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BASIC HAZARDOUS WASTE MANAGEMENT

Third Edition

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law — the Resource Conservation and Recovery Act (RCRA) as amended. Such an overview must also include an introduction to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or "Superfund" as it pertains to site remediation and other environmental, occupational health and safety, and hazardous materials transportation statutes.

In reality, it is difficult to separate "generic" hazardous waste management practice from RCRA requirements since the structure and format of this very comprehensive and complex law so completely define the practice in the U.S. and territories. Nevertheless, we will attempt to begin each chapter with a description of the subject or activity, followed by a summary of accepted practice, and conclude with the application of RCRA, CERCLA, and the other related statutes and regulations.

The first chapter provides some historical background, some of it anecdotal, to portray the kinds of events, reactions, policies, and outcomes that helped to shape the original RCRA, the amendments that have followed, and the practice of hazardous waste management.

Dawning of the Problem

Among students of environmental management in the U.S., it is generally postulated that the beginnings of the nation's effort to gain control of hazardous wastes began with (1) the Love Canal episode and (2) the discovery that the circle of environmental laws (Clean Water Act [CWA], Clean Air Act [CAA], Toxic Substances Control Act [TSCA], Safe Drinking Water Act [SDWA]), enacted since the beginning of the "Environmental Decade" (1970–1980), required closure by the enactment of a hazardous waste control measure.

Love Canal, a water conveyance originally excavated for a hydroelectric project in Niagara Falls, New York, was used by Hooker Chemical Company as a dump site for nearly 22,000 tons of waste chemicals. Hooker closed and capped the site in 1952, and in 1953 the City of Niagara Falls pressured Hooker to sell the canal land, to the city, for a school site. Hooker filed disclaimers, citing the possible dangers of building over the landfill, but the school board and the city were determined to have the site. After threats of an eminent domain proceeding, Hooker sold the land to the city for $1.[1]

The site was developed and a school and homes were built thereon. In 1978, the site was declared to be a public environmental emergency because hazardous wastes were seeping into the basements of the houses. Nearly 900 families were evacuated. After years of legal wrangling, Occidental Petroleum Corporation, the parent company of Hooker, recently agreed to pay $98 million to the state of New York to cover some of the cleanup costs and will assume responsibility for monitoring the remaining cleanup operations. In 1994, a federal court rejected the state's claim for $250 million in punitive damages against Occidental, but the company faced additional lawsuits by the federal government, the City of Niagara Falls, and hundreds of former residents who contended that their health problems resulted from toxic materials in the area. A recently signed consent decree filed with the U.S. District Court for Western New York (*U.S. v. Occidental Chemical Corp,* W.D.N.Y., No. 79-987C, 7/19/99) supposedly ends all pending federal litigation related to the site. A few families are moving back into their homes or into the area.

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[1] For a more detailed account of the Love Canal episode, *see:* Wentz (1989), p. 306ff.

It is correct that the Love Canal horror galvanized public opinion and stimulated much regulatory activity by governments (federal, state, and local). However, hazardous waste horror stories were emerging before Love Canal became a household word, and the frequency and intensity increased on a near-daily basis. Following the Love Canal disclosures, the U.S. Environmental Protection Agency (EPA) and others mounted studies which determined that more that 750,000 generators had deposited almost 60 million tons of hazardous waste in as many as 50,000 sites. (Even these seemingly shocking numbers did not adequately describe the problem.) At that time (1977), the EPA estimated that only 10% of the waste had been disposed of in an environmentally safe manner (Worobec 1986, p. 12) (Figures 1.1 through 1.3).

Early Hazardous Waste Management

Other episodes shocked the nation and brought forth new and intensified efforts to gain control of the problem. In discussing a few of them here, we refer to them as past practices, realizing full well that similar situations and practices can and do continue to this time (Figure 1.4).



FIGURE 1.1 Abandoned hazardous waste site. (Courtesy of Envirosafe Services of Ohio, Inc. (ESOI).)



FIGURE 1.2 Abandoned hazardous waste site. (Courtesy of Envirosafe Services of Ohio, Inc. (ESOI).)

The ABM-Wade Site. The ABM-Wade site in Chester, Pennsylvania, was typical of dozens of sites throughout the industrialized areas of the nation. During the mid-1970s the operator accepted hazardous wastes; filled the former factory building and pipe tunnels with drums of hazardous waste; filled discarded tank trailers with hazardous waste and parked them on the site; and when aboveground space was filled, underground storage tanks and trenches were filled with wastes.



FIGURE 1.3 Land disposal of hazardous waste. (Courtesy of MAX Environmental Inc., Pittsburgh, VA.)



FIGURE 1.4 Hazardous waste dump site. (From the Arizona Department of Arizona Environmental Quality.)

In February 1978, the site burned. Nearby residents were endangered by clouds of toxic air pollutants, by the proximate natural gas storage tanks, and by contaminated run-off to the Delaware River (Figures 1.5 through 1.9). The site was remediated by a 10-year, $3 million Superfund project (see Chapter 11).

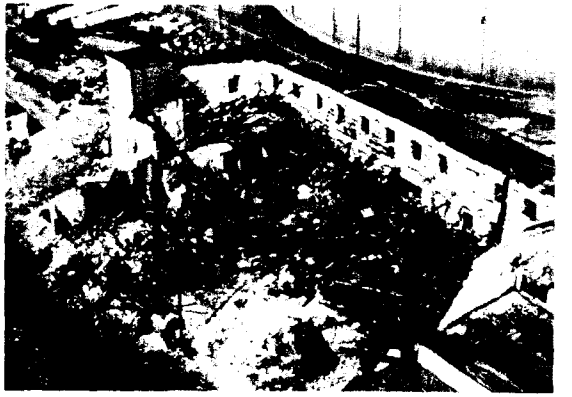


FIGURE 1.5 ABM-Wade site (Chester, Pennsylvania). (From the U.S. Environmental Protection Agency.)



FIGURE 1.6 ABM-Wade site (Chester, Pennsylvania). (From the U.S. Environmental Protection Agency.)



FIGURE 1.7 ABM-Wade site (Chester, Pennsylvania). (From the U.S. Environmental Protection Agency.)

The Hardeman County Landfill. In Hardeman County, Tennessee, 40 families near a rural landfill drank from wells polluted with such pesticides as endrin, dieldrin, aldrin, and heptachlor. The Velsicol Chemical Company had used a neighboring 300-acre site from 1964 to 1972 for shallow burial of 300,000 55-gal drums of pesticide production residues. Residents complained of a wide variety of ailments including liver and urinary tract problems, dizziness, nausea, and rashes (Council on Environmental Quality 1979, p. 179).

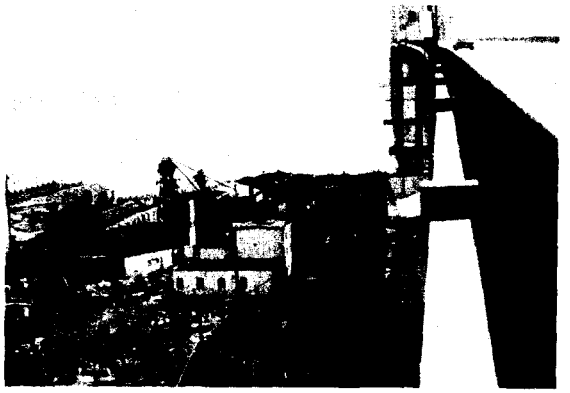


FIGURE 1.8 ABM-Wade site (Chester, Pennsylvania). (From the U.S. Environmental Protection Agency.)

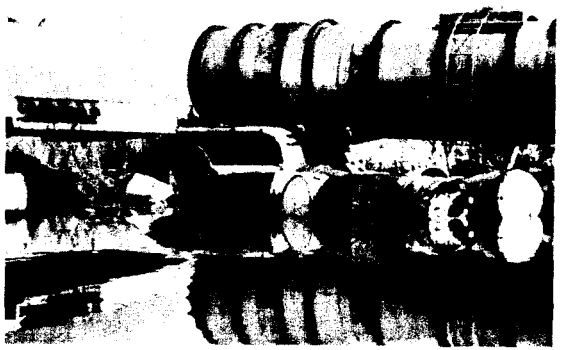


FIGURE 1.9 ABM-Wade site (Chester, Pennsylvania). (From the U.S. Environmental Protection Agency.)

The LaBounty Dump. Salsbury Laboratories, a major manufacturer of veterinary pharmaceuticals, is located in the small northern Iowa community of Charles City. From 1953 until December 1977, Salsbury disposed of 6.4 million cubic feet of arsenical sludge and organic chemical wastes in the LaBounty Dump along the Cedar River (Figure 1.10). The Cedar River flows southeasterly through much of the state (Figure 1.11). Wells in the river alluvium supply domestic water to more than 300,000 users along its course. The Iowa Department of Environmental Quality (DEQ) discovered that pollutants (arsenic and a variety of organic chemicals) had



FIGURE 1.10 LaBounty dump site (Salsbury Laboratories, Charles City, Iowa). (From the U.S. Environmental Protection Agency.)

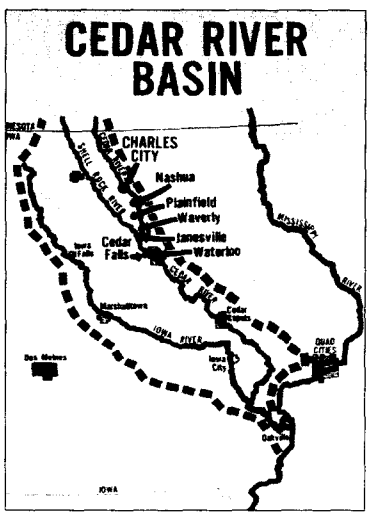


FIGURE 1.11 Cedar River basin downstream of LaBounty (Iowa) dump site. (From the U.S. Environmental Protection Agency.)

leached from the dump to the underlying groundwater and to the Cedar River. The Iowa DEQ issued an executive order requiring Salsbury to remove all hazardous wastes and contaminated materials from the LaBounty site, but Salsbury convinced the courts that the cleanup costs would exceed the company's net worth, and the removal order was stayed (Dahl 1980).



FIGURE 1.12 "Treatment" pond, Union Carbide (Uravan, Colorado). (From the U.S. Environmental Protection Agency.)

Union Carbide — Uravan. In the early 1950s, the Union Carbide Corporation began uranium mining and milling operations on the banks of the San Miguel River at Uravan, Colorado. During the years of operation, the mill produced more than 10 million tons of uranium-vanadium ore, in excess of 10 million tons of tailings, millions of gallons of waste liquid raffinate, raffinate crystal residue, and other milling wastes containing radioactive materials (uranium, radium, and thorium), metals (selenium, aluminum, arsenic, cadmium, zinc, and others), and other inorganic contaminants. Mining, milling, and waste disposal practices have resulted in:

- Wind and surface water dispersal of the tailings materials and the uncontrolled release of radon from the tailings piles
- Seepage of contaminated liquids into soils and groundwater from several areas in the mill complex and waste disposal areas
- Concentrations of large quantities of wastes in locations that pose a risk to public health and the environment

Prior to remediation, soils in the vicinity of the mill contained elevated levels of heavy metals and radionuclides. The San Miguel River, a tributary to the Dolores River, the Colorado River, and Lake Powell, was contaminated with radium 226. For nearly two decades, process wastewaters were discharged to seepage ponds scooped in the alluvium of the San Miguel (Figure 1.12). Contaminated groundwater from the tailings area emerged from the walls of the San Miguel Canyon (Figure 1.13) and continued subsurface movement toward the river.

The site was listed on the National Priorities List (NPL)[2] in 1986, but the massive cleanup was conducted under a consent decree in the U.S. District Court for the

[2] *See:* National Priorities List in Glossary.

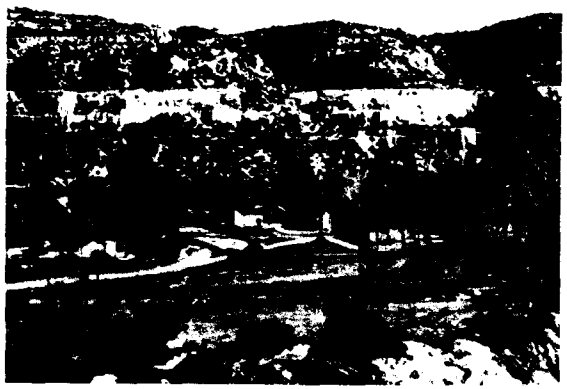


FIGURE 1.13 San Miguel River Canyon — emergent seepage from tailings ponds, Union Carbide (Uravan, Colorado). (From the U.S. Environmental Protection Agency.)

District of Colorado (State of Colorado v. Union Carbide Corporation and Umetco Minerals Corporation, 1983).

The Kepone Disaster. In 1973, Allied Chemical Company subcontracted the production of the pesticide Kepone to Life Sciences Products, a small company operating out of a converted service station in Hopewell, Virginia, near the James River. Within 2 months following startup, discharges from the plant had killed the aerobes in the Hopewell sewage treatment system. Life Sciences employees were poisoned by Kepone; the site was hopelessly contaminated; fish, shellfish, waterfowl, and a variety of aquatic organisms from the James River and Chesapeake Bay demonstrated classic bioaccumulation of Kepone; Kepone-contaminated sediments accumulated in the James River and Chesapeake Bay; and particulates from air samplers near the plant were found to contain as high as 40% Kepone. Life Sciences was unable to pay for the cleanup, and Allied settled with the court by donating $8 million to establish the Virginia Environmental Endowment. Allied then recouped much of the settlement by taking a tax deduction on the endowment (Wentz 1989, pp. 59–68).

Reilley Tar & Chemical Corporation. The site in St. Louis Park, Minnesota, was the location of the Republic Creosote Company from 1917 until 1972. Reilley Tar & Chemical Corporation operated the facility after 1972. Extensive soil and groundwater contamination has resulted from discharge of contaminated wastewater over land to wetlands adjacent to Minnehaha Creek. Polynuclear aromatic hydrocarbon (PNA) contamination of the Prairie du Chien-Jordan Aquifer has forced closing of seven municipal water supply wells (Beckwith 1990, personal communication). Investigative and cleanup activity has continued for nearly two decades and has included cleanout of two contaminated water supply wells *which had been used for waste disposal*, several pumping wells for removal of contaminants and containment of the contaminant plume, and two granular activated carbon treatment plants. By 1996 an estimated 6.2 billion gallons of groundwater contaminated with PNAs had been pumped and treated. An additional pumping well was constructed in 1997 (EPA ID#MND980609804).

Minamata Bay. As Americans began learning hard lessons from hazardous waste disposal practices and began looking to ocean disposal as an easy solution, the Japanese began learning hard lessons from that very practice. During the period 1932 to 1968, an acetaldehyde production facility discharged mercury-laden wastes to a river which flowed to nearby Minamata Bay. The mercury was converted to the methyl form, in the bottom sediments, and became concentrated in marine organisms, including fish and shellfish. Among nearby villagers, for whom the fish and shellfish were a diet staple, at least 46 died and an estimated 3000 were poisoned. Japanese courts continued to struggle with liability rulings throughout most of the 1990s. In 1997, Governor Joji Fukushima of the state of Kumamoto declared the bay clean and stated that mercury levels were lower than those permitted by government safety standards (Dawson and Mercer 1986, p. 422; *Los Angeles Times*, November 27, 1993; Nebel and Wright 1993, p. 316; *The Associated Press*, July 29, 1997).

Dioxin Discovered. In Italy, near Seveso, Industrie Chemiche Meda Societa Aromia (ICMSA) operated a plant producing 2,4,5-trichlorophenol. A production unit was allowed to overheat and released 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) or "dioxin." A small quantity of this highly toxic material was released to the atmosphere and drifted southward toward Milan. This necessitated the evacuation of residents, slaughter of livestock, and condemnation of fruit and vegetable crops. Exposed children developed chloracne and adults were sickened (Wentz 1989, p. 7ff). After 7 years of cleanup activity, the dioxin waste was concentrated into 41 drums. This deadly concentrate passed through the hands of several handlers and was hauled from one end of France to the other, through Paris, and ultimately to a barn in Anquilcourt-le-Sart. Throughout this odyssey the drums were identified only as containing tar (Lesser 1984).

The Stringfellow Acid Pits. From 1956 until 1972, the 17-acre site in a Riverside County, California ravine, known as the Stringfellow Acid Pits, was operated as a state-authorized hazardous waste disposal facility. Evaporation ponds received over 34 million gallons of metal finishing, electroplating, and pesticide production wastes. In 1969, run-off from rainfall caused the ponds to overflow and contaminate a downstream creek. Heavy rains in 1978 threatened another overflow, and 800,000 gal of wastewater were released from the site, in order to prevent further overflow and possible massive release of the ponds contents. Another 500,000 gal were transferred to a federally approved facility. Between 1975 and 1980, approximately 6.3 million gallons of liquid wastes and pesticide contaminated materials were removed from the site. A groundwater plume containing volatile organic compounds and heavy metals threatened private water supply wells in the community of Glen Avon, forcing users to change to public water supplies. A long and costly Superfund cleanup followed, and additional work may be required (EPA ID#080012826).

After 15 years of litigation, an agreement in principle was reached in January 1999 to settle liability at the Stringfellow site. Total cleanup costs are now estimated at $800 million, of which California's share is estimated at $200 million. A California

Environmental Protection Agency official estimated that remediation will take 100 years (*Environment Reporter*, January 15, 1999, p. 1797).

The list could be extended for many pages, with familiar and obscure names such as Times Beach, Missouri, the "Valley of the Drums," USAF Plant Forty-Four (at Tucson International Airport), etc. Indeed the NPL now contains 1217 such sites, another 57 sites have been formally proposed for listing, and 205 sites have been cleaned under Superfund program auspices. Many other sites have been cleaned up under other federal and state regulatory programs and/or without regulatory oversight. Although these brief summaries seem similar to each other, the sites differ greatly in size, on-site activities, complexity, range of remedial options, resources, and time required to accomplish remediation, and extent to which remediation can be achieved. These regulatory actions will be introduced in Chapter 11.

"Take It Out Back and Dump It"

In 1950, before North Korea interrupted my academic endeavors, I took a part-time job at a local dry cleaning establishment. As the owner finished demonstrating how I was to clean the filters, I asked what to do with the filter sludge. His response was "take it out back and dump it." The dump site was easily recognized and frequently used. Later, after some enlightenment regarding such practices, the memory of that scenario returned to haunt me repeatedly. Thirty-five years later, the discovery that a dry cleaner in Phoenix, Arizona, took his used Perc out back and dumped it down a dry well was sad irony indeed. What we did in 1950 was assignable to ignorance. The 1985 episode tells us something about our progress in hazardous waste management and in educating the public regarding hazardous waste management (Author).

Disposal of hazardous waste has been accomplished in every mode of behavior — careful and careless, casual and furtive, clever and mindless, etc. The simple "take it out back and dump it" practice was commonplace. As case histories of contaminated sites continue to be developed, the practice of dumping solvents and other liquid wastes onto the ground, into ditches, (incredibly) into drainage wells, into seepage pits, and into trash dumps is often found to have been the mechanism or practice involved.

"Midnight dumping" became a familiar term, as disposers sought to find ways to "get rid of the stuff." The 55-gal drum rolled into the roadside ditch or onto unwatched property became a commonplace environmental insult. Disposers contrived dump and tank trucks with discharge devices arranged to discharge the cargo of hazardous wastes while in motion. Such "tippers," as they were known in Britain, drove along country roads and dumped the contents of the tanks by tipping them to a high angle. The intent was, of course, to distribute the wastes over a great area and to do so without being detected.

Workers in manufacturing facilities where environmental rules were being enforced discovered drums or other containers of unknown wastes that suddenly

appeared on loading docks or elsewhere in the plants. These sudden appearances were referred to as "immaculate conception" events, but created serious hazards and disposal problems. "In-house" incidents of this nature demonstrated the fact that ignorance as well as unsavory and irresponsible attitudes toward hazardous waste management were present among rank-and-file workers, as well as corporate cost-center managers.

Even more reckless schemes were not uncommon. A favorite among criminal elements was the theft of a semitrailer (or tractor and trailer), acceptance of a load of hazardous wastes in drums (for a fee, of course), and abandonment of the stolen truck with load intact. Others carelessly or unknowingly discharged loads of waste into dumps or pits containing incompatible wastes and were overcome or killed on the spot or subjected others to similar fates.

As indicated previously, these examples of earlier activity should not lead to the assumption that such practices have been eliminated. Hazardous waste statutes, codes, and regulations have made it difficult for practitioners of illegal dumping to avoid detection and prosecution. Nevertheless, attempts to avoid the effort and/or cost of proper hazardous waste management continue to be made. A case in point is the recent prosecution and sentencing of two Florida entrepreneurs who attempted to hire an undercover police officer to dump drums of hazardous waste in the Everglades (U.S. v. Rojas, S.D. Florida, No. 98-579, 1999).

"Treatment" and Other Assorted Techniques

Very large volumes of liquid hazardous wastes were provided "treatment" and/or disposal in depressions, impoundments, and excavations which EPA referred to as "pits, ponds and lagoons" or PPLs (Figure 1.14). The expression referred to unlined holding and flow-through facilities that provided no protection against seepage and contamination of groundwater. Most provided no treatment other than settling of



FIGURE 1.14 Surface impoundment. (From the U.S. Environmental Protection Agency.)

solids, radiation from the sun, and some modicum of aeration. Very large numbers of today's remedial sites are former PPLs.

Solid hazardous wastes, wastes that should have been recognized as "hazardous," and wastes of unknown composition were allowed to accumulate in piles and later were

- Awarded legitimacy as treatment units (see Subparts L of 40 CFR 264 and 265)
- Excluded from definition as hazardous wastes because of their "high volume-low toxicity" character (40 CFR 261.43)
- Declared to be materials that were "awaiting recycling"

Many of these waste piles also became today's remediation sites, and some were recycled in a process known as "dump leaching."[3] Great strides were realized in extraction processes during recent years and previously worked ores became lucrative targets for further working. In practice, waste piles containing metals or other values were sprayed with weak acid or other solute-producing liquid, and the leachate was collected for extraction. Without underlining or removal to an impervious surface for leaching, much of the leachate was lost to the groundwater or resurfaced with base-flow of nearby streams. The emerging metals-laden acidic leachate mixed with the natural alkalinity of receiving streams, resulting in precipitation of metallic salts and/or hydroxides. The precipitate, known by practitioners as "Yellow Boy," can destroy a stream by blanketing the streambed as illustrated in Figures 1.15 and 1.16. A related practice, known as "heap leaching,"[4] is used to extract precious metals from low-grade ores. Heap leaching practitioners claim that liners or impervious layers used to capture the valuable leachate also prevent surface or groundwater contamination. Even today, these leaching processes are commonly used in copper mining areas of the southwestern U.S. The strong metals extraction lobby has been highly successful in obtaining exclusions from various of the hazardous waste compliance requirements.[3]

Early and mid-1900s industrial waste generators also enjoyed the option of discharge of hazardous wastes to publicly owned sewerage. Prior to imposition of the National Pollutant Discharge Elimination System (NPDES) permitting, it made little difference whether industrial wastes were discharged directly into surface waters or reached the discharge point via municipal sewerage. As publicly owned, secondary sewage treatment plants came online, it soon became evident that untreated industrial wastes "... can have serious impacts on the ability of systems to operate properly, on options for sludge disposal, and on water quality" (Council on Environmental Quality 1977, p. 37).

Not only were industrial wastes passing through publicly owned treatment works (POTWs) with ineffective or inadequate treatment, the toxic constituents in the industrial wastes were deleterious to the biota in the secondary treatment systems. Moreover, "municipal" sludge from the POTWs receiving industrial waste contained

[3] *See:* Bevill Amendment in Glossary.
[4] *See:* Dump Leaching and Heap Leaching in Glossary.



FIGURE 1.15 Surface stream ruined by inflow from heap leaching operation.



FIGURE 1.16 "Yellow-Boy" blanket on streambed ruined by heap leaching operation.

high concentrations of heavy metals, making digested sludge unsuitable for land disposal or recycling.

The 1972 Federal Water Pollution Control Act Amendments[5] and the 1977 amendments[6] required that EPA establish national standards for "pretreatment of industrial wastes that are not compatible with municipal treatment plants." EPA had, in February 1977, reissued proposed national pretreatment guidelines (42 FR 5986) and in 1978 began adopting pretreatment standards (43 FR 27736). However, major delays in implementation of pretreatment programs, as well as "loopholes" in the RCRA regulations, allowed the continued discharge of some hazardous industrial waste components to POTWs. Pretreatment needs received much-needed emphasis when, in 1981, a 3-mile segment of the Lexington, Kentucky, sewer system exploded. The explosion, caused by excessive discharges of hexane, caused more than $20 million in damages (EPA 1999b).

EPA and some state agencies have recently strengthened enforcement of pretreatment rules, and EPA has proposed "streamlining" the 40 CFR Part 403 regulations. Industries discharging to municipal systems, as well as the entities responsible for implementing pretreatment programs, are the subject of enforcement actions. A case in point is the recent guilty plea of MRS Plating Inc. of Lockport, New York, and its manager Ron Jagielo, to felony violations of Clean Water Act pretreatment requirements (Title 33, USC Section 1319[c]). The company was alleged to have discharged hazardous waste into the Lockport, New York, sewer system on numerous occasions in 1997. MRS Plating was fined $120,000 and Mr. Jagielo is subject to a 1- to 2-year prison sentence (*Environment and Natural Resources News*, June 1999).

Numbers and Impacts

Uncontrolled releases of hazardous wastes to the environment continued through the 1970s. EPA estimated hazardous waste generation at 20 to 50 million tons annually in 1977, adding the estimate that no more than 10% was disposed of in a manner that was safe to the environment (Council on Environmental Quality, 1977, p. 50). Dams and dikes forming hazardous waste impoundments routinely failed, contaminating streams, rendering water supplies useless, and killing fish. Regulatory gaps and inadequacies continued to provide options for release of hazardous wastes to the air, water, or land. Early remediation of sites having groundwater contaminated with volatile organics frequently involved pumping the contaminated groundwater to the surface and air-stripping the contaminant, without further treatment or capture, to the atmosphere (*see also*: Dawson and Mercer 1986, pp. 3–4).

As was the case with the Love Canal exposures, the Hardeman County contamination of domestic water supplies, and the Minimata Bay fish and shellfish contamination, mismanagement of hazardous waste was clearly exacting a price in human health. The mechanisms were not well understood (and some continue to be so), but there could be no doubt of the connection between exposure and disease

[5] 33 USC § 1311(b)(1).

[6] The Clean Water Act, 33 USC § 1314(g)(1).

incidence. Increased incidence of carcinogenic, mutagenic, and teratogenic effects, damage to reproductive systems, respiratory effects, brain and nervous system effects, and many lesser effects were increasingly associated with direct and indirect exposure to hazardous wastes (*see also*: Enger et al. 1989, Chapter 15).

Environmental effects were even more pronounced and frequently better understood. Release by a major chemical manufacturing company of more than 4000 metric tons of DDT[7] manufacturing residue to a marsh near Triana, Alabama, resulted in DDT contamination of Indian Creek and the catfish from the creek. Mallard ducks from a nearby wildlife refuge were found to contain 480 parts per million (ppm) DDT. Entire populations of waterfowl disappeared from the area. Similar environmental tragedies were related to hazardous waste mismanagement throughout the nation and world.

The esthetic effects of hazardous waste mismanagement through the mid-1900s are well understood by most citizens. The rise of the NIMBY (not in my backyard) syndrome exemplifies the fear and revulsion of the public toward hazardous materials[8] in general, and hazardous wastes[8] in particular. The esthetic concerns quickly transition to economic issues as property values are affected, jobs are created or eliminated, and public administrators come under increasing pressures to craft solutions that solve all problems and resolve all issues. Facility siting became a major preoccupation among governments, the regulated industries and facilities, and the public. By the 1980s, public opposition to hazardous waste facilities had become so pervasive and intense that even sites with excellent operating records faced closure, simply because they were "there." Environmental equity issues, usually arising from actual or proposed location of hazardous materials/waste facilities in poor or minority neighborhoods, came to the forefront of the urban agenda in the 1990s. By the late 1990s, the equity issues had become focused in an identified EPA Environmental Justice program.

The economics of hazardous waste management and mismanagement have intruded upon nearly every facet of life in America. From the relatively minor costs of the local dry cleaner's shift from dumping to recycling to the projected $230 billion for cleanup of the nation's nuclear weapons facilities, management of currently generated and earlier mismanaged hazardous waste has become a major element of the economy.

By 1979, the EPA estimate of hazardous *waste* generation was 51 million tons per year (Council on Environmental Quality, 1979, p. 181). Estimates by the chemical industry and various federal agencies in subsequent years (Table 1.1) indicate that generation of hazardous wastes continued in the 200 to 300 million ton range. In more recent years, the EPA has established two inventories that include data on hazardous waste quantities managed in the U.S. The National Biennial RCRA

[7] DDT (dichlorodiphenyltrichloroethane) is a highly persistent insecticide that was banned for use in the U.S. in 1972.

[8] As is developed in later chapters, the distinction between hazardous *materials* and hazardous *waste* is derived largely from (1) lists of each that are published by various agencies and (2) whether a material is used or unused (virgin). However, much of the lay public generally perceives no distinction between the two.

TABLE 1.1
Estimated Quantities of Hazardous Waste Generated in the U.S.

Source	Million Tons	Comment
1981 EPA National Survey	247 (135–402)[a]	Sample survey
1981 Office of Technology Assessment (OTA)	255–275[a]	State data
1983 Congressional Budget Office (CBO)	266 (223–308)[a]	Industry data
1984 Chemical Manufacturers Association (CMA)	247	Chemical industry survey
1985 EPA National Survey	272	Census of treatment, storage, and disposal facilities
1986 CMA	220.5	Chemical industry survey
1989 EPA	198	EPA 530-S-94-039
1991 EPA	306[b]	EPA 530-S-94-039
1993 EPA	258[b]	EPA 530-S-97-022
1995 EPA	214[b]	EPA 530-S-97-022
1997 EPA	40.7[c]	EPA 530-S-99-036

[a] Range.
[b] EPA attributes this increase to newly regulated wastes.
[c] Not a directly comparable number. EPA excluded wastewaters in the 1997 inventory.

Hazardous Waste Report[9] and the Toxics Release Inventory[10] provide useful data for evaluation of waste minimization, comparisons of industrial categories, etc. As noted below, both have significant shortcomings with respect to year-to-year comparisons of hazardous wastes managed. Nevertheless, these data provide a gross estimate indicating that some reduction in quantities managed may have occurred in the 1996–1997 biennium.

Table 1.1 statistics do not include other important data. For example, by the mid-1980s the amounts of hazardous waste "created" by site cleanup activity had become significant, and these quantities continue to be significant. In the 1991 through 1997 Biennial RCRA Reports, the quantities managed "on-site" are not included, nor are they included in the TRI. Moreover, until 1998, the TRI reported only releases by manufacturing industries listed in the 20 Standard Industrial Classification (SIC) codes[11] 20 through 39. Thus, an unknown quantity of the waste created by site cleanup and other activity is not "captured" by the reporting system. Between 1980 and 1995 the numbers of generators which were brought under regulation increased greatly, but the number of reporting generators fell sharply in 1997 due to the exclusion of

[9] U.S. EPA, The Biennial RCRA Hazardous Waste Report (Based on 1991 Data), EPA 530-S-94-039; U.S. EPA, The National Biennial RCRA Hazardous Waste Report (Based on 1995 Data), Executive Summary, EPA 530-S-97-022; U.S. EPA, The National Biennial RCRA Hazardous Waste Report (Based on 1997 Data), Executive Summary, EPA 530-S-99-036.

[10] U.S. EPA, Toxics Release Inventory Public Data Release, EPA 745-R-96-002; U.S. EPA Toxics Release Inventory 1987–1994, EPA 749-C-96-003; U.S. EPA, Toxics Release Inventory 1987–1995, EPA 749-C-97-003; U.S. EPA, 1987–1996 Toxics Release Inventory Reporting and the 1997 Public Data Release, EPA 749-C-99-003.

[11] Established and Published by the Office of Management and Budget (OMB).

wastewaters that are regulated under the CWA.[12] Then in 1998, EPA added industries represented by six SIC codes to the reporting lists.[13] An interesting aside is that when/if petroleum products and or other mining wastes are brought under the hazardous waste regulations, the quantities of "hazardous waste" generated may again rise sharply.

Early Efforts — What Worked/Didn't Work

Any summary of "What Worked/Didn't Work" is incomplete without mention of the key role played by Murray Stein and his Enforcement Conference procedure, conducted under the authorities of the Federal Water Pollution Control Act (FWPCA) (33 U.S.C. 466 et. seq.), the precursor to the Clean Water Act. Stein, a lawyer, was Chief Enforcement Officer of EPA's predecessors the Federal Water Quality Administration and, earlier, the Division of Water Supply and Pollution Control, U.S. Public Health Service.

The FWPCA contained provisions for collective action to abate interstate pollution or contamination of fish or shellfish. The extreme limitations (compared to present legislative and regulatory powers) of those authorities notwithstanding, Stein convened Enforcement Conferences on all manner of environmental issues from industrial wastes in Raritan Bay to radioactivity in the Colorado River Basin and from mining waste in the Great Lakes to petrochemical wastes in Galveston Bay.

Stein gathered federal, state, and local officials, media, scientists, and industrialists together, orchestrated the Conferences as if they were judicial proceedings, extrapolated from the most minimal of technical "evidence," and extracted wide-ranging concessions, compromises, and commitments from polluters. The early cleanup achievements of Stein and his Conferences and the impacts of these pioneering enforcement procedures deserve a prominent place in whatever form is eventually given to the environmental history of America.

Legislation/Litigation

As the hazardous waste mismanagement outrages were thrust upon an unknowing public, governments — local, state, and federal — began attempts to coerce and force perpetrators, variously, to clean up contaminated sites, stop dumping, stop generating, treat properly, recycle, reclaim, or destroy the waste. Individuals and governments sought relief in the courts by tort actions. Nuisance is the most common of tort claims in the field of environmental law.

[12] *See:* Bevill Amendment and Benson Amendment in Glossary.

[13] The newly listed categories and SIC Codes are Metal Mining (10), Coal Mining (12), Electric Utilities (49), Chemical Wholesalers (5169), Petroleum Bulk Terminals (5171), RCRA/Solvent Recovery (4953/7389).

> Nuisance is defined as ... the class of wrongs that arise from the unreasonable, unwarrantable, or unlawful use by a person of his own property either real or personal or from his own lawful personal conduct working an obstruction of or injury to the right of another or of the public and producing material annoyance, inconvenience, discomfort, or hurt (Sullivan 1985, p. 10).

It should be noted that prior to 1972 with the promulgation of the Clean Water Act Amendments, most environmental remedies were conducted under nuisance legislation, and nuisance law was only minimally helpful in addressing the broad range of environmental insults. Two pre-RCRA cases are illustrative.

- In a 1973 case, Harrison v. Indiana Auto Shredders, the Seventh Circuit Court of Appeals refused to permanently enjoin operation of an automobile shredding and recycling plant based on a nuisance action. The court held that under the evidence presented and in the absence of an imminent hazard to health and welfare — none of which was established — the defendant could not be prevented from continuing to engage in its operation (Sullivan 1985, p. 15).
- The Earthline Corporation attempted to operate an industrial waste recovery, treatment, storage, and disposal site on a 130-acre site in Illinois. Ninety acres are located within the village of Wilsonville and the remaining acres are adjacent to the village. The operation accepted hazardous wastes and toxic substances. In 1979, the village sued Earthline to stop the operation and also to require the removal of those hazardous wastes and toxic substances that had been deposited on the site. The court ruled that the site was a public/private nuisance, issued an injunction against Earthline's further operation of the site, and required them to remove all wastes and contaminated soil (Sullivan 1985, p. 16).

In the Stringfellow Acid Pits settlement in principle, noted earlier in this chapter, one of several key elements was the settlement of a 1984 toxic tort action filed by 3800 Glen Avon residents (Newman v. Stringfellow, Cal. Super. Ct., Riverside Cty., No. 165994). After a jury awarded $160,000 to 6 of 17 test plaintiffs on September 15, 1993, most of the defendants paid residents a combined $109 million to settle the tort case (*Environment Reporter*, January 15, 1999, p. 1798).

In 1970 the federal government resurrected the long-dormant 1899 Rivers and Harbors Act[14] and established a permit system for control of water pollution. The efficacy of the act and the permit system for control of hazardous wastes was limited in that it applied only to "navigable waters." (Debate over the "navigable waters" designation became the focus of many of the actions.) The Act was successful in beginning the long-overdue elimination of indiscriminate dumping of all wastes into

[14] Also known as the "Refuse Act" (33 U.S.C. 407).

the streams and rivers of the nation, but the enforcement process was cumbersome, and the Federal Water Pollution Control Act (FWPCA) and the successor Clean Water Act processes soon obscured the earlier mechanism.

The Atomic Energy Act of 1954 vested authority for management of most *radioactive* wastes in the Atomic Energy Commission (AEC) and the Nuclear Regulatory Commission (NRC). The AEC was responsible for managing nuclear wastes generated by the 17 nuclear weapons production facilities that it operated. Nuclear weapons development and production activities were assumed by the U.S. Department of Energy (DOE) in 1977. The NRC has responsibility for nuclear waste management oversight at the nation's nuclear-generating plants. For many years, the AEC gave weapons production the highest priority, generating huge quantities of radioactive process wastes. These wastes were stored or disposed of without treatment, or with inadequate treatment, at the production sites, some of which are now so badly contaminated that they may require 50 to 60 years to clean up, and "... there are some sites we are not going to be able to clean up" (Satchell 1989, p. 20). Radioactive waste management is the subject of Chapter 13.

The Solid Waste Disposal Act of 1965 was the first federal government attempt to improve solid waste disposal practice. It provided funding for development of state solid waste management programs and began the regulation of municipal waste management. The increasing concerns for human health and environmental protection led to amendment of the Act with the 1970 Resource Recovery Act, but neither the 1965 SWDA nor the 1970 RRA had significant impact on the emerging problems of hazardous waste management. These two statutes were the predecessors to the Resource Conservation and Recovery Act (RCRA) of 1976, discussed later in this overview.

The Clean Air Act (CAA) of 1970 was, as implied by the name, directed at controlling sources of air pollution and improving ambient air quality. The 1970 Act did little to enhance hazardous waste management. In fact, emission control equipment installed by industry to meet CAA-required National Ambient Air Quality Standards (NAAQS), as well as CAA-required State Implementation Plans, has generated large volumes of hazardous and toxic material that must be managed as hazardous waste. By 1990, National Emission Standards for Hazardous Air Pollutants (NESHAPS), required by Section 112 of the Act, had been established for only seven chemicals. The 1990 CAA Amendments required EPA to issue standards for 189 additional NESHAPS by November 2000. In December 1999, EPA had promulgated 42 of the standards.

The National Environmental Policy Act of 1970 (NEPA) required agencies and activities of the federal government to prepare an Environmental Impact Statement (EIS) for any project that might affect the environment. Unquestionably, NEPA stimulated some hazardous waste management activity and improvement by many agencies. Numerous lawsuits have been filed against the agencies; however, the suits did not directly compel cleanup nor compliance with environmental law. The nature of the suits has been largely to the effect that (1) no EIS was prepared, (2) the EIS was inadequate, or (3) the environmental assessment performed was inadequate (Wentz 1989, pp. 39–40). The Departments of Defense and Energy have, until recently, largely ignored NEPA requirements. To their credit, both departments now

have extensive site remediation programs under way *(see also:* Vanderver 1985, pp. 374–375; Satchell 1989, pp. 20–22; and Chapters 11 and 13, this text).

The Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA) as amended regulates storage and disposal of pesticides and requires informative and accurate labeling of pesticide products. In May 1974, EPA promulgated regulations for the storage and disposal of pesticides (39 FR 15236, May 1, 1974) (40 CFR 165) and proposed others that were never implemented (39 FR 36874, October 15, 1974). These regulations detailed the appropriate conditions for incineration, soil injection, and other means of disposal of pesticide wastes. They devote considerable attention to the disposal of pesticide containers, which have caused a significant proportion of accidental poisonings (M. Miller 1985, p. 430).

The Marine Protection Research and Sanctuaries Act of 1972 (MPRSA) or "Ocean Dumping Act" regulates the dumping of materials at sea and was intended to prevent or limit the dumping of materials that would have adverse effects. However, ambiguities in the original language of the Act left unclear the intent of Congress as to ending all ocean dumping or allowing it only where it is the best disposal alternative and will not unduly affect the marine ecosystem. This ambiguity was heightened by Congress and EPA permitting ocean dumping of sludge from POTWs along the East Coast [33 USC Section 1412(a)]. Municipal sludge, particularly that generated by older cities in the East, may be laced with heavy metals from industrial sources on the collection systems. The 1988 amendment to MPRSA, the "Ocean Dumping Ban Act" (33 USC Chapter 27) effectively ended ocean dumping of municipal sludges and industrial wastes after December 31, 1991 (EPA, 1991, p. 1, 40).

The Federal Water Pollution Control Act of 1972[15] was significantly modified in 1977 to deal with toxic water pollutants and was renamed the Clean Water Act (CWA). The Act has five main elements:

- The National Pollutant Discharge Elimination System (NPDES) permit program which requires all municipal and industrial waste sources that discharge wastes into "waters of the United States" to have a permit
- A system of minimum national effluent standards for each industry
- Receiving water quality standards
- Specific provisions for oil spills, discharges of toxic chemicals, and non-process discharges such as contaminated plant site run-off
- A construction grant program to assist in funding POTW and related construction (The grant program was replaced by the State Revolving Loan Fund (SRLF) Program, established per Title VI of the CWA.)

Similar to the Clean Air Act, implementation of the Clean Water Act achieved the intended removal of waste materials from municipal and industrial wastewater streams, but created new waste management challenges. Sludges and residues from

[15] The 1972 FWPCA was also the first federal environmental statute to use "technology-forcing" standards. Where existing treatment technology did not meet industrial treatment needs, Congress reasoned that it could "force" the desired technological development and achieve the "zero discharge" goal by 1983. This was highly significant lawmaking and a harbinger of laws of the future.

pretreatment and treatment systems were not regulated initially and were frequently mismanaged.

Industrial facilities that discharge into collection systems serving POTWs are required to meet pretreatment standards. Thus, the CWA controls and limits discharges of hazardous wastes directly to surface waters and indirectly through POTWs. The CAA controls (at least some) emissions of hazardous wastes to the atmosphere. MPRSA limits dumping of hazardous wastes at sea. Through these various statutes, Congress had, by the mid-1970s, theoretically and statutorily shifted the entire burden of ultimate disposal to the land.

The SDWA of 1974 embodied the potential to provide significant protection to underground sources of drinking water through two major provisions:

- The EPA was authorized to designate individual areas as having an aquifer which is the sole source of water supply to the area and which would create a significant hazard to public health if contaminated. Once an area is so designated, no federal assistance may be provided for any project in the area that the EPA determines may contaminate the aquifer. Any "person"[16] may petition the EPA for a Sole Source Aquifer designation (U.S. EPA 1987, p. 1). By December 1999, EPA had applied this provision to 74 areas.
- The Act regulates underground injection to protect usable aquifers from contamination. Underground injection is usually thought of as being accomplished with a deep, high-pressure pumped injection well. The 40 CFR 144 standard defines underground injection as the subsurface emplacement of fluid through a well or dug-hole, whose depth is greater than its width. This definition encompasses five classes of injection wells used for a variety of purposes including the disposal of hazardous wastes. The EPA designated all states as requiring underground injection control (UIC) programs, and the agency must promulgate the program where a state fails to do so. The EPA missed the 1979 deadline for these promulgations, and the program moved forward slowly in the early 1980s (J. Miller 1985, pp. 199, 204–205). A new 40 CFR 148 brought injection of hazardous wastes in Class I (deep) wells under the land disposal restrictions, with implementation dates ranging from August 1988 through June 1995, and a new standard for "high risk" Class V shallow injection wells was proposed on July 29, 1998 (63 FR 40586).

The TSCA of 1976 provides the EPA with authority to require testing of chemical substances, both new and old, entering the environment and to regulate them where

[16] Individual, corporation, company, association, partnership, state municipality, or federal agency.

necessary. It may also be used to regulate the development of biotechnology and genetic engineering (M. Miller 1985, pp. 141–142). The TSCA empowers the EPA administrator to place restrictions on the production, distribution, use, and disposal of toxic substances. The TSCA was the first legislation in which Congress singled out a specific substance, by name, for regulation. Section 2605(e) directed the EPA to phase out the manufacture and use of polychlorinated biphenyls (PCBs) according to a statutorily regulated timetable. Subchapter II provides the authority and structure for regulation and control of asbestos.

The RCRA of 1976, as indicated earlier, was the outgrowth of the SWDA of 1965 and the RRA of 1970. RCRA Subtitle D continued and expanded the solid waste management programs of the 1965 act, but the Act and implementing programs remained relatively weak on hazardous waste management. Subtitle C, the framework for the federal hazardous waste management program, was strengthened somewhat by amendments in 1980, but more significantly by the Hazardous and Solid Waste Amendments of 1984 (HSWA). The HSWA required the EPA to develop and implement the land disposal restrictions, created the new small quantity generator (SQG) and "conditionally exempt" small quantity generator categories, and in Subtitle I authorized the underground (petroleum) storage tank regulations. Subtitle J, the Medical Waste Tracking Act (MWTA), was enacted in 1988, but was allowed to expire at the end of the 5-year statutory life.

In RCRA, Congress attempted to provide "cradle-to-grave" management of hazardous waste by imposing regulatory requirements upon generators, transporters of hazardous wastes, and owners and operators of treatment, storage, and disposal facilities. Although this text deals with hazardous waste management, in general, the focus will be upon RCRA Subtitle C, which is the statutory authority for federal regulation of the control and management of hazardous waste in the U.S. and its territories (*see also:* Hall and Bryson 1985, Chapter 2; U.S. EPA 1990, Section I).

The RCRA did not address the equally serious problem of abandoned and inactive hazardous waste sites. Legislation establishing remedies and allocating responsibilities for correcting problems at these sites is contained in CERCLA of 1980, commonly known as Superfund. CERCLA provides federal funding for response and site remediation where responsible parties cannot be identified or are unwilling or unable to accomplish the necessary cleanup. The EPA then may sue identified responsible parties for recovery of funds expended in the remediation. CERCLA was extensively modified by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In addition to renewal of Superfund authorities and funding, SARA significantly broadened the reach of CERCLA. Title I of SARA required the Secretary of Labor to issue workplace health and safety standards for hazardous waste workers. Title III of SARA, known as the Emergency Planning and Community Right-to-Know Act (EPCRA), imposed an emergency planning regime upon states and communities and required community right-to-know and toxic release reporting. The intent was to make information regarding chemical use and storage information available to communities and to require states and communities to prepare and implement planning for chemical disasters such as the disaster that devastated Bhopal, India.

The Hazardous Materials Transportation Act of 1975 (HMTA) authorizes the regulation of marking, labeling, and packaging of hazardous materials for transportation and thereby includes the transportation aspects of hazardous waste management. In RCRA, Congress recognized the potential for overlap of regulatory issue by EPA and the Department of Transportation (DOT) and specifically instructed EPA to coordinate all transportation-related hazardous waste management regulations with DOT. The HMTA was substantially amended by the Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA). The 1990 amendments were implemented in the form of a general overhaul of the packaging standards, to bring American practice into accord with international standards.

Political

Early efforts at hazardous waste management, by state and local governments, ranged from effective to nonexistent. The early federal legislation was intended to provide funding, technical assistance, and moral support to state and local governments and to prod them into more effective actions and postures. The federal grant-in-aid was the most common mechanism. Typically, the grant provided start-up funds to staff, train, and equip state and local agencies enabling them to launch specific programs. As time passed, the federal statutes, regulations, and policies increasingly tied funding to levels of performance. Federal programs were "delegated" to states and funding depended upon the favorable outcomes of periodic reviews of program accomplishments. RCRA delegation and state program oversight by EPA continues to this day. Most states have opted for delegation, and many have adopted RCRA regulations "by rule." The state agency director thereby takes on the role of the EPA administrator in implementation of RCRA within the state.

States' rights and police powers issues helped to shape the form of early legislation and policy toward environmental management and cleanup of hazardous waste sites. It was widely held that environmental problems were best managed at the state and local level, and that view was reflected by Congress in the federal legislation and by the federal agencies in the implementation thereof.

Although there were obvious exceptions, the state and local agencies were frequently inadequately funded and hampered by limited staff and equipment. EPA and its predecessor agencies, although similarly limited, were able to focus staff and laboratory capability on specific problems. Congress sought to assist state and local governments in the development of decentralized programs by funding technical assistance capability in the federal agencies. Technical assistance programs were frequently helpful in source identification, problem definition, and impact assessment, but somewhat less helpful in securing prevention and remediation of hazardous waste problems.

The early legislation, programs, and policies were too frequently ineffective in securing the intended protection of public health and the environment. Activists and the public demanded direct and rigorous action to bring hazardous wastes under control.

A careful review of the progression of federal legislation, from the 1965 Solid Waste Act through the 1984 Hazardous and Solid Waste Amendments, shows increasingly direct and detailed involvement by Congress in hazardous waste management in the U.S. As will be shown later in this text, this same impatience with progress was not ameliorated by the direct involvement of federal agencies. In HSWA, Congress took the then unprecedented step of writing regulatory language, standards, and calendar deadlines into the statute.

By 1994, the extent, range, and detail of congressional and federal agency involvement in hazardous waste management, and environmental management in general, had burgeoned to the point that public and political sentiment had turned against these regulatory programs. Federally imposed "unfunded mandates" were a major issue of the 1994 election campaigns, and the new Congress promised to "review" many of these programs. Environmental equity issues arose in poorer urban neighborhoods wherever hazardous waste management activity was proposed. Individual members of Congress were frequently involved in efforts to prevent construction or enlargement of such facilities. Nevertheless, with the exception of the 1990 CAA Amendments, Congress did little to strengthen, weaken, or in any way change environmental statutes during the 1990s. Superfund reauthorization was allowed to languish through most of the 1990s, and the "Brownfields"[17] concept was left to the Administration to develop.

Administrative

As the "Environmental Decade" (1970s) progressed, federal, state, and local agencies and officials learned that large numbers of constituents have lively interests in environmental matters. Public hearings, and similar forums, became procedurally ingrained in most legislation, regulation, and policy. It is now taken as routine that no significant environmental decision is made at any level of government, without full public participation, usually through a hearing process. In countless instances, these hearings have sharply affected the course of resolution of major issues.

In recent years, several federal agencies have been shown to be among the worst offenders of hazardous waste management statutes, regulations, and policies. In 1978, President Carter ordered federal agencies to comply with the nation's environmental laws, but his executive decree had little effect. In 1980, Congress passed CERCLA, but exempted federal government facilities. Not until 1986 were federal agencies brought under Superfund rules. During this same period, the Departments of Energy and Defense hid their hazardous waste practices behind the national security curtain, and the true picture of these practices is now emerging. As noted earlier, these practices have so severely contaminated some sites that officials of the Departments of Energy and Defense have been quoted to the effect that there may

[17] A "Brownfield" is a site, or portion thereof, that has actual or perceived contamination and an active potential for redevelopment or reuse (*see:* Glossary).

be no way to clean them up (Satchell 1989). In these matters, public meetings, hearings, and forums were ineffective, and administrative approaches to hazardous waste management actually served to conceal the extent of the problems.

"Administrative" actions and policies brought about serious delays in the implementation of the newly enacted RCRA and CERCLA, under the direction of EPA Administrator Anne Gorsuch (Burford), during the early 1980s. Gorsuch and her hazardous waste program manager Rita Lavelle held strongly negative views toward environmental regulation in general and toward hazardous waste regulation in particular. These ideologies were further strengthened by political activism that put party advantage far above environmental urgency. In sworn testimony before a congressional committee, Lavelle offered a "frankly political motive for shutting off Superfund help to western mining states. She was afraid that the mining states would resent the federal intrusion and that the 1984 election campaigns of western Republican senators might suffer." Gorsuch testified that "she had held up a $6 million grant to clean up the huge Stringfellow acid pits in Riverside, California because Jerry Brown, then governor of California and Democratic candidate for the Senate, might get the credit" (Lash et al. 1984, pp. 82–83). The serious student of the politics of the environment should read the referenced book in its entirety (*see also*: Davis 1993).

Technical

Approaches to definition of hazardous wastes, their identification, impacts, and remedies have progressed along similar lines to the developments cited previously. The initial environmental and public health concerns with hazardous waste sites had a "fires and explosions" focus. The early history is replete with cases and episodes wherein sites burned and/or exploded, releasing huge amounts of heat energy, toxic vapors, and particulates. Many were confirmed as arson cases and many more were suspect. Other sites emitted toxic vapors without fire or explosion.

Such events were often spectacular, frequently hazardous to human health and/or safety, and always frightening to the public. However, the exposures they created tended to be short-lived (i.e., a few hours or days), with a relatively small number of acute health effects, fewer fatalities, and even fewer cases of chronic health effects.

In 1975, a senior engineer, assigned to an EPA field office, was detailed to the Office of the Assistant Administrator for Water and Hazardous Materials and given the task of evaluating the Agency's groundwater management efforts. When he had completed his report, he made the rounds briefing the program managers on his findings. As he attempted to explain to a Deputy Assistant Administrator (DAA) the threat to groundwater quality posed by toxic metals and organics

leaching from land disposal of hazardous wastes, the DAA interrupted him and sneered, "Ah b___ s___, the rocks and the sand strain that stuff out."

A drinking water program official declared, "... we don't have a groundwater problem."

Not until the January 1977 rendition of *The Report to Congress: Waste Disposal Practices and Their Effects on Groundwater*, prepared by a major consulting firm under contract to the EPA Offices of Water Supply and Solid Waste Management Programs, did the magnitude of the groundwater impacts begin to be understood by policy makers. The report confirmed what a few professionals in the Agency had been saying — the real human health and environmental impacts of hazardous waste mismanagement were (are) to the groundwater resources of the nation.

The groundwater resource was then known to supply drinking water to over half the populace and to be the source of water for 30% of the domestic water systems (EPA 1977, p. 1). Aquifers were being contaminated with a wide range of soluble and leachable inorganic and organic pollutants, many of which are toxic.

Whereas the release of toxic air pollutants and heat energy from fires and explosions could be measured in days, hours, minutes, or even seconds, the impacts of groundwater contamination may persist for decades or centuries. As experience was gained, it was seen that similar differences of scale prevailed in cleanup costs. Congress and the regulatory agencies began to shift their focus to prevention of groundwater pollution and remediation of contaminated aquifers. This shift of focus became most evident in the 1984 HSWA provisions, which will be a frequent topic throughout this text.

Large East Coast cities, for many years, barged their industrial waste-laden sewage sludge to ocean dumping areas. During the 1970s the ever-tightening restrictions of the CAA and CWA regulatory programs, together with the disappearing land disposal sites, caused ocean disposal of hazardous wastes to become a popular alternative. Opposition to these practices mounted, and in 1977 Congress amended MPRSA to require EPA to "end the dumping of sewage sludge and industrial wastes into ocean waters." EPA had never developed criteria for safe ocean disposal, and the new amendment contained language defining sewage sludge and industrial wastes as materials which unreasonably degrade or endanger human health or the environment (J. Miller 1985, pp. 465–467). The lack of a more precise definition of "industrial waste" hampered the effectiveness of the amended MPRSA and several court decisions allowed some dumping to continue. Public pressure and the Ocean Dumping Ban Act of 1988 effectively ended the practice (EPA 1991, p. 40).

Thus, the legislation and implementation of the 1970s had the effect of diverting most hazardous wastes onto the land or beneath the land surface. Surface impoundments and land "farming" were offered up as "treatment," and landfills and deep well injection systems were regarded as acceptable disposal techniques. The realities were that the impoundments and land "treatment" facilities provided little treatment and made their hazardous constituents available to the groundwater resource. The landfills similarly made leachable and liquid hazardous constituents available to the

groundwater, and the environmental safety of deep well disposal was in doubt among many professionals. These considerations were paramount when Congress enacted HSWA in 1984 (*see also*: Piasecki and Davis 1987, Chapter 3).

By the early 1990s, a wide range of treatment and destruction technologies had evolved, and prospects for significant reductions in quantities of hazardous waste managed in land "treatment" and disposal were good. However, increasingly vigorous activism and public opposition to siting of new treatment and destruction facilities caused widespread withdrawal of RCRA permit applications, cancellation of construction plans and contracts, and a marked reluctance toward corporate involvements in major new facilities. Old line waste management companies adopted strategies of buying out smaller companies, expanding and upgrading existing facilities, and generally lowering profiles. These developments were both cause and effect of the rise of the environmental equity/justice issues and of the brownfields concept, both of which are discussed in Chapters 10 and 11.

International Aspects

Western Europeans have been perceived to be several steps ahead of the U.S. in the evolution of hazardous waste management. The long-standing perception has been that land has not been available in Europe for land disposal to have its day as the alternative of choice. Incineration became the early choice and remains so to this day, but land disposal is practiced in varying degrees. Britain is a case in point, with 85% of hazardous waste disposed of in landfills (Skinner 1987, p. 7). Denmark, (Muller 1987, p. 118), France (Leroy 1987, p. 144), and the former West Germany (Sierig 1987, pp. 128–130) utilize land disposal, but clearly emphasize treatment and destruction processes.

The West German chemical industry began ocean incineration of waste chlorinated hydrocarbons to avoid costly scrubbers for land-based incinerators. High-temperature incineration effectively destroys the wastes, but there is insufficient space on ocean-going incinerators for stack gas treatment equipment, and the units emit hydrochloric acid (HCl) in the exhaust gases. The buffering capacity of the limitless sea water was counted upon to neutralize the HCl emitted by ocean-going incinerators. Europeans became disenchanted with this technology and, in two international agreements, forced the phase-out of ocean incineration (Piasecki and Davis 1987, p. 68). As is discussed in Chapter 7, a U.S. company made major investments of money and resources in an ocean incineration venture. The project was eventually abandoned (*see also*: Piasecki and Davis 1987, Chapters 3 and 4; U.S. EPA 1991, Chapter 5).

The shortage of land for land disposal notwithstanding, Europeans made some costly errors in land treatment/disposal, as did their U.S. counterparts. In Britain, an early cornerstone of the toxic waste plan was co-disposal — the deliberate mixing of hazardous wastes with conventional municipal wastes in permeable landfills. The practice was based upon the belief that the leaching of toxic chemicals would change the wastes into nontoxic substances over time by dilution and biological degradation (Piasecki and Davis 1987, p. 193). Skinner (1987, p. 7) stated ... "there is little evidence of problem landfill sites in the UK ... This is attributed to comprehensive land use controls, favorable geology and control of groundwater

usage." Nevertheless, the U.K. government subsequently found it necessary to adopt more aggressive definitions of the key terms "contaminated land" and "harm" and to give higher priority to groundwater protection in the Environmental Protection Act of 1990 and the Environment Act of 1995 (Petts et al. 1997, pp. 4–5; *see also:* Wilson 1987, pp. 256–257).

In Holland, much of which is below sea level, fill is often required before construction can take place on land. For more than 40 years, solid wastes containing hazardous chemicals were utilized as fill material. Authorities estimate that up to 8 million metric tons of hazardous chemical waste may be buried in that small country (Enger et al. 1989, p. 379). The government estimates that there are now nearly 5000 leaking waste sites. The small village of Lekkerkerk is the Dutch version of Love Canal, where local government allowed dumping of chemical wastes as fill material (Piasecki and Davis 1987, pp. 190–191; USEPA, 1992). Some 250 houses had to be abandoned temporarily and approximately 156,000 tonnes (nearly 175,000 tons) of contaminated fill was removed and barged to Rotterdam for high temperature incineration (Petts et al., 1997, p. 17; *see also*: Page 1997, Chapter 10)

Denmark, notably, places very heavy emphasis on waste minimization, recycling, and incineration in combined power and heating plants. Landfilling of wastes (municipal and hazardous) has been reduced to 20%. Since 1997, it has been forbidden to landfill waste that could have been incinerated for energy recovery (Veltze 1999, p. 78). Pump-and-treat methods for cleanup of contaminated aquifers has been widely used, apparently with success at some sites in Denmark (Madsen 1998, p. 257).

Western European hazardous waste management practice has been generally optimal compared to practices in the former Soviet Bloc/Warsaw Pact nations. As the Soviet Union disintegrated, Russian military units withdrawing from their Central and Eastern European training sites, garrisons, airfields, and seaports left thousands of contaminated sites. These include artillery ranges, training grounds, above- and below-ground storage areas and tanks, fueling areas, and maintenance and repair areas. The sites are contaminated with hydrocarbons, heavy metals, acids, PCBs, PAHs, solvents, ordnance, biological agents, and numerous other wastes. The former occupants have accepted no financial responsibility for remediation of these sites and the host countries must now find ways and means of responding to the potential hazards (Voss 1995, p. 7). Similar conditions exist in Latvia, Estonia, and Lithuania (Hadonina 1998, p. 63ff; Tammemae 1998, p. 305ff). The Baltic countries have also found it necessary to clean up their polluted harbors, bays, and estuaries, as well as the open Baltic Sea, as a result of Russian naval activity. The ports, bays, fuel stations, communications centers, ammunition depots, and rocket bases were contaminated with a wide variety of fuels, munitions, and chemical residues. The seawater areas are also polluted with the wrecks of sunk and scuttled vessels (Tammemae 1998, p. 306–308; *see also*: Page 1997, Chapter 12; Krosshavn and Fonnum 1998, pp. 343–345).

The North Atlantic Treaty Organization (NATO) has long recognized that the mismanagement of radioactive waste is an international problem, but had little information on the extent of the problem in the former Soviet Union states. In an effort to gain better understanding of this Cold War legacy, in 1997 NATO made funds available to researchers of the Environmental Technology Program at the East Campus, Arizona State University (ASU), to conduct joint studies at missile sites near St. Petersburg and Moscow, Russia. Their preliminary field investigations indicated widespread disposal of radioactive wastes at the former military installations; however, Russian government officials are reluctant to allow thorough investigation and analysis of the problems. This unofficial reluctance has brought about a halt in the investigations. The ASU professors (Drs. Nicholas Hild, Larry Olson, and Danny Peterson) believe that the potential problem areas may rival the U.S. Department of Energy weapons facilities in both magnitude of wastes and geographic areas requiring cleanup.

American military forces have created unique contamination problems along the former Distant Early Warning (DEW) Line, which was constructed across the North American Arctic in the 1950s. The contaminants, primarily fuel, lubricants, and PCBs, pose especially difficult remediation problems due to the remoteness of sites, the harshness of the environment, and the short fieldwork seasons. The Canadian government established the National Contaminated Sites Remediation Program (NCSRP) to oversee a methodical decommissioning procedure for industrial and military sites. In 1998, 3 of the 42 DEW Line sites had been restored to a state that allows natural attenuation to take place (Reimer and Zeeb 1998, pp. 41–54).

Canadian provincial hazardous waste management programs parallel, to some extent, those in the U.S. Primacy for regulatory programs resides with the provinces; however, the federal government has some interprovincial authority (Dawson and Mercer 1986, p. 37; Assante-Duah and Nagy 1998, p. 11). Canadian national capacity for off-site treatment and volume reduction of hazardous wastes is growing, with modern, integrated treatment facilities in operation or planned. The Bovar facility at Swan Hills, Alberta, which recently began accepting hazardous waste imports, is a case in point. Therefore, extensive and prescriptive regulations governing treatment and disposal of hazardous wastes are not in effect. The Canadian Environmental Protection Act (CEPA) lists nine hazardous classes of materials which are either prohibited or release is controlled. Recent amendments add a Leachate Extraction Procedure similar to that of RCRA (Krieger and Austin 1995, p. 90). In April 1999, the Canadian Environment Minister announced new regulatory action by the federal government to achieve reductions in dichloromethane (methylene chloride) releases by 63% by 2002 and 85% by 2007 and in hexavalent chromium releases by 75% by 2005 (*Environment Reporter,* April 16, 1999, p. 2486).

In the outlying areas of Mexico, discharge of toxic materials goes on virtually uncontested (Dawson and Mercer 1986, p. 37). This absence of controls invited the import of hazardous wastes from the U.S., but RCRA requires exporters to provide detailed notification to EPA and to obtain the consent of the receiving country (40 CFR 262,263). Burgeoning industrial development along the U.S.-Mexican border

has brought hazardous waste management sharply into focus. The maquiladora[18] industries supposedly bring their hazardous wastes from their Mexican facilities into the U.S., to ensure safe treatment and/or disposal and to meet "duty-free" requirements of U.S. and Mexican customs regulations. RCRA (40 CFR 262) also regulates import of hazardous waste into the U.S. As discussed later in this text, accountability of maquila-generated hazardous wastes has not proven satisfactory, and the environmental impacts of these activities in some of the industrialized border areas are severe.

In April 1999, a Mexican attorney and private consultant, lecturing in a series organized by the government's National Ecological Institute stated that "... Mexican trade officials are giving scant attention to environmental protection in their trade development policies ...." He cited as an example the actions of the government to reconsider the environmental impact statement it had originally rejected, for a joint venture between a Mexican company, Exportadora de Sal, and Japan's Mitsubishi. The company, which pays 20% of its earnings to the Mexican government in taxes, wants to expand operations of one of the largest salt-producing enterprises in the world, in a natural [sic] protected area in which thousands of gray whales arrive each year. The attorney gave other examples and noted passage in December 1998 of an amendment to the Mexican constitution that requires government consideration of "sustainable development" in all trade affairs (*Environment Reporter,* April 16, 1999, p. 2487).

Hazardous waste management in Central and South America is primitive at best. Management is hampered by less than vigorous enforcement. Page quotes a (World Bank, 1992) report stating: "The worst toxic pollution in the developing world comes from heavy metals from smelters and manufacturing plants, especially in Eastern Europe, and from chemical and fertilizer plants in Latin America, Asia, and Eastern Europe ... Even though the volume of toxic waste being produced in the developing countries is increasing rapidly, it is still below the level found in the industrial economies" (Page 1997, p. 106; *see also*: Assante-Duah and Nagy 1998, Chapter 4).

The Japanese environmental focus has been on protection of worker health, but new more comprehensive legislation has been enacted. More recently, Japanese laws and regulations, as well as enforcement mechanisms are said to be "... comparable to those found in other industrialized countries" (Assante-Duah and Nagy 1998, p. 17). Other Pacific Rim countries' hazardous waste management programs have generally lagged industrial development (Krieger and Austin 1995, pp. 92–99).

The United Nations Environment Programme (UNEP) has limited global environmental oversight functions. Acting through various suborganizations and in concert with international organizations, such as the World Health Organization (WHO), UNEP organizes various conventions and manages environmental databases, some of which are specific to hazardous waste management. Pertinent conventions include the London Convention on Ocean Dumping, the Oslo Convention on Incineration-At-Sea, and the Basel Convention on the Control of Transboundary Movements of

[18] Maquila (twin) industrial facilities are established on both sides of the U.S.-Mexican border, usually by U.S. companies, to take advantage of significantly less stringent regulatory burdens and labor costs on the Mexican side. Work that is labor-intensive or that may involve use of toxic chemicals is performed in the Mexican facility. Subassemblies, etc. are shipped to the U.S. side for final assembly, inspections, distributions, etc. (*see:* "maquiladora" entry in the Glossary).

Hazardous Wastes and their Disposal. A database specific to international hazardous waste management is the International Register of Potentially Toxic Chemicals (IRPTC) (U.S. EPA 1991, pp. 9ff; UNEP 1992, pp. 28–29, 42).

TOPICS FOR REVIEW OR DISCUSSION

1. The hazardous waste mismanagement episodes summarized in the "Early Hazardous Waste Management" section of this chapter suggest several regulatory measures that might be needed to protect human health and the environment. Discuss a few such possibilities.
2. Discuss two undesirable effects of the discharge of toxic industrial wastes to municipal sewerage.
3. Review the progression of environmental laws and regulations that culminated in the need to regulate hazardous waste management in the U.S.
4. Identify at least two provisions of the 1984 Hazardous and Solid Waste Amendments that had major significance or impact.
5. What event(s) of the mid-1980s has/have caused, and will continue for some time to cause, annual increases in the quantities of hazardous wastes generated?
6. SARA Title I was an unusual legislative step. Discuss.
7. Public hearings on environmental issues are now taken for granted. Discuss any that may have been held in local jurisdictions and any impacts they may have had.
8. If major and minor world powers suddenly began development of new weapons systems that threatened world peace, or even human survival, would the U.S. be justified in again postponing environmental controls on weapons production in order to quickly build an offsetting defensive arsenal of these weapons?

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2 Definition of Hazardous Waste

OBJECTIVES

At completion of this chapter, the student should:

- Understand the generally accepted definitions of "hazardous waste" and why the *definition* is of singular importance.
- Understand the Resource Conservation and Recovery Act (RCRA) definition of "hazardous waste" and the importance, application, and limitations thereof.
- Understand the relationship of RCRA "solid waste" and RCRA "hazardous waste."
- Have an overview familiarity with the perspective of various professionals in the management and control of hazardous wastes.
- Understand the differences in perception of hazardous *waste* and hazardous *materials* management by regulators, environmentalists, the public, and the media.
- Be familiar with other definitive approaches — state and foreign — and their strengths and weaknesses.

INTRODUCTION

If every person who creates, handles, or manages hazardous waste was sufficiently knowledgeable, motivated, capable, and unfailingly trustworthy regarding roles and responsibilities, regulation of hazardous waste management would not be necessary. Unfortunately, we live in an imperfect world, and it has become obvious that the practice of hazardous waste management must be regulated. Clearly, if a regulatory agency is to regulate something, there should be an unambiguous means of identifying and describing that something which is to be regulated.

One source tells us that:

> ... The definition of hazardous waste varies from one country to another. One of the most widely used definitions, however, is contained in the U.S. Resource Conservation and Recovery Act of 1976 (RCRA). RCRA considers wastes toxic and/or hazardous if they "cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or pose a substantial present