Chapter 2

Mining Wastes

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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

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[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 mineral 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 (*EnvironmentaZDefenseFund 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 ferochromiumsilicon 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).

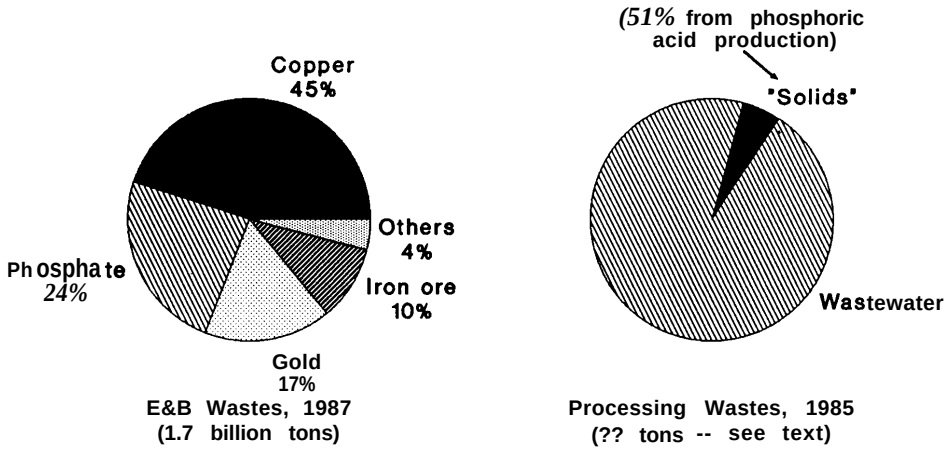
The U.S. Bureau of Mines (BOM) also collects data on waste rock, crude ore, and marketable products; the difference between crude ore and products provides a rough estimate of the amount of tailings. The Office of Technology Assessment (OTA) used BOM data to estimate that the nonuranium mining industry 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-l—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 t. 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 to 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

[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 million 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 (μg/L) as a 24-hour average, with concentrations not to exceed 52 μg/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 thathe 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]

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[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

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[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

[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 gas ification; 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

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[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, r$_{ev}$i$_{ew\ cemen}$ts, 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] *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.

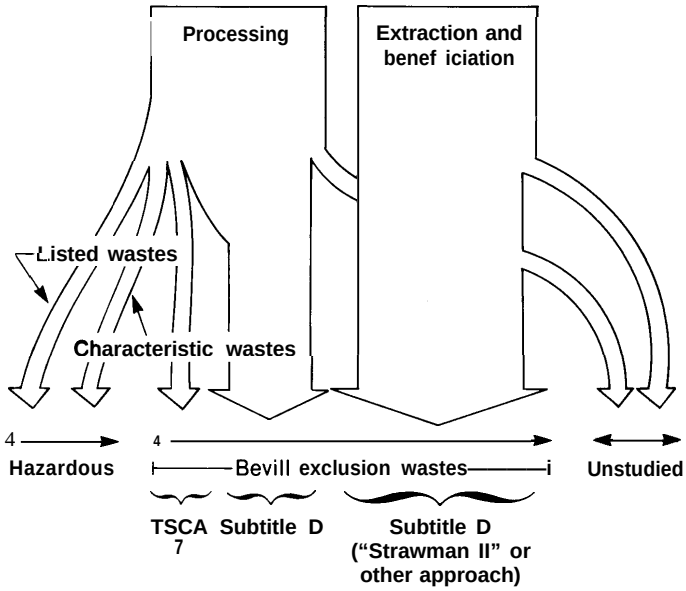
Current RCRA Status of Extraction and Beneficiation Wastes

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

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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;
o 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 approaches 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 reming 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?