Resources Defense Council filed suit contesting EPA's failure to promulgate pretreatment and effluent standards in a timely fashion, and the results of this suit are still pending.[48]

Neither NPDES nor the pretreatment program directly addresses groundwater. Most Subtitle D surface impoundments and landfills were unlined as of the mid- 1980s, and contamination of groundwater has been documented (see "Frequency-of Pollution Controls" above).

Clean Air Act

The Clean Air Act Amendments of 1990 require EPA to propose standards for emissions from incineration units handling commercial or manufacturing waste, within 3 years of enactment. Primary or secondary smelters that combust waste materials for the purpose of recovering metals are not included among these units.

ISSUES/QUESTIONS

Development of a Federal Subtitle D regulatory program for manufacturing wastes is generally further behind than similar programs for exempted special wastes. EPA believes it is necessary to understand Subtitle D manufacturing wastes in greater detail and to assess their relative risks before developing new regulatory efforts. However, many groups have expressed interest in an interim program for Subtitle D manufacturing wastes, to help bridge the gap until (and if) a final Subtitle D program is developed.[49] Under the auspices of The Keystone Center, representatives of these diverse interests have been meeting to develop consensus agreements on requirements for an interim program that would be as self-implementing as possible.[50] The group is attempting to reach agreements on notification of manufacturing solid waste activity; waste characterization, minimization, and tracking; site characterization and environmental assessments; release notification and corrective action; closure; State implementation of legal authority for interim measures; and funding for State enforcement of such measures. EPA is participating in the discussions, but the Agency is concerned that it might not have sufficient information or resources to define or implement some of these interim requirements.[51] Thus the Agency questions whether such a program should be mandated at this time.

Some issues and questions related to manufacturing waste management that Congress might address include, but are not necessarily limited to, the following:

- **Relationships Among Federal and State Agencies-what degree** of primacy does Congress wish States to have in managing Subtitle D manufacturing wastes? Should EPA develop a State-implemented regulatory program with Federal oversight and enforcement or should it

[46] 55 Federal Register 30105, July 24, 1990.

[47] This is a one-time notification requirement, as long as the discharge does not change substantially.

[48] The NRDC sued EPA in 1989 for failure ''to promulgate a comprehensive set of effluent standards and systematically to revise and strengthen its existing standards' under the Clean Water Act and for failure "to promulgate the pretreatment standards called for by the Domestic Sewage Study" under RCRA (*Natural Resources Defense Council, Inc., et al., v. U.S. Environmental Protection Agency*, U.S. District Court for the District of Columbia, Civ. No. 89-2980 (RCL)).

[49] This would b, similar in a sense t. the interim program developed for hazardous wastes after RCRA was passed in 1976.

[50] T. Mealey, The Keystone Center, review comments, Aug. 8, 1991. Represented interests include a variety of industry sectors (e.g., chemical, petroleum, pulp and paper, commercial waste management), State and Federal regulatory agency representatives, national environmental groups, and congressional staff.

[51] U.S. EPA, review comments, Aug. 22, 1991.

restrict its role to developing voluntary guidelines and providing technical and financial support for individual State programs? Does EPA need additional oversight and enforcement authority under RCRA to support effective State programs? In addition, should relationships between RCRA and the Clean Water Act—which, for example, regulate different aspects of surface impoundments-be better clarified and coordinated?

- Interim Regulatory Program-Should EPA be directed to establish interim requirements for Subtitle D manufacturing wastes or to gather additional information before developing any program?
- Pollution Prevention/Waste Reduction—Should EPA's pollution prevention program, which focuses primarily on reducing the generation of hazardous wastes, include more efforts to address the generation of non-hazardous manufacturing wastes and to reduce the use of toxics in general? Should non-hazardous manufacturing wastes destined for land-based disposal be subject to treatment regulations (e.g., similar to BDAT for hazardous wastes) to encourage pollution prevention? Should additional chemicals or even wastestreams be included in the TRI? Should the Domestic Sewage Exemption be continued?
- Recycling-Should facilities that recycle hazardous residuals from manufacturing processes, and the residuals themselves, be regulated under Subtitle C or Subtitle D, exempted, or otherwise regulated? How should recycling of non-hazardous wastes be regulated?
- Adequacy of Existing Toxicity Tests-Is the TC an appropriate means of determining the potential for long-term migration of the full spectrum of contaminants of concern from waste management facilities? Should additional characteristics be promulgated to ensure that Subtitle D wastes are of less concern than Subtitle C wastes? If so, what characteristics?
- Resources for Administration and Enforcement of Programs-Are resources sufficient to administer and enforce Federal and State manufacturing waste regulatory programs? If not, what mechanisms are available to provide such resources? What emphasis should be given to enforcement of these programs relative to other Subtitle D programs and, in turn, relative to other environmental protection programs? Should independent audits be conducted to assess how effectively various Federal and State regulations are being enforced?

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Appendixes

Appendix A
Acronyms

AMC —American Mining Congress
API —American Petroleum Institute
BAT —best available technology economically achievable
BDAT —best demonstrated available technology
BLM —Bureau of Land Management
BOM —Bureau of Mines
BPT —best practicable control technology currently available
CERCLA-Comprehensive Environmental Response, Compensation, and Liability Act
CESQG -Conditionally Exempt Small Quantity Generator
CFR --Code of Federal Regulations
CMA -Chemical Manufacturers Association
CWA -Clean Water Act
DOI —U.S. Department of the Interior
E&B -extraction and beneficiation
E&P -exploration and production
EDF —Environmental Defense Fund
EOR -enhanced oil recovery
EP —Extraction Procedure
EPA —U.S. Environmental Protection Agency
EPRI —Electric Power Research Institute
F&WS —U.S. Fish and Wildlife Service
FGD —flue gas desulfurization
FLPMA —Federal Land Policy and Management Act
GAO -General Accounting Office
HSWA —Hazardous and Solid Waste Amendments
IMCC —Interstate Mining Compact Commission
IOGCC —Interstate Oil and Gas Compact Commission
MSW —municipal solid waste
NAAQS —National Ambient Air Quality Standards
NEPA —National Environmental Policy Act
NESHAP —National Emission Standard for Hazardous Air Pollutants
NORM —naturally occurring radioactive material
NPDES —National Pollutant Discharge Elimination System
NPL —National Priorities List
NRDC —Natural Resources Defense Council
OSHA -Occupational Safety and Health Administration
OWEP -oily waste extraction procedure
PCB —polychlorinated biphenyl
POTW —publicly owned treatment work
RCRA —Resource Conservation and Recovery Act
SARA —Superfund Amendments and Reauthorization Act
SDWA —Safe Drinking Water Act
SIC —Standard Industrial Classification
SMCRA -Surface Mining Control and Reclamation Act
SP -Synthetic Precipitation
TC —Toxicity Characteristic
TRI —Toxics Release Inventory
TSCA —Toxic Substances Control Act
UIC —Underground Injection Control
USDA —U.S. Department of Agriculture
USWAG —Utility Solid Waste Activities Group
VOCc —volatile organic compound
WGA —Western Governors' Association

Appendix B
Federal Statutes and Public Law (P.L.) Numbers

Asbestos Hazard Emergency Response Act-P.L. 99-519
Clean Air Act-P.L. 95-95
Clean Air Act Amendment-P.L. 101-549
Clean Water Act-P.L. 95-217
Comprehensive Environmental Response, Compensation and Liability Act-P.L. 96-510
Endangered Species Act-P.L. 93-205
Federal Advisory Committee Act—P.L. 92-463
Federal Insecticide, Fungicide, and Rodenticide Act—P.L. 92-516
Federal Land Policy and Management Act-P.L. 94-579
Federal Oil and Gas Royalty Management Act—P.L. 97-451
Forest and Rangeland Renewable Resources Planning Act—P.L. 93-378
Hazardous and Solid Waste Amendments-P.L. 98-616
Historic Sites, Buildings and Antiquities Act—Ch. 593, 49 Stat. 666
Medical Waste Tracking Act—P.L. 100-582
Migratory Bird Treaty Act-P.L. 86-732
Mine Safety and Health Act-P.L. 95-164
Mining Law of 1872
National Environmental Policy Act-P.L. 91-190
National Forest Management Act-P.L. 94-588
National Park System Mining Activity Act—P.L. 94-429
Occupational Safety and Health Act-P.L. 91-596
Pollution Prevention Act-P.L. 101-508
Resource Conservation and Recovery Act-P.L. 94-580
Resource Recovery Act-P.L. 91-512
Safe Drinking Water Act—P.L. 93-523
Solid Waste Disposal Act-P.L. 89-272
Solid Waste Disposal Act Amendments-P.L. 96-482
Superfund Amendments and Reauthorization Act—P.L. 99499
Surface Mining Control and Reclamation Act-P.L. 95-87
Toxic Substances Control Act—P.L. 94-469
Uranium Mill Tailings Radiation Control Act of 1978—P.L. 95-604

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