VOLUME #4 (BD-25 - BD-32)

DRAFT BACKGROUND DOCUMENTS

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3004 - STANDARDS APPLICABLE TO OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

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Resource Conservation and Recovery Act
Subtitle C-Hazardous Waste Management
Section 3004 - Standards Applicable
to Owners and Operators of Hazardous Waste
Treatment, Storage, and Disposal Facilities

DRAFT

BACKGROUND DOCUMENT

Section 250.45-1 Standards for Hazardous Waste Incineration

U.S. Environmental Protection Agency
Office of Solid Waste
December 15, 1978

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft for comment. As new information is obtained, changes may be made in the regulations, as well as in the background material.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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Regulations to Control

Incineration

1.0 Introduction

1.1 Authority

The Congress of the United States via Section 3004 of Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976 (PL 94-580) mandates that the Administrator of the U.S. Environmental Protection Agency promulgate regulations establishing performance standards applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities as may be necessary to protect human health and the environment. These standards are to include, but need not be limited to, requirements respecting: (1) operating methods, techniques, and practices; (2) location, design, and construction; and (3) contingency plans for effective action to minimize unanticipated damage that might occur at these facilities.

All provisions of this Act (including Section 3004) must be integrated with the Clean Air Act (42 U.S.C. 1857 and following), the Federal Water Pollution Control Act (33 U.S.C. 1151 and following), the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135 and following), the Safe Drinking Water Act (42 U.S.C. 300f and following), the Marine Protection Research, and Sanctuaries Act (33 U.S.C. 1401 and following) and such other Acts of Congress as grant authority to the EPA Administrator. A stated purpose of the above requirement was to avoid duplication to the maximum extent possible. Such integration, however, is to be effected only in a manner consistent with the goals and policies expressed in RCRA and the above-listed acts.

1.2 Definitions

The following definitions should aid the reader in understanding the area of concern covered by this document and the regulations for which this document is intended as background information.

1. "Disposal of Solid or Hazardous Waste" (as defined in the RCRA), means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters.
2. "Disposal Facility" means any facility which disposes of hazardous waste.
3. "Facility" means any land and appurtenances thereto used for the treatment, storage, and/or disposal of hazardous waste.
4. "Fugituve Emissions" means air contaminant emissions other than those from stacks, ducts, or vents or from non-point emission sources.
5. "Hazardous Waste" means hazardous waste as defined in the RCRA and in Subpart A.

6. "Incinerator" means an engineered device using controlled flame combustion to thermally degrade hazardous waste. Examples of devices used for incineration include rotary kilns, fluidized beds, liquid injection incinerators, pathological incinerators, cement kilns, and utility boilers.

7. "Incompatible Waste" means a waste unsuitable for commingling with another waste or material, because the commingling might result in:

   (1) generation of extreme heat or pressure,

   (2) fire,

   (3) explosion or violent reaction,

   (4) formation of substances which are shock-sensitive friction-sensitive, or otherwise have the potential of reacting violently,

   (5) formation of toxic (as defined in Subpart A) dusts, mists, fumes, gases, or other chemicals, and

   (6) volatilization of ignitable or toxic chemicals due to heat generation, in such a manner that the likelihood of contamination of groundwater, or escape of the substances into the environment, is increased, or

   (7) any other reactions which might result in not meeting the air human health and environmental standard.

8. "Monitoring" means all procedures used to

systematically inspect and collect data on operational parameters of the facility, or on the quality of the air, groundwater, or surface water.

9. "Open Burning" means the combustion of any material without the following characteristics:

   (1) Control of combustion air to maintain adequate temperature for efficient combustion,

   (2) Containment of the combustion-reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion, and

   (3) Emission of the gaseous combustion products through a stack duct or vent adequate for both visual monitoring and point source sampling.

10. "Owner/Operator" means the person who owns the land on which a facility is located and the person who is responsible for the overall operation of the facility.

11. "Point Source" means any discernible, confined, and discrete conveyance, including, but not limited to, the following:

   (1) For point sources of water effluent, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated feeding operation, or vessel or other floating craft from which pollutants are or may be discharged; and

(2) For point sources of air contaminant emissions, any stack, duct, or vent from which pollutants are or may be discharged.

12. "Retention Time" means the time hazardous waste are subjected to the combustion zone temperature.

2.0 Rationale for Regulatory Action

The authority for regulatory action comes from section 3004 of RCRA. This section requires the Administrator to promulgate regulations establishing such performance standards applicable to owners and operators of facilities for the treatment, storage and disposal of hazardous wastes as may be necessary to protect human health and the environment.

The direction to address the air environment is specified in the RCRA definition of disposal. Disposal is defined as any act which allows hazardous wastes to enter the environment or be "emitted into the air." Since Section 3004 of RCRA requires the Administrator to establish performance standards necessary to protect human health and the environment, that are applicable to facilities that by the definition of hazardous waste can emit constituents of the waste into the air, standards for hazardous waste incinerators must be promulgated to ensure that air pollutants do not adversely affect human health and the environment.

2.1 Actual Damage

TRW Inc., under contract to EPA to evaluate emission control criteria for air emission standards under 3004 of RCRA, summarized information compiled by the Office of Solid Waste staff on specific incidents for which damage to human health and the environment took place at hazardous waste treatment, storage and disposal facilities.

These hazardous waste disposal damage reports are included as appendix A. A summary is provided in Table I.

Table 1

SUMMARY OF DAMAGE INCIDENTS

Incident No.[a]	Management Method	Waste	Pollution
1	Incineration	Solvent Recovery Residue	Pb, Zn containing gases
2	Landfill	Mg chips and Misc.	Explosion & Fire
3	Landfill	Unidentified Indust. (Compaction)	Explosion & Fire
4	Evaporation Ponds	Misc. Industrial	Noxious Fumes
5	Landfill	Industrial and Minicipal	Fire
6	Holding Basin	Alkyl Lead	Alkyl Lead Fumes
7	Evaporation Pond	Mixed Allylic Amine	Fumes (amines, chlorides, hydro-carbons)
8	Landfill	Pesticide (uncovered)	BHC Fumes
9	Landfill	Asbestos	Wind blown asbestos
10	Landfill	Asbestos	Wind blown asbestos
11[b]	Landfill	HCB	HCB
12[c]	Landfill	Agricultural Chem.	H_2S from reaction
13[d]	Landfill	Unidentified Indust. (Compaction)	Explosion & Fire
14[e]	Sand Pit	Misc. Industrial	Noxious fumes, fires

[a] See Appendix for corresponding Incident Report.

[b] EPA/530/SW-151.3, pp. 6-9 (June 1976)

[c] EPA/530/SW-151.3, pp. 10-12 (June 1976)

[d] EPA/530/SW-151, pp. 6-8 (June 1975)

[e] EPA/530/SW-151.2, pp. 9-11 (December 1975)

2.2 Potential Damage: Identification of Sources of Hazards to Human Health and the Environment.

As can be readily seen from the summary of damage incidents, damage to the environment and to human health can occur from several methods of disposal. The damage incidents demonstrate in most cases negligence on the part of owners and operators of facilities that treat and store hazardous wastes using one or more of the methods. For example, sludges from oil and solvent recovery operations could contain a large amount of heavy metals including lead, zinc, and cadmium. Uncontrolled incineration of these sludges will result in significant air emissions of hazardous waste constituents.

Properly run "physical" disposal methods (e.g., incineration, pyrolysis) impose restrictions on the kinds and quantities of hazardous materials present by virtue of design limitations (e.g., attainable incineration temperatures, throughput requirements for efficient burning, pollution control technology, waste volatility or reactivity). Failure to respect those limitations increases the probability of adverse environmental and health impact.

Whether or not physical limitations inherent to proper use of incineration are sufficient to protect human health or the environment is an important question to be answered by the regulatory agency charged with the mandate to do so.

2.4EPA Testing of Commercial Incineration

EPA completed a program in 1976 which had as one of it's objectives, development of background data for standards for incineration of hazardous wastes. A series of test burns was conducted in pilot and full-scale units to demonstrate the state-of-the-art capability of incineration. These tests showed that existing incinerator facilities are capable of destructing a wide variety of organic hazardous wastes to 99.99 percent or better. This efficiency is attained by control of the major and minor performance variable using standard incineration equipment. Table 2 presents operating conditions used which attained destruction efficiencies of 99.99 percent or better for various typical hazardous wastes in different types of facilities. While only contact time and temperature are defined, it should be noted that efficient combustion will only occur when attention to other major and minor performance features are also considered. Major performance features include turbulence of fuel and air in the combustion zone, oxygen supply, and conversion of waste material to fine particle form. Minor performance affecting the attainment of adequate temperature, time, turbulence, or particle size include: use of auxiliary fuel, quenching control, bypass control, back-mixing control, turn-down effects, lining heat retention, burner on-time and shut-off efficiency, use of pretreatment and use of additives.

The EPA tests provide the hard operating data that

Facility + Type	Waste Tested	Temperature °C	Residence Time	Destruction Efficiency %	Combustion Efficiency %	Particulates in Stack mg/m³	Scrubber Efficiency % HCL Removed
Marquardt Liquid Injection	Ethylene	1349-1752	0.14-0.19 sec.	> 99.999	99.98	20-25	N/A
	C-56	1348-1378	0.17-0.18 sec.	> 99.999	99.98	36-113	> 99
Surface Combustion Pyrolysis	APS separator bottoms	760	12.5 min.	N/A	N/A	23-88	N/A
	Styrene	650-760	12.5 min	N/A	N/A	28-43	N/A
	Rubber	760	15 min	N/A	N/A	9-14	N/A
Chem-trol Cement kiln	Chlorinated aromatic blend	1450	5-10 sec.	≥ 99.989	—	196	—
	Above with PCB's	1450	5-10 sec.	≥ 99.986	—	178	—
Systems Technology Fluidized Bed	Phenol	740-757	12-14 sec.	> 99.999	> 99.96	1280-1430	N/A
	Methyl Methacrylate	774-788	12 sec	> 99.999	> 99.47	560-630	N/A
Zimpro Wet Air Oxidation	Coke Plant	279 @ 107 Atm	1.15 hr.	~ 90	N/A	3	N/A
	Amiban®	281 @ 107 Atm	1.0 hr	~ 90	N/A	11	N/A
3M Rotary Kiln	Polyvinyl Chloride	870 in kiln 980-1090 in Secondary Zone	2-3 sec.	≥ 99.996	99.97	71	> 99
Rollins Rotary Kiln	PCB capacitors, Hammermilled	1252 in kiln 1331 in Afterburner	3.2 sec.	≥ 99.999	> 99.98	35	—
	PCB Capacitors, whole	1334 in kiln 1332 in Afterburner	3.08 sec.		> 99.98	53	—
Rollins Liquid Injection	M. Trichlorobenzene	1307-1332	2.3	> 99.999	99.99	14-16	99.8

Sources: Facility Reports numbers one through six, Destroying Chemical Wastes in Commercial-Scale Incinerators, EPA contract 68-01-2966, (1976-1977).

Burning Waste Chlorinated Hydrocarbons in a cement kiln, Report EPS 4-WP-77-2 Fisheries and Environment Canda, (1977).

demonstrates the state-of-the-art of incinerator technology. Regulations based on the excellent results of this test program seem reasonable and prudent.

3.0 Identification of Regulatory Framework

3.1 Performance Standards

The following discussion outlines the development of performance standards to protect human health and the environment from damage by facilities that incinerate hazardous wastes.

3.1.1 Performance Standards

In the Report to Congress, Disposal of Hazardous Waste 1974, the types of hazardous wastes standards that might be used in regulations were described. Because this report to the Congress provided background for the passage of the Resource Conservation and Recovery Act of 1976, part of this discussion is reproduced below:

> "Because of the nature of the discharges associated with improperly managed hazardous waste, two types of standards are likely to be necessary in order to satisfactorily regulate hazardous waste treatment and disposal: (1) the "performance" standard would set restrictions of quantity and quality of waste discharged from the treatment process and on the performance of the disposal site (e.g., the amount and quality of leachate allowed); (2) the "process" standard would specify treatment procedures or process conditions to be followed (e.g., incineration of certain wastes) and minimum disposal site design and operating conditions (e.g., hydraulic connections are not allowed)."

3.1.2 Best Available Technology

Performance standards normally do not specify design, construction and operating requirements.

However, process standards may prescribe specific requirements as to what must be done with the waste in what kinds of facilities. The Congress mandated in Section 3004 that performance standards would include requirements respecting:

"(3) treatment, storage or disposal of all such waste received by the facility pursuant to such operating methods, techniques and practices as may be satisfactory to the Administrator;

"(4) the location, design, and construction of such hazardous waste treatment, disposal or storage facilities."

Thus, performance standards which include process specifications to meet these requirements have been developed.

3.1.3 Summary

The requirement to promulgate performance standards that include design, construction, and operating methods, techniques and practices at facilities that incinerate hazarsous wastes as necessary to protect human health and the environment requires two distinct and separate tasks:

- Identify standards and guidelines limiting pollutants from the facility which have health or environmentally based criteria, apply a safety factor to protect human health and the environment, and require that the facilities not exceed these levels beyond their property lines.
- Describe the design, construction, and operating methods, techniques and practices that represent good practicable technology for the incineration of hazardous waste, and prescribe their use.

3.2 The Clean Air, Provisions Respecting Hazardous Waste

The following discussion reviews provisions of the Clean Air Act, as amended, (CAA), and its relationship to the regulation of hazardous waste incinerators. The applicable sections related to the Air Quality Criteria and Control Techniques (Section 108), National Primary and Secondary Ambient Air Quality Standards (NAAQS) (Section 110), Standards of Performance for New Stationary Sources (NSPS) (Section 111), and National Emission Standards for Hazardous Air Pollutants (NESHAPS) (Section 112).

3.2.1 Air Quality Criteria and Control Techniques.

Section 108 of the CAA mandates the Administrator to:

> "publish... a list which includes each air pollutant -
>
> "(A) which in his judgment has an adverse effect on public health and welfare;
>
> "(B) the presence of which in the ambient air results from numerous or diverse mobile or stationary sources; and
>
> "(C) for which air quality criteria had not been issued before the date of enactment of the Clean Air Amendments of 1970, but for which he plans to issue air quality criteria under this section."

3.2.2. National Ambient Air Quality Standards

CAA Section 109 mandates the Administrator to:

"publish proposed regulations prescribing a national primary ambient air quality standard and a national primary secondary ambient air quality standard for each air pollutant for which air quality criteria have been issued prior to such date of enactment; and

"...by regulation promulgate such proposed national primary and secondary ambient air quality standards with such modifications as he deems appropriate."

"(2) With respect to any air pollutant for which air quality criteria are issued after the date of enactment of the Clean Air Act, the Administrator shall publish, proposed national primary and secondary ambient air quality standards for any such pollutant."

"(b) (1) National primary ambient air quality standards, prescribed under subsection (a) shall be ambient air quality standards the attainment and maintenance of which in the judgement of the Administrator, based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health. Such primary standards may be revised in the same manner as promulgated."

Standards have been promulgated for particulate, sulfur dioxide, carbon monoxide, photochemical oxidants, hydrocarbons, nitrogen dioxide and more recently for lead. Owners and operators of facilities which incinerate hazardous wastes must, comply with these standards if they emit any of the pollutants for which there is a National Primary or Secondary Standard. An "ambient air quality standard," however, requires translation to an "emission" standard for purposes of enforcement since by definition the sources of any one pollutant for which there is an ambient standard are "numerous and diverse" (not Section 108 (a) (1) (8) above). No one source therefore, is held "responsible" for meeting an NAAQS, (without an emission standard) although emissions from such a source must not by themselves exceed the NAAQS. Emission standards are established under Federal law either by the states under the authority of Section 110 of the CAA and/or established by EPA under the authority of Section 111 of the CAA.

3.2.3 Section 110 - State Implementation Plans

The translation of National Ambient Air Quality Standards (NAAQS) into emission standards that will ensure ambient air concentrations of the "criteria" pollutant takes place in part through Section 110. Here Congress mandated the States to adopt and submit plans which provide for the implementation, maintenance, and enforcement of the NAAQS. Thus, emission limitations which apply under the CAA Sections 109 and 110 to facilities which hazardous wastes would be found within the respective state implementation plans (published in 40 CFR Part 52, Approval and Promulgation of Implementation Plans). Incineration emission standards, where they exist, are most often regulated by the States to control suspended particulate concentrations, (by weight), or to control visible emissions (by opacity).

3.2.4 The New Source Performance Standards promulgated under CAA Section 111 are primarily emmision standards for sources of any of the pollutants for which there is a National Primary of Secondary Ambient Air Quality Standard. For municipal incinerators, a limit of .08 grains of particulate per dry standard cubic foot was established while sewage sludge incinerators particulate emissions were limited to 1.30 pounds of particulate per ton of dry sludge input. Neither of these standards applies to hazardous waste incinerators unless municipal solid waste or sewage sludge is burned.

Under Section 111(d), emission standards may be established for existing sources and new sources as well as for those pollutants other than those for which there is a National Primary or Secondary Ambient Air Quality Standard or which have been listed as "hazardous pollutants" under CAA Section 112. The authority under Section 111(d) is rarely used. Regulated "designated" pollutants, as they are called under Section 111(d), and their sources include fluorides from phosphate and aluminum plants, sulfuric acid mist from acid plants, and total reduced sulfur compounds from paper mills.

Performance standards promulgated under Section 111 are based upon the best practicable technology approach, and are defined under Section 111(d) as:

> "...a standard for emissions of air pollutants which reflects the degree of emission limitations

achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction), the Administrator determines has been adequately demonstrated."

3.2.5 Section 112, National Emission Standards for Hazardous Air Pollutants mandates the Administrator to list hazardous air pollutants and establish emission standards which "...provides an ample margin of safety to protect the public health from such hazardous air pollutants."

Unlike the "best practicable technology" method mandated under Section 111 for "New Source Performance Standards" this Section of the CAA provides no mechanism for prescribing the best system of emission reduction. A maximum allowable concentration provides an ample margin of safety to protect the public health which therefore requires a threshold first be determined for the lowest concentration for which an adverse effect to the public health might occur in addition to incorporate an "adequate margin of safety."

Alternatively, for substances for which a low threshold cannot be determined, values must be assigned as a maximum allowable concentration which incorporate an adequate margin of safety. Assigned values to the low threshold for adverse effects of such pollutants are not determined.

An adequate "margin of safety" is also required in developing the source emission standards, since one numerical value and conversion factor must be used to translate the ground level concentration exposure limit, "ambient air goal", to an emission standard while taking into account the conditions that could reasonably take place to allow high concentrations at human breathing level.

Although the assumptions made in determining this "diffusion factor" are quite general, the meteorological assumptions that were used for beryllium and mercury typlify conditions of atmospheric stagnation and poor dispersion of the hazardous pollutants emitted. This "National Atmospheric Dispersion Model" used a gaussian plume equation similiar to that described by Turner in his workbook of Atmospheric Dispersion Estimates (1970).

Five air pollutants have been "listed" as Hazardous Air Pollutants: abestos, beryllium, mercury, vinyl chloride, and more recently, benzene. For asbestos, an adequate threshold for which an emission standard would be developed could not be established since measurement techniques for asbestos fibers had not been established. For beryllium and mercury, such thresholds or ambient air objectives were established and the "National Atmospheric Dispersion Model" was applied. The ambient goals were 0.01 and 1.0 $\mu g/m^3$ 30-day average concentrations respectively.

Vinyl chloride was the first (and latest) hazardous air pollutant for which emission standards were promulgated under CAA Section 112. Because vinyl chloride had been shown to be carcinogenic, the EPA judged that a threshold for no adverse effects to human health could not be established. However, a judgement was made that a "zero emissions" limit was unduly restrictive and impossible to meet without shutting down a major segment of our economy. The issue was resolved by using the "best practicable technology."

Though the use of "best practicable technology" was not expressly required by the CAA, a value was nonetheless set for human exposure. This technologically fixed amount of emissions may or may not allow the "theoretical threshold," that may have been set, however imprecisely, to be exceeded. This exposure level and the definitive threshold that was indirectly set is the emissions that will result from best practicable technology, however good the controls. Data are not available for comparision of this theoretical threshold and a definitive threshold that might have been set based upon the "health" data that was available. Additionally, emissions are, in theory, allowed to be discharged with no limits wherever the best technological control methods were not applied (hence prescribed).

The best practicable technology based standard effectively replaced the dose-effect or health-based standard for Section 112. Best technology may be described as one of several options listed below:

1. Technically feasible, regardless of costs;
2. Technically feasible, at a cost that does not shut down the industry;
3. Technically feasible at a reasonable cost (new source performance standards).

Concept 1 is always the most stringent (where it is applied). Concept 3 is the least stringent. EPA (OAQPS) applied Concept 2 to vinyl chloride under the authority of Section 112. EPA constructed the regulation by finding the best technology for individual emission points at a variety of plants and used judgement to extend those controls where it was determined more control was feasible, and developed a regulation that applied the collective technology to all plants.

Although the Clean Air Act Amendments of 1977 provides a mechanism for a shift from "ambient concentration-based standards" to "best technology" a judgement that a threshold or limit cannot be determined is not one of those mechanisms. This section of the CAA of 1977 is shown below:

"(e) (1) For purposes of this section, if in the judgement of the Administrator, it is not feasible to prescribe or enforce an emission standard for control of a hazardous air pollutant or pollutants, he may instead promulgate a design, equipment, work practice, or practical standard or combination thereof, which in his judgement is adequate to protect the public health from such pollutant or pollutants with an adequate margin of safety. In the event the Administrator promulgates a design or equipment standard under this subsection, he shall include as part of such standard such requirements as will assure the proper operation and maintenance of any such element of design or equipment.

"(2) For this purpose of this subsection, the phrase "not feasible to prescribe or enforce an emission standard" means any situation in which the Administrator determines that (A) a hazardous pollutant or pollutants cannot be emitted through a conveyance designed and constructed to emit or capture such pollutant, or that any requirement for, or use of, such a conveyance would be inconsistent with any Federal, State, or local law, or (B) the application of measurement methodology to a particular class of sources is not practicable due to technological or economic limitation

"(3) If after notice and opportunity for public hearing, any person establishes to the satisfaction of the Administrator that an alternative means of emission limitation will achieve a reduction im emissions of any air pollutant at least equivalent to the reduction in emissions of such air pollutant achieved under the requirements of paragraph (1), the Administrator shall permit the use of such alternative by the source of purposes of compliance with this section with respect to such pollutant.

"(4) Any safeguard promulgated under paragraph (1) shall be promulgated in terms of an emission standard whenever it becomes feasible to promulgate and enforce such standard in such terms."

Additionally, the Clean Air Act of 1977 requires that EPA determine if cadmium, arsenic, polycylic organic matter (POM) and certain radioactive pollutants should be added to the "list" published under Section 108 (a) (1) or 112 (b) (a).

3.2.6 In summary, National Ambient Air Quality Standards for total suspended particulate, carbon monoxide, sulfur dioxide, ozone, total hydrocarbons, nitrogen dioxide and lead or pollutants have been promulgated. New Sources Performance Standards for five of the above six criteria pollutants and three "designated pollutants" are applicable to a variety of sources including municipal and sewage sludge incinerators (particulate emissions). National Emission Standards for four hazardous air pollutants have been promulgated. Standards for benzene and arsenic are currently under development. Cadmium, arsenic, POM, and certain radioactive pollutants also must be evaluated for inclusion as a result of the Clean Air Act Amendments of 1977.

3.3 Air Contaminant Concentration Limits to Protect Workers

The American Conference of Governmental Industrial Hygienists (ACGIH) was organized in 1938 to provide a medium for the promotion of standards and techniques in industrial health. The USPHS Bureau of State Services was established in 1944 and contained the industrial hygiene program, which included until 1955, the federal air pollution program. The ACGIH publishes and updates yearly a list of chemicals with specific concentrations, called "Threshold Limit Values" (TLV). The lists are published as guides in the control of health hazards and were not intended to be legal requirements The Occupational Safety and Health Administration (OSHA) adopted the TLVS (1968) as legal requirements in 1972.

Worker standards and guidelines (TLVS) represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, withour adverse effect. The TLVS are the weighted average concentrations for a normal workday.

Although the standards apply to human health, they can not be considered adequately protective of the population at large. The health status of workers is more healthy than the general population which contains more susceptible subpopulations including the elderly, young children and the infirm. Additionally the public may be exposed to hazardous air pollutants continuously rather than on an eight hour basis. The ACGIH in their annual publication listing of the TLVS preface those values by warning,

> "These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use or for modification for use: (1) as a relative index of hazard or toxicity; (2) in the evaluation for control of community air pollution nuissances; (3) potential of continuous uninterpreted exposures...

Data demonstrating that 90-day continuous exposures of TLV concentrations can result in effects ranging from mild toxicity to 100% mortality became available during tests to insure safe atmospheres for space-craft occupants (Back and Thomas, 1970; House, 1964; Sandage, 1961 a and b).

Despite known pitfalls, and expressed ACGIH warnings, the TLVS have been "interpreted" by many persons who are not industrial hygienists. Additionally, the TLVS have been compared with one another to determine toxicity. The TLVS have been used as legal limits rather than guidelines (OSHA) and used as a benchmark for comparison in determining maximum allowable air contaminant concentrations in the community (Battelle, 1976 and Cleland et al. 1977).

The modification of TLVS for use as maximum allowable air contaminant concentrations in the community is covered in the next section.

3.4 Air Contaminant Concentration Limits to Protect Workers Non-Workers, and the Environment.

It should appear from the above discussion in 3.3 that protection of human health and the environment on a continuous basis from air contaminants on the ACGIH TLV list would require an additional measure of safety or numerical division than an adoption of the TLV concentration limits alone. At issue, however, is whether a singular factor applied to all of the OSHA or ACGIH TLV's can or should "guarantee" freedom from harm at an exposure equivalent to the limit that is set. On the one hand, no limits, per se, could be interpreted by some as allowing unlimited emissions. In counter argument, limits are also "safe exposure levels" since, in effect, an exposure to concentrations of contaminants less than a "limit" is allowed. It is important to recognize however that owners and operators of facilities that emit hazardous air pollutants may be liable for damages to health and environment, if it can be proven in a court of law to a reasonable person, a judge, that air contaminants caused the harm (regardless of whether the level was above or below a given limit).

The use of the ACGIH TLV's times a safety factor for the protection of more than the working force for more than a working day ~~was instituted by the American Society for~~ Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 62-73 "Natural and Mechanical Ventilation." ASHRAE Standards for Natural and Mechanical Ventilation were developed in accordance with American National Standards Institute (ANSI) approved procedures. ASHRAE in an active accredited ANSI standard writing organization (ASHRAE, 1973).

The purpose and scope of ASHRAE Standard 62-73 is to define "ventilating requirements for spaces intended for human occupancy and specify minimum and recommended ventilation air quantitites for the preservation of the occupant's health, safety, and well being." In Section 3.3 (of ASHRAE 62-73), the Standard states that:

"air shall be considered unacceptable for ventilation use in accordance with this standard if it contains any contaminant in a concentration greater than one-tenth the Threshold Limit Value (TLV) currently accepted by the American Conference of Governmental Industrial Hygienists."

One-tenth is, of course, convenient since it allows a simple manipulation of the decimal point of the TLV. The greater lack of precision (in terms of the number of significant figures) relates to the general inability to quantify in exact terms factors such as protection of susceptible individuals. Adding or multiplying such factors is also not precise since their sensitivities and relative degrees of importance differ.

Examples of such safety factors and their use is shown in Table 3

Table 2 - Factors to adjust Workplace Limits to Community Wide Limits

Factor	Basis	Use	Comments
1/3	8 hrs for workers 24 hrs a day	not used by itself; used in factor 1/300	one exact number (3) among many inexact factors.
5/21	40 hrs for workers 168 hrs per week community	not used alone used in factor 1/420	(as above)
1/4	40/168 as above rounded to even fraction	interim guide-line by Navy	(as above)
1/10	One order magnitude from workers to public health standard	ASHRAE; New York State guideline	This factor and those preceeding assumes OSHA standards adequate to protect workers.
1/30	1/3 x 1/10(?)	Colorado Dept. of Health Maximum Allowable Concentration	(as above)

Table 2 - Factors to adjust Workplace Limits to Community Wide Limits (cont.)

Factor	Basis	Use	Comments
1/100	10 for each 8/24; HABER'S LAW	TRW recommended action to HWMD (1973) (provisional limits)	
1/300	8/24 x 1/100	Monsanto Research Corp. for EPA	
1/420	40/168 x 1/100	Battelle Columbus Lab. (1976) for EPA; Research Triangle Inst. (1977) for EPA	See comments above for 5/21. 5/21 x 1/100

There is little disagreement among toxicologists and industrial hygienists that an application of a singular safety factor or time weighted adjustment factor to convert occupational standards to community wide standards is most often inappropriate. All might agree that the data that support TLV's should be reviewed by regulatory bodies on a pollutant by pollutant basis including data of more recent vintage that may be compiled from those investigations that have taken place since the TLV decisions were made. Of significance to this question, however, is the amount of time, money, and data that are necessary to set a particular health based standard, particularly, when the data consists solely of rat or mouse acute toxicity studies. Although efforts may be better spent focusing on the control technologies, criteria for the amount of control to be applied are paramount.

The use of an adjusted worker standard, so long as it is on an interim basis until a pollutant by pollutant risk assessment is made and a concentration limit for each pollutant is developed may be permissable.

3.5 Existing Federal, State or Local Regulations

Most states have not established regulations dealing specifically with incinerators combusting hazardous wastes. Generally, state regulations specify particulate emissions standards for incinerators which are consistent with the federal performance standards for incinerators, or which are to some degree more stringent than federal regulations.

Many states have also adopted some form of the federal emissions standards for the hazardous pollutant beryllium. However, few states have incorporated explicit regulations which would restrict the numerous other pollutants emitted during incineration of hazardous wastes.

Federal regulations for municipal incinerators limit particulate emissions to .08 grains per dry standard cubic foot corrected to 12% CO_2 for municipal incinerators burning more than 50 tons/day. Sewage sludge incinerator emissions are limited to 1.3 pounds of particulate matter per ton of dry sludge input, and to 20 percent opacity or greater. Federal emission standards for hazardous materials limit air emissions of beryllium from incinerators (or other sources) to 10 grams per day. In some instances, states have adopted more stringent versions of these federal regulations (e.g., in Maryland particulate emissions from municipal incinerators are limited to .03 grams/dscf.

In the absence of conclusive regulations which address potential emissions from incinerator burning hazardous waste, states have restricted the operations of hazardous waste incinerators by the authority of a general protection or "nuisance" rule. The general nuisance rule of the Wisconsin Department of Natural Resources is a typical example:

> NR 154.19 Control of Hazardous Pollutants. General Limitations No person shall cause, suffer, allow, or permit emissions into the ambient air of hazardous substances in such quantity, concentration, or duration as to be injurious to human health, plant or animal life unless the purpose of that emission is for the control of plant or animal life. Hazardous substances include but are not limited to the following materials, their mixtures, or compounds: asbestos, beryllium, cadmium, chromium, clorine, fluorine, lead, mercury, pesticides, or radioactive material.[1]

While the rule provides no specific regulatory guidelines, the general authority of this type of regulation has been used to impose a variety of emission restrictions on a case by case basis in different states. The formality and criteria associated with the determination of suitable restrictions varies greatly from state to state. Typically, the permitting agency requires the applicant to demonstrate the environmental acceptability of the proposed incinerator operation. This usually involves documentation of proposed equipment design and operating procedures, and expected emission levels of specific pollutant Dispersion modeling is often required to determine if ambient air quality will be maintained to the agencies definition of acceptable concentration limits.

While the existing restrictions on incinerator operations can be expanded by authority of the general protection rules, this is often unnecessary because the existing state and federal regulations for incinerator emissions of particulate matter alone have resulted in costly control equipment requirements which make incineration of both municipal or hazardous waste less economical than landfill disposal

Thus, in many states, there are currently no facilities which operate a hazardous waste incinerator. It is estimated that less than 15% of all hazardous waste is currently destructed by incineration and that only 6% is managed by controlled incineration which is environmentally acceptable (i.e. controlled by federal or state incinerator regulations).[2]

The most explicit regulations applicable to hazardous waste incineration have been developed in Colorado (Regulation No. 8) and New York (Part 212). The Colorado regulations provide specific direction for establishing emission standards for a large number of chemical substances or physical agents on a source-specific basis. The New York regulations also provide for source-specific determination of an allowable emissions rate, however, the criteria for determining this are less definitive than those of the Colorado rules.

The Colorado Emissions regulation is intended to set emission standards such that ambient air concentrations resulting from the emissions source will not exceed 1/30 the occupational threshold limit value when emissions are generated continuously or for more than nine (9) hours per day. For some specific materials, as defined by the regulation, the ambient air objective may deviate from 1/30. These materials include: 1) compounds which are human or experimental carcinogens and have no assigned TLV, 2) fluorocarbon chain (e.g., fluon, teflon) decomposition products, and 3) mixtures of compounds. The regulation provides for application of best available technology in the former two cases and specifies procedures for consideration of mixtures of toxic compounds in the latter case.

The Colorado Regulation allows greater emission levels when the emitter source duration is short term, or less than 9 hours per day. Specified excursion factors are applied to the long term allowable emission standard to define the maximum allowable short term emissions rate (for a 9 hour period).

Figure 3-12 illustrates the variables which are considered in establishing emission standards for a given facility emitting hazardous pollutants in the State of Colorado. The allowable emissions level is determined from the TLV and a nomograph, which incorporates the air quality/emissions relationships of the Pasquill-Gifford diffusion equation[3] plus assumed values for meteorological variables representing the "worst case" conditions for air pollution. The only input needed to the nomograph is the effective stack height of the source, which is calculated using the Moses Kaimer plume rise technique.[4] The parameters needed to determine effective stack height are stack height, effluent flowrate, and effluent temperature.

~~The Colorado Air Pollution Control Commission regards Regulation~~ No. 8 as inadequate in its present form and is proposing amendments concerning two major drawbacks: 1) the arbitrary ambient objective (1/30 TLV) of the regulation, and 2) the air diffusion relationships which are overly generous in distributing of emissions. The Commission is not satisfied that the 1/30 TLV ambient target is appropriate, or whether a single factor should be applicable to pollutants of different toxicities. The Commission is critical of the diffusion model because it is not sensitive to topographical effects and may not incorporate consideration of "worst case" meteorology for a site specific case. In one case where permit approval had been given, emission rates meeting the required levels resulted in ambient levels exceeding OSHA Standards when the stack plume looped to the ground on a hill above the facility stack. The operator was cautioned by the Commission of the health hazard and has installed a monitoring and alarm system to enable mitigating action when the meteorology causes high ambient levels of H_2S. The "generosity" of the model in dictating control requirements has also been apparent in other applications of Regulation No. 8. The Commission is considering a regulatory amendment

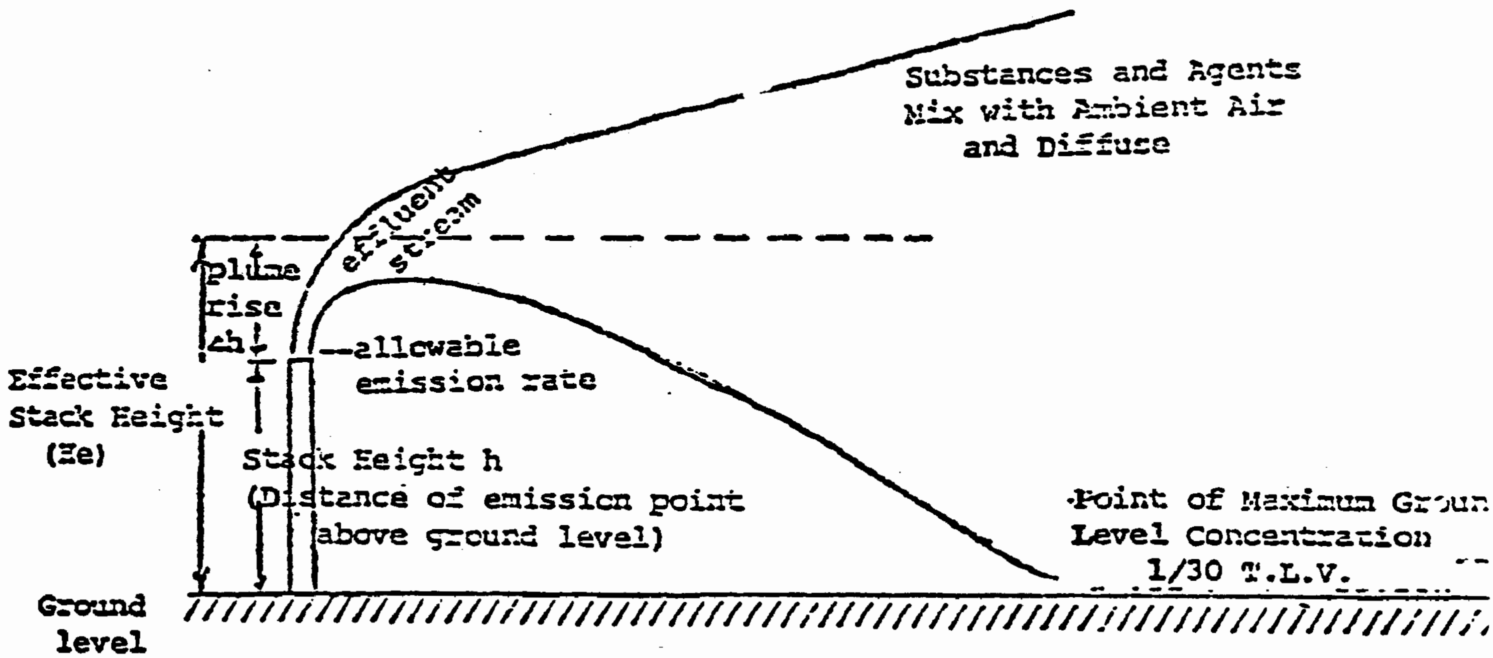

Figure 1. Site Specific Considerations Incorporated in the Determinationsof Colorado Emissions Standards [5].

in which source-specific determination of emissions standards will be maintained, but in which a discretionary judgement for model selection may be permitted. Model selection would include consideration of special meteorological and topographic factors affecting high local ambient concentrations.

In New York, Part 212 of the State air pollution regulations outlines criteria for assessing an environmental rating for any specific emission source, and specifies the degree of emission control required for permit approval based on the environmental rating and the potential emission rate. Table III-17 shows the environmental rating criteria of the regulation. The criteria are judgemental, although the Department of Environmental Conservation utilizes some internal guidelines which are more specific to establish A, B, C, or D ratings for hazardous substances. In general, any source emitting a carcinogen is rated "A", and other sources emitting substances on the toxic contaminants list of the New York Process Source Handbook are also rated "A", with the exception of those sources whose emissions do not reach receptor areas. Previously the Department had also used an ambient air quality criteria, assigning an "A" rating to any source creating receptor exposures greater than 1/10 the listed TLV of the contaminant. Judgement of the environmental rating using the ambient air quality criteria required air diffusion modeling, a questionable means of assessment because of prevailing topographic effects not generally considered by standard models. The ambient criteria still serves as an attainment goal, but is seldom used in assessing the environmental rating of a substance. The control technology required to attain the safe ambient air quality near any source operation is specified by fixed criteria as shown in Table III-18. Sources emitting "A" rated contaminants must generally be equipped with best available technology regardless of size.

TABLE 3. CRITERIA FOR ENVIRONMENTAL RATING OF EMISSION SOURCES, NEW YORK AIR RESOURCES REGULATION PART 212

Rating	Criteria
A	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants results, or would reasonably be expected to result, in serious adverse effects on receptors or the environment. These effects may be of a health, economic or aesthetic nature or any combination of these.
B	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants results, or would reasonably be expected to result, in only moderate and essentially localized effects; or where the multiplicity of sources of the contaminant or contaminants in any given area is such as to require an overall reduction of the atmospheric burden of that contaminant or contaminants.
C	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants would reasonably be expected to result in localized adverse effects of an aesthetic or nuisance nature.
D	Includes processes, and exhaust and ventilation systems where, in view of properties and concentrations of the emissions, isolated conditions, stack height, and other factors, it can be clearly demonstrated that discharge of the contaminant or contaminants will not result in measurable or observable effects on receptors, nor add to an existing or predictable atmospheric burden of that contaminant or contaminants which would reasonably be expected to cause adverse effects.

The following items will be considered in making a determination of the environmental rating to be applied to a particular source:

a) properties, quantities and rates of the emission
b) physical surroundings of emission source
c) population density of surrounding area, including anticipated future growth
d) dispersion characteristics at or near source
e) location of emission source relative to ground level and surrounding buildings, mountains, hills, etc.
f) current or anticipated ambient air quality in vicinity of source
g) latest findings relating to effects of ground-level concentrations of the emission on receptors
h) possible hazardous side effects of contaminant in question mixing with contaminants already in ambient air

While other states have not established definitive regulations controlling the incineration of hazardous waste, the requirements imposed on incinerator operators through individual permit approvals typically reflect the approach defined by the New York regulation. Operators are generally required to demonstrate the environmental adequacy of the facility to dispose of toxic wastes, and this is usually accomplished by utilization of best practical technology and reference to previous experience defining the proper operating conditions for optimal destruction of wastes. In many cases, the permitting agency will require test burns prior to permitting full scale incineration. The test burn is utilized to define appropriate stipulations for the permit approval.

TABLE 4. DEGREE OF AIR CLEANING REQUIRED VS. ENVIRONMENTAL RATING OF EMISSIONS[6]

	EMISSION RATE POTENTIAL (LB/HR)									
Environmental Rating	Less than 1.0	1 to 10	10 to 20	20 to 100	100 to 500	500 to 1,000	1,000 to 1,500	1,500 to 4,000	4,000 to 10,000	10,000 and Greater
A	*	99% OR GREATER								
B	*		90-91%	91-94%	94-96%	96-97%		97-98%	98-99%	99% or Greater
C	*		70-75%	75-85%	85-90%	90-93%		93-95%	95-98%	98% or Greater
D	*									

* Degree of air cleaning required shall be specified by the commissioner.

While incineration may enable nearly complete destruction of hazardous materials, the combustion products may not be environmentally acceptable if emitted to the atmosphere. Therefore, certain wastes should not be incinerated unless the combustion products are treated with an emission control device such as a wet scrubber, electrostatic precipitator, baghouse, or catalytic or thermal afterburner. Wastes of concern include chlorinated hydrocarbons (resulting in hydrochloric acid), materials containing heavy metals, and wastes with high sulfur content. The degree of control required would be based on the expected level of toxic emissions and the resulting impact on ambient air quality. Because of the wide variability of wastes accepted by incineration facilities, the ability of the facility to manage these wastes depends on versatile air pollution control equipment. High efficiency wet scrubbers usually provide the versatility required, as chemical solution may be varied suitably to treat different effluent contaminants, including toxic loadings of incomplete combustion materials resulting from improper or transient operating conditions.

Precautionary control equipment to prevent unacceptable transient emission loadings may also be included in the design of the incineration facility. Such equipment includes gas monitors for continuous measurement of combustion products (e.g., CO, CO_2, NO_x, O_2) combustion temperature monitors, and automatic feed shut-down following malfunctions or undesirable variations in operating conditions.

Whatever the regulatory approach adopted for controlling thermal destruction of hazardous wastes, the numerous performance variables of the system, including the type of waste itself, suggest the need for test burns prior to full scale incineration to 1) insure the desired destruction is attainable, and 2) identify system operating parameters corresponding to the desired destruction or emission control goals.

Section 4.0

Analysis of Regulatory Options

The following options represent strategies for standards development. Option 7 summarizes the performance standards as presently proposed. A summary of issues related to adoption of each of the options is discussed.

4.1.1 Option 1

Promulgate standards which require only compliance with provisions of the Clean Air Act.

Pro: New Source Performance Standards (NSPS) are based on the best available (practicable) control technology method while National Emissions Standards for Hazardous Air Pollutants (NESHAPS) have been based on ambient air goals for beryllium and mercury and best available technology for asbestos and vinyl chloride.

Con: To set such standards, however, a pollutant must first be listed, which sets in motion a significant EPA commitment to limiting emissions of this singular pollutant at all significant sources. For each singular pollutant, hazardous waste incinerators as a whole may qualify as low emitters in terms of the amount of each pollutant emitted. In many cases, however, the species or contaminants are many and the total amount can be significant to nearby residents.

In summary, the Clean Air Act alone does not provide a mechanism that enables EPA to limit hazardous air emissions from facilities that incinerate hazardous wastes as directly or efficiently as Section 3004 of the Resource Conservation and Recovery Act. Other regulations in addition to applicable provisions of the Clean Air Act must be established that will focus on the air emitting operations of hazardous waste incinerators.

4.1.2 Option 2

Promulgate standards which require compliance with the following:

1. All provisions of the Clean Air Act, and,
2. On an interim basis, worker standards times a safety factor to account for the difference between protection of workers on an eight-hour bases and the protection of (all) human health and the environment (e.g., worker standards times 0.1).

This option possesses similar pros and cons as the previous option since it also requires compliance with the Clean Air Act with the addition of the adapted worker standards. However, uner this option, those air contaminants which are of conern in the work place will also have limits in the community.

Pro: The number of pollutants covered (400-600) by worker standards could be judged necessary to protect human health and the environment since it effectively requires that owners and operators of hazardous waste treatment, storage and disposal facilities know to what extent possible concentrations of hazardous air emissions are emitted and may be found at the property line of the facility.

Con: This option may not be considered protective since thousands of pollutants potentially may be emitted. Attempting to prescribe limits for every potential pollutant would be a costly and time consuming effort. Also this option lacks design, construction, and operating standards mandated in RCRA. Without such standards, owners and operators of hazardous waste incineractors would not be given the benefit of knowing how to meet these emissions standards. The lack of precision of models to predict limits at the fenceline and thus the inability to specify exact emission rates from incinerators, make this option a poor choice on which to regulate.

4.1.3 Option 3

Promulgate performance standards which require only compliance with design, construction, and operating prescriptions which are based upon a best technology approach.

Pro: This option would not require any compliance with ambient air standards. Being based on the best technology approach, it would also be the most easily enforceable and least costly to determine compliance.

Con: With no standards that are health based, this option alone could not be considered for adoption as performance standards "necessary to protect human health and environment." Complete data for all techniques, mothods and the factors that must be prescribed is not available at this time to comprehensively cover the many sources of waste disposal emissions.

The best technology prescribed may not be adequately protective, and conversely, "good" technology which is much less costly than the "best" may be all that is "necessary" taking into account factors related to risks and controls.

4.1.4 Option 4

Performance standards would include two previsions as follows:

A. Promulgate those design, construction, and operating procedures that can be identified as best practical technology. Compliance with these procedures allows the owners and operators of hazardous waste facilities to be permitted.

B. Promulgate standards which require compliance with the following:

1. All provisions of the Clean Air Act as amended, and,

2. On an interim basis until standards prescribed by a pollutant by pollutant risk assessment are promulgated by EPA, compliance with one-tenth the TLV's published by the ACGIH.

This option combines the requirements for protection of human health and the environment inherent in Option 2, and the requirements for design, construction, and operating procedures found in Option 3.

Pro: Like the law (Section 3004), there is no precedent for both the use of emission standards/ambient air goals based upon health and the use of good practicable technology together. The latter are based upon health and the use of good practicable technology together.

The latter are based upon design, construction and operating principles demonstrated to perform their intended function (i.e. destruction via incineration) practically and most completely without threatening the communities that they are located in. Monitoring is conducted to ensure that the technology is operating as designed (e.g., CO, CO_2, temperature to ensure that incinerators operate towards maximum combustion and destruction efficiencies).

Facilities applying for permits to operate a process which is not covered under the recommended procedures must prove or demonstrate that human health and the environment will not be threatened. To do so a comparison of probable emissions based on the wastes accepted will be required to be compared, via an acceptable dilution model with the ambient goals at the property line. Once the technology, however, is determined to be adequate, operating, design and construction procedures may be written as permit conditions. A more direct approach for obtaining a permit for new technologies is to demonstrate technological equivalence with those technologies covered under the recommended procedures. Like OSHA, monitoring for more than 400 pollutants for which standards apply will not be required at every facility. Enforcement activities should focus on design, operating and construction standards compliance.

Con: AN acceptable dilution model requires at the very least emission rates or concentrations for the pollutants regulated. No data is presently available nor a method presently in use to provide EPA or owners and operators with emission values.

The standards especially the ambient goals, must be carefully reviewed, revised and promulgated as amendments to Section 3004 of RCRA provisions or Section 112 of the CAA in order to more precisely define what is necessary to protect human health and the environment. In this option, emphasize must be placed on updating maximum concentration values for those judged inadequately protective or those for which limits are not prescribed already.

This option is a poor choice for regulating since resources must be devoted towards fenceline values and dispersion modeling. Such models are not available nor are means to relate disposal emissions to ambient.

4.1.5 Option 5

Promulgate performance standards which require compliance with design, construction, and operating procedures. Ambient air guidelines are provided via Section 1008 of RCRA in order to compare the adequacy of procedures to health-based goals.

Pro: This option reflects a strategy towards controlling air contaminant concentration levels and the need for air quality goals. In this option, prescribed operating and design specifications are the basis for performance standards, with ambient air guidelines (promulgated under Section 1008 of RCRA) provided to compare monitored air concentration levels with those listed in the guidelines. Since the ambient air guidelines would not be mandatory standards, they could be reviewed, evaluated, and revised without amending the Section 3004 regulations.

New toxicological and epidemiological information could be used to periodically revise the guidelines for particular air contaminants.

This option avoids prescribed ambient concentration limits which have not been evaluated by EPA for their adequacy or validity on a pollutant-by-pollutant basis. Additionally, this option avoids the complexity and costs associated with area source emission rate determinations, atmospheric dispersion modeling, or establishing individual air contaminant background levels. This option could be adopted as a permit condition at the discretion of permitting officials.

Con: As guidelines, the ambient air requirements are not enforceable unless adopted as permit conditions. As unenforceable standards, the use of ambient guidelines may not satisfy the mandate to protect human health and the environment by establishing performance standards. Additionally this option like Option 5 assumes faith in the prescribed concentration limits, the ability to determine emission rates and to model their transport.

Also, since this option involves utilizing a section (1008) of the Act for a purpose for which it was not intended it is a poor choice for regulations.

4.1.6 Option 6

Promulgate performance standards which require compliance with design, construction, and operating procedures. Provide a list of ambient air pollutants of concern to be monitored.

This option, like options 2 and 3 relies primarily on best available technology. Unlike option 2 extensive monitoring would be required to determine the adequacy of the technologies prescribed. Unlike option 3, no numerical ambient air goals are included. Regulatory activities would focus on evaluation of the ambient air data obtained, via monitoring, to determine if the air contaminant concentrations are of concern.

Pro: Like option 5 this option avoids a prescribed ambient air contaminant concentration limit. Also, the complexity and costs to industry and the government (associated with determining source emission rates and atmospheric dispersion modeling) would be avoided.

Con: This option would require extensive and costly ambient air quality monitoring anddata interpretation. This option does not provide a means for interpreting the data obtained by air quality monitoring. Also, the decision of what contaminant concentrations are of concern (or what standard of performance is necessary to protect human health and the environment) would, as in option 5, be made outside of Section 3004 and the public participation that accompanies the regulatory process.

Finally, this option may not satisfy the mandate to protect human health and the environment if more comprehensive standards based upon health are not prescribed. This option alone is a poor choice for air emission standards.

Option 7

4.1.7 <u>Performance standards proposed include the following provisions:</u>

A. <u>Compliance with applicable regulations promulgated pursuant to Clean Air Act (Sections 110, 111, and 112)</u>.

B. <u>For point sources (e.g., incineration); Compliance with design, construction, and operating procedures identified as good practicable control technology. Variances may be granted on the basis that proposed alternative methods for specific waste cases will result in equivalent degree of control (e.g., destruction) that would have been achieved by the control technology standards.</u>

This option comprises facets of the previous options to prescribe operating, design, and construction standards while also providing for variances for procedures that can be shown to be the equivalent of those prescribed.

<u>Pro</u>: Several facets of the previous options and their policy implications have been incorporated. However, this option does not include fenceline standards comprised of the worker standards times a safety factor. While this would limit the number of contaminants for which ambient human health and environmental limits are prescribed, it would also limit the formidable problems associated with the fenceline worker adopted limits. In summary these problems included:

1. a general lack of air modeling techniques for non-point sources that are sufficiently developed to be legally defensible.

2. A significant lack of support by the regulators and the regulatees that the limits provide human health and environental protection since a "limit" is also considered to be a "safe exposure".

Since OSHA regulations apply to the workplace, workers at hazardous waste treatment, storage and disposal facilities are also protected. Thus, air concentrations from the facilities must be less than OSHA limits. An adoption of these regulations by EPA provides a necessary measure of protection to human health and the environment since owners and operators could effectively meet OSHA standards by requiring workers to wear breathing protective devices.

OSHA air contaminant monitoring regulations are not expressly required unless non-point sources receive a reactive waste, an ignitable waste, a waste that is incompatable with those already disposed or is a volatile waste. Monitoring for compliance with the OSHA limits would be required if the owner/operator choses to dispose of any of the above listed waste in a non-point source.

5.0 Rationale for Chosen Regulations

Based on the selection of Option 7 which specifies compliance with design, construction and operating procedures identical as practicable control technology for incineration, the following regulations have been developed.

The basis for these design, construction and operating standards are explained in this section.

5.1 Proposed Regulations for Incineration

250.45-1 Incineration

(a) An owner/operator of an incinerator shall comply with the requirements of this Section when burning hazardous waste.

(b) Trial Burns

(1) The owner/operator shall conduct a trial burn for each hazardous waste which is significantly different in physical and chemical characteristics from any previously demonstrated under equivalent conditions. The trial burn shall include as a minimum the following determinations:

(i) An analysis of the hazardous waste for concentrations ~~of halogens and principal~~ hazardous components;

(ii) An analysis of the ash residues and scrubber effluent for the principal hazardous components;

(iii) An analysis of the exhaust gas for the concentrations of the principal hazardous components, hydrogen halides, CO, CO_2, O_2, and total particulates;

(iv) An identification of sources of fugitive emissions and their means of control;

(v) A measurement of combustion temperature and computation of residence time;

(vi) A computation of combustion efficiency and destruction efficiency;

(vii) A computation of scrubber efficiency in removing halogens;

(2) The results from each trial burn shall be submitted to the Regional Administrator.

(c) Monitoring

The owner/operator shall monitor and record the following in each trial burn and each operational burn:

(1) Combustion temperature;

(2) Carbon monoxide and oxygen concentrations in the exhaust gas on a continuous basis, and

(3) The rate of hazardous waste, fuel, and excess air fed to the combustion system at regular intervals of no longer than 15 minutes.

(d) Combustion Criteria

(1) The incinerator shall operate at greater than 1000° C combustion temperature, greater than 2 seconds retention time, and greater than 2 percent excess oxygen during incineration of hazardous waste, unless the waste is hazardous because it contains halogenated aromatic hydrocarbons, in which case the incinerator shall operate at greater than 1200° C combustion temperature, greater than two seconds retention time, and greater than 3 percent excess oxygen during incineration of the hazardous waste.

(2) The incinerator shall be operated at a combustion efficiency equal to or greater than 99.9 percent, as defined in the following equation:

$$CE = \frac{C_{CO_2}}{C_{CO_2} + C_{CO}} \times 100$$

Where:

CE = combustion efficiency

C_{CO_2} = concentration of CO_2 in exhaust gas

C_{CO} = concentration of CO in exhaust gas

Incinerators that burn waste that is hazardous only because it is listed in Section 250.14(b)(1) are exempt from this requirement.

Note to (b)(1) and (2): Incinerators may operate at other conditions of temperature, retention time, and combustion efficiency if the facility owner/operator can demonstrate that an equivalent degree of combustion will be provided under alternate combustion criteria to the conditions prescribed above.

(3) The incinerator shall be operated with a functioning device to cut off automatically waste feed to the incinerator when significant changes occur in flame combustion temperature, excess air, or scrubber water pressure.

(e) Destruction and Emission Control Criteria

(1) The incinerator shall be designed, constructed, and operated to maintain a destruction efficiency of 99.99 percent as defined in the following equation:

$$DE = \left(\frac{W_{in} - W_{out}}{W_{in}}\right) X\ 100$$

Where:

DE = destruction efficiency

W_{in} = mass feed rate of principal toxic components of waste going into the incinerator (g/min)

W_{out} = mass emissions rate of principal toxic components in waste in the incinerator combustion zone (g/min).

Incinerators that burn waste that is hazardous only because it is listed in Section 250 .14(b)(1) are exempt from this requirement.

(2) An incinerator used to thermally degrade hazardous waste containing more than 0.5 percent halogens shall be equipped with emission control equipment capable of removing 99 percent of the halogens from the exhaust gases.

(3) The incinerator shall be operated in a manner that assures that emissions of particulate matter do not exceed 270 milligrams per dry standard cubic meter (0.12 grains per dry standard cubic foot) at zero excess air. Compliance with this requirement may be achieved by having particulate emissions which, when corrected to 12 percent CO_2 by the formula below, are less than 180 milligrams per standard cubic meter (0.08 grains per dry standard cubic foot).

Where:

$$PE_c = PE_m \times \frac{C_s}{C_m \times 1.5}$$

PE_c = corrected particulate emissions, mg/m^3 (gr/dscf)

PE_m = measured particulate emissions, mg/m^3 (gr/dscf)

C_s = stoichiometric CO_2 concentration, ppm

C_m = measured CO_2 concentration, ppm

(4) The incinerator shall be designed, constructed, and operated so that fugitive emissions of unburned hazardous waste and combustion products are controlled.

5.2. Rationale for Proposed Incineration Regulations

<u>Regulation</u>

(b) Trial Burns

(1) The owner/operator shall conduct a trial burn for each hazardous waste which is significantly different in physical and chemical characteristics from any previously demonstrated under equivalent conditions. The trial burn shall include as a minimum the following determinations:

(i) An analysis of the hazardous waste for concentrations of halogens and principal hazardous components;

(ii) An analysis of the ash residues and scrubber effluent for the principal hazardous components;

(iii) An analysis of the exhaust gas for the concentrations of the principal hazardous components, hydrogen halides, CO, CO_2, O_2, and total particulates;

(iv) An identification of sources of fugitive emissions and their means of control;

(v) A measurement of combustion temperature and computation of residence time;

(vi) A computation of combustion efficiency and destruction efficiency;

(vii) a computation of scrubber efficiency in removing halogens;

(2) The results from each trial burn shall be submitted to the Regional Administrator.

Rationale

This regulation requires test burns to be conducted to demonstrate that the incinerator will comply with all of the regulations under 250.45-1. Measurements and analysis of the waste feed, combustion gases, and scrubber effluent will allow the determination of the degree of destruction of the waste. Also operating conditions adequate to destroy the waste such as temperature, residence time, air flow and other variables can be determined and be made part of the permit conditions.

EPA is preparing a guidance document on incineration of hazardous wastes which will address the aspects of test burns and monitoring methodology. Also specific guidance will be given to permitting officials to make a determination of what is a significantly different waste and decide if a test burn will be required.

Regulation

(c) Monitoring

The owner/operator shall monitor and record the following in each trial burn and each operational burn:

(1) Combustion temperature;

(2) Carbon monoxide and oxygen concentrations in the exhaust gas on a continous basis, and

(3) The rate of hazardous waste, fuel, and excess air fed to the combustion system at regular intervals of no longer than 15 minutes.

<u>Rationale</u>

Monitoring for carbon dioxide and carbon monoxide allows incinerator operators to determine the combustion efficiency (the extent to which an introduced organic waste is being oxidized). This combustion efficiency can be determined by the following formula:

$$\frac{C_{co_2}}{C_{co_2} + C_{co}} \quad x \quad 100$$

The higher the amount of carbon dioxide and the less the amount of carbon monoxide, the higher will be the combustion efficiency.

Destruction efficiency is a comparison of the amount of a waste or chemical substance introduced to incineration compared with the amount emitted as in the following formula:

$$\frac{C_{input} - C_{emitted}}{C_{input}} \quad x \quad 100$$

For selected wastes this is information obtained during test burns. On a daily basis, however, it is impractical to monitor every chemical substance in the hazardous waste fed into the incinerator and every possible product that may result. Monitoring carbon dioxide and carbon monoxide and comparing the two allows an indication of destruction efficiencies since it compares the amount an organic waste has been partially (CO) and completely (CO_2) oxidized.

Although an organic waste may be less oxidized than to carbon dioxide and water (ketones, alcohols acids), the amount of carbon monoxide will indicate that the waste requires more activation energy or oxygen atoms to reach complete oxidation and destruction of any intermediates. Hence, the hydrocarbon bonds need not be monitored.

Excess oxygen allows owners and operators another means for insuring that sufficient oxygen is available for thermal oxidation.

Pursuant to the authority of Section 6 (e) (1) the Toxic Substances Control Act (TSCA) precedent setting regulations for the disposal of polychlorinated bipehenyls were prescribed. These requirements included benchmarks for PCB incinerator operations. The following was promulgated in 40 CFR 761.40 (a)(7).

> "At a minimum continous monitoring and recording of combustion products and incineration operations shall be conducted for the following parameters whenever the incinerator is incinerating PCBs: (i) O_2 (ii) CO; (iii) CO_2".

This above precedent for the monitoring of CO, CO_2, and O_2 is also needed for incinerating hazardous wastes other than PCBs since many will be more toxic and more difficult to incinerate.

The requirement to monitor and record the rate of hazardous waste feed, fuel and excess air to the incinerator every 15 minutes assures that these important operating variables will be controlled and a permanent record established for enforcement.

The PCB Disposal and Marking regulation, 40 CFR 761.40 (a) (3), promulgated under authority of section 6 (e) (1) of the Toxic Substances Act requires:

> "The rate and quantity of PCB's (liquid) which are fed to the combustion system shall be measured and recorded at regular intervals of no longer than 15 minutes."

This precedent for measuring operating parameters is needed since many hazardous wastes are more toxic and more difficult to incinerate.

<u>Regulation</u>

(d) Combustion Criteria

(1) The incinerator shall operate at greater than 1000^{o} C combustion temperature, greater than 2 seconds retention time, and greater than 2 percent excess oxygen during incineration of hazardous waste, unless the waste is hazardous because it contains halogenated aromatic hydrocarbons, in which case the incinerator shall operate at greater than 1200^{o} C combustion temperature, greater than two seconds retention time, and greater than 3 percent excess oxygen during incineration of the hazardous

waste.

Rationale

An incinerator must be properly designed to provide adequate mixing of the waste and combustion air to obtain complete oxidation of the waste. Temperature, residence time and turbulance are interrelated in the combustion process.

Incinerator operating conditions for a two second retention time at or near 1000° with adequate excess air has proved to be sufficient for more than 99.9 percent destruction of most organic pesticides studied. Most test burn data collected by EPA has been on the incineration of pesticides (MRI, 1978). EPA in 1974 defined a pesticide incinerator in regulations for pesticide disposal as an installation capable of controlled combustion of pesticides at a temperature of 1000°C (1832°F) and a two second retention or dwell time in the combustion zone, or some lower temperature and sufficient swell time to assure complete conversion of the specific pesticide to inorganic gases and solid ash residues.

The decomposition temperatures and products vary widely for the variety of organic wastes amenable for destruction in hazardous waste incinerators.

Temperatures for "complete" combustion for those pesticides tested in laboratory experiments by Mississippi State University and University of Dayton Research Institute, and in pilot scale studies by the Midwest Research Insitute are shown in table 4. The definition of complete combustion varies from 99.9 to 99.99 percent, dependent upon the sensitivity of the tests used by three groups of researchers.

Incinerators designed to destruct hazardous wastes should insure a minimum of 1000°C and a minimum two second retention time, although a design could be tailored for specific wastes with an adequate margin of safety.

Halogenate aromatic hydrocarbons, as a class are the most thermally stable organic compounds in commercial use today. The use of Polychlorinated Biphenyls and polychlorinated biphenyls in high temperature heat resistant applications is the most common example of this thermally stable group of organics. The PCB Disposal and Marking regulations 40 CFR 751.40 (a) (2) (i), promulgated under the Toxic Substance Act recognizes this:

> "Maintenance of the introduced liquids for a 2 second dwell time at 1200°C (1100°C) and 3 percent excess oxygen in the stock gas..."

Thus this regulation recognizes the need for more stringent destruction conditions for this class of compounds.

TABLE 5 TEMPERATURES OF COMPLETE COMBUSTION OF PESTICIDES DETERMINED IN LABORATORY EXPERIMENTS

Pesticide	Temperature of complete combustion °C	(°F)	Source[a]
Aldrin			
Recrystallized	570	(1058)	MRI
19% granular	700	(1292)	MRI
Atrazine			
Reagent grade	650	(1202)	MSU
Technical grade	600	(1112)	MRI
80% wettable powder	600	(1112)	MSU
80% wettable powder	600	(1112)	MRI
Bromacil			
Reagent grade	716	(1321)	MSU
80% wettable powder	671	(1240)	MSU
Captan			
Technical grade	600	(1112)	MRI
50% wettable powder	600	(1112)	MRI
2,4-D (isooctyl ester)			
Reagent grade	602	(1116)	MSU
4 lb/gal. formulation	623	(1153)	MSU
DDT			
Reagent grade	500	(932)	UDRI
Reagent grade	560	(1040)	MSU
Technical flakes	850	(1560)	MSU
DNBP			
Reagent grade	639	(1182)	MSU
3 lb/gal. formulation	656	(1213)	MSU
DSMA			
Reagent grade	665	(1229)	MSU
3.2 lb/gal. formulation	612	(1135)	MSU
Dalapon			
Reagent grade	250	(482)	MSU
85% wettable powder	850	(1562)	MSU

(continued)

TABLE 5 (continued)

Pesticide	Temperature of complete combustion °C	(°F)	Source[a/]
Dicamba			
Reagent grade	840	(1544)	MSU
4 lb/gal. formulation	850	(1562)	MSU
Dieldrin			
Reagent grade	620	(1148)	MSU
1.5 lb/gal. formulation	640	(1148)	MSU
Diuron			
Reagent grade	775	(1427)	MSU
80% wettable powder	550	(1022)	MSU
Kepone®			
Reagent grade	500	(932)	UDRI
Malathion			
Reagent grade	663	(1225)	MSU
5 lb/gal. formulation	715	(1319)	MSU
25% wettable powder	650	(1202)	MRI
Mirex			
Reagent grade	700	(1292)	UDRI
Technical grade	850	(1562)	MRI
Nemagon®			
Reagent grade	800	(1472)	MSU
8.6 lb/gal. formulation	596	(1105)	MSU
PMA			
Reagent grade	545	(1013)	MSU
95% water dispersible	646	(1195)	MSU
Paraquat			
Reagent grade	613	(1135)	MSU
2 lb/gal. formulation	592	(1098)	MSU

(continued)

TABLE 5 (continued)

Pesticide	Temperature of complete combustion °C	(°F)	Source[a/]
Picloram (potassium salt)			
Reagent grade	550	(1022)	MSU
Recrystallized	900	(1652)	MRI
11.6% solution	640	(1184)	MSU
10% pellet formulation	400	(752)	MRI
Carbaryl			
Reagent grade	724	(1335)	MSU
10% dust	678	(1252)	MSU
2,4,5-T (acid)			
Reagent grade	717	(1323)	MSU
4 lb/gal. formulation	731	(1348)	MSU
Toxaphene			
Technical grade	300[b/]	(572)	MRI
20% dust	710	(1310)	MRI
Trifluralin			
Reagent grade	879	(1614)	MSU
4 lb/gal. formulation	842	(1548)	MSU
Vernolate			
Reagent grade	447	(837)	MSU
6 lb/gal. formulation	508	(946)	MSU
Zineb			
Reagent grade	840	(1544)	MSU
Technical grade (85%)	800[c/]	(1472)	MRI
75% wettable powder	690	(1274)	MSU
75% wettable powder	800	(1472)	MRI

Source: State-of-The Art-Report: Pesticide Disposal Research, Wilkinson, R.R.; Kelso, G.L.; and Hopkins, F.C.; EPA-600/2-78-183

Regulation

(2) The incinerator shall be operated at a combustion efficiency equal to or greater than 99.9 percent, as defined in the following equation:

$$CE = \frac{C_{co_2}}{C_{co_2} + C_{co}} \times 100$$

Where:

CE = combustion efficiency

C_{co_2} = concentration of CO_2 in exhaust gas

C_{co} = concentration of CO in exhaust gas

Incinerators that burn waste that is hazardous only because it is listed in Section 250.14(b)(1) are exempt from this requirement.

Rationale

As described in (e) Monitoring above, the quantities of CO and CO_2 in the combustion gases are direct indicators of the degree of combustion of hydrocarbons in an incinerator. Combustion efficiencies in excess of 99.9 percent were attained in the series of test burns performed by EPA in commercial scale incinerators under contract 68-01-2966 see table 2, page 13 . Thus, 99.9 percent combustion efficiencies are state-of-the-art and can be achieved in day to day operations of incinerators.

Waste listed in 250.14(b)(1) are hazardous due to their infectious nature only. 250.14(b) specifies conditions for incineration or sterilization of these waste by reference to appendix VII which details treatment, storage and disposal procedures for these wastes.

Regulation

Note to (b) (1) and (2): Incinerators may operate at other conditions of temperature, retention time, and combustion efficiency if the facility owner/operator can demonstrate that an equivalent degree of combustion will be provided under alternate combustion criteria to the conditions prescribed above.

Rationale

This note allows flexability in prescribed operating conditions for wastes and incinerator types. Equivalency must be determined for different temperatures and retention times. Normally test burns will be required to determine the destructuon efficiency of a given incinerator for the waste or wastes that will be burned during the lifetime of the incinerator.

Regulation

(3) The incinerator shall be operated with a functioning device to cut off automatically waste feed to the incinerator when significant changes occur in flame combustion temperature, excess air, or scrubber water pressure.

Rationale

Numerous damage incidents have occured at municipal and chemical incinerators due to one of several operating problems. For example, the flame may be extinguished but wastes may continue to be fed into the hot combustion chamber. These wastes entering the hot chamber may volatilize some of the constituents, depending on the temperature of the hot zone and the vapor pressure of the constituents. Without the flame the combustion process will be incomplete and all of the wastes feed may not reach a high enough pressure or a sufficiently high temperature for chemical oxidation.

Similiarly, when the temperature in the combustion zone decreases ~~due to a lack of oxygen, a flame out,~~ excess moisture, or other reason, the wastes introduced to the combustion zone will not be completely oxidized, and products of incomplete combustion will not necessarily result. Odors from incineration of municipal waste may result when temperature decreases to below 700°C. In the case of the incineration of hazardous wastes, however, the loss of sufficient combustion temperature can result in the formation of hazardous partially oxidized by-products. Some of the most odorous oxygenated organics include the aldehydes, ke tones, esthers, and alcohols. If complete combustion is provided, CO_2 and H_2O will be formed instead.

Waste feed cut-off, when temperatures in the combustion zone decrease to a range where incomplete combustion by-products are formed would prevent emissions of these by-products significantly. The proper temperatures for various wastes must be prescribed in the permit based upon the type of design of the incinerator being permitted and the chemical and physical characteristics of the wastes expected to be burned.

The specific amount of air required for complete combustion relates to the stoichiometry of the oxidation of a given waste to its complete oxidation s tates. If a fan were to malfunction such that no air (and hence oxygen) were supplied to the combustion zone, the amount of oxygen present would be used swiftly until not enough was available for complete combustion of the wastes. Similiar to flame out and low temperature conditions, a lack of sufficient air is conducive to formation of the products of incomplete combustion. Again, automatic waste feed connected to the fans or other source of excess oxygen will lessen the risk to adverse effects of such a condition.

Wet or caustic scrubbers are important not only in controlling acid gases from entering the environment but also entering the stack where significant corrosion of the stack may take place. For example should a scrubber malfunction during the combustion of chlorinated organic waste such as PVC, HCL will be introduced to both the stack and the enviroment.

(e) Destruction and Emission Control Criteria

(1) The incinerator shall be designed, constructed, and operated to maintain a destruction efficiency of 99.99 percent as defined in the following equation:

$$DE = \left(\frac{W_{in} - W_{out}}{W_{in}} \right) X\ 100$$

Where:

DE = destruction efficiency

W_{in} = mass feed rate of principal toxic components of waste going into the incinerator (g/min)

W_{out} = mass emissions rate of principal toxic components in waste in the incinerator combustion zone (g/min).

Incinerators that burn waste that is hazardous only because it is listed in Section 250 .14(b)(1) are exempt from this requirement.

Rational

The test work performed by EPA under contract 68-01-2966 to demonstrate destruction of hazardous chemical wastes produced destruction efficiencies of 99.99 percent in five commercial scale different incineration units. See Table 2 for a summary of the test work. The destruction efficiencies in each of the tests was calculated using the proposed formula above.

Thus, EPA has determined that 99.99 percent destruction efficiency is state-of-the-art and can be routinely obtained in commercial scale incinerator.

Regulation

(2) An incinerator used to thermally degrade hazardous waste containing more than 0.5 percent halogens shall be equipped with emission control equipment capable of removing 99 percent of the halogens from the exhaust gases.

Ratonal

Water and caustic scrubbers are capable of significantly controlling particulate and gaeous combustion products that would otherwise be released directly to the environment through the incinerator stack. Hydrogen halides, (HCL, HF,HBr), are extremely corrosive gases, which also are hazardous to

both human health and the environment at low concentrations. Scrubbers effectively remove these acids from the gases, in addition to removing other hazardous soluble combustion products (i.e. SO_x). The Technology for removing 99 percent of any of the hydrogen halides has been effectively demonstrated. (See table 2). Pursuant to the authority of Section 6(e)(1) the Toxic Substances Control Act (TSCA), regulations for the disposal of polychlorinated biphenyl were prescribed. These requirements include bench marks for PCB incineration. "Water scrubbers shall be used for HCL control during PCB incineration and shall meet any performance requirement specified by the Regional Administrator. Scrubber effluent shall comply with applicable water quality Standards, EPA Water Quality Criteria, and any other State and Federal laws and regulations. An alternate method of HCL control may be used if the alternate method has been approved by the Regional Administrator."

Regulation

(3) The incinerator shall be operated in a manner that assures that emissions of particulate matter do not exceed 270 milligrams per dry standard cubic meter (0.12 grains per dry standard cubic foot) at zero excess air. Compliance with this requirement may be achieved by having particulate emissions which, when corrected to 12 percent CO_2 by the formula below, are less than 180 milligrams per standard cubic meter (0.08 grains per dry standard cubic foot).

Where:

$$PE_c = PE_m \times \frac{C_s}{C_m \times 1.5}$$

PE_c = corrected particulate emissions, mg/m^3 (gr/dscf)

PE_m = measured particulate emissions, mg/m^3 (gr/dscf)

C_s = stoichiometric CO_2 concentration, ppm

C_m = measured CO_2 concentration, ppm

Rationale

For this correction CO_2 shall be measured in the combustion zone. Stack testing shall be conducted once a year to measure particulate emissions. Stack samples shall be collected using EPA Method 5.

Particulate emissions from a hazardous waste incinerator may contain toxic metal particles as well as uncombusted or partially combusted hazardous waste. In the case where a wet scrubber is required to remove hydrogen halide and other adverse combustion product gases, the particulate emissions level is expected to be controlled below the proposed standard. Currently municipal incinerator particulate levels are regulated at 180 mg/m^3 by Federal Standards for units handling over 50 tons/day. Therefore, the state-of-the-art exists for control of particulate matter at the proposed level.

Regulation

(4) The incinerator shall be designed, constructed, and operated so that fugitive emissions of unburned hazardous waste and combustion products are controlled.

Rationale

Fugative emissions are defined as those emitted from other than a stack or vent. A stack or vent is designed to allow air contaminants to be emitted to the atmosphere at elevations that are conducive to dispersion.

Fugitive emissions often are a significant source of local air contamination at ground level particularly when dispersion takes place in a horizontal plane without mixing into the thousands of cubic feet of air between the top of a stack and human breathing level.

Fugitive emissions from hazardous waste incinerators can be of particular concern since the constituents of the emissions could include unburned waste materials and by-products of the combustion process. Fugative emissions can be adequately controlled by two methods. The first is to seal all leaks in the incinerator system. The second method to control fugative emissions is to operate the incinerator at a negative pressure (i.e. less than atmospheric pressure). The negative pressure will insure that any system leaks will pass outside air into the system rather than combustion gases flowing out.

Appendix I

The following are damage incidents of importance to the development of a strategy to protect human health and the environment from hazardous air emissions.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 1

July 8, 1977

Waste Incineration Causes Air Pollution in Connecticut

In early 1974 reports of air and groundwater pollution cause by the incineration of wastes were made. The Air Compliance Division of the Connecticut Department of Environmental Protection subsequently closed down two organic solvents recovery operations. Solvents Recovery in Southington, Connecticut was contaminating the air with heavy metals from the incineration of solvent sludges including lead and zinc, which in turn contaminated the soil and groundwater in the area and the company's own well. Incineration was ceased in early 1974. In Beacon Falls, Connecticut, a similar operation was closed for reasons of air pollution.

REFERENCES

The information summarized above was recorded by Alice Giles, February 1975. Her sources of information were:

1. Jeff Heidtmann, Hydrogeologist, Connecticut Department of Environmental Protection.
2. Bill Hegener, Water Compliance Division, Connecticut Department of Environmental Protection

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 2

July 8, 1977

Air Pollution from Frequent Landfill Fires

1. Personal Damage - None documented

2. Environmental Damage - Contamination of the air from burning of magnesium chips in the landfill.

3. Economic Damage - None documented

4. Cause of Problem - Improper disposal of magnesium chips and filings

5. Type and Quantity of Hazardous Waste - An unknown quantity of magnesium chips and filings were discarded via surface disposal for an unknown number of years. Other wastes which also may have been dumped at the site were not identified.

6. Source of Waste - Valley Metal Co., Centerbrook (town or village) in Essex, Connecticut

7. Date of Incident - About 1970

8. Location - Essex, Connecticut

9. Status - Unreported

10. Remedial Action Taken - Unreported

11. Legal Action Taken - Unreported

12. Narrative - Valley Metal, Co., Essex, Connecticut disposed of magnesium chips and filings in a privately owned dump site for an unspecified period of time. The waste was probably co-mingled with other fill material, however, no information is available on the type and quantity of such material. Around 1970 frequent intense fires and explosions were reported. No information is available concerning remedial actions or legal actions. It is not known whether disposal of the magnesium wastes and/or fires and explosions are still occuring at the site.

REFERENCES

The above information was recorded by Alice Giles, OSW, EPA in February 1975. Her source of information was Bill Hegener, Water Compliance Division, Connecticut Department of Environmental Protection.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 3

July 7, 1977

Springfield Township, Pennsylvania[1]

1. Personal Damage - None documented

2. Environmental Damage - Contamination of air, and surface and groundwater down gradient from the landfill. Contaminants include oily wastes and nickel.

3. Economic Damage - Compacting bulldozer destroyed, unidentified number of fish killed

4. Cause of Problem - Drums containing unidentified industrial wastes exploded during compaction. Resulting fire burned for several days. Fish kill is attributed to runoff from a recently oiled access road. Probable groundwater contamination attributed to chemical wastes in the landfill.

5. Type and Quantity of Hazardous Waste - Occasionally tank-car quantities and many barrels of unidentified chemical wastes were compacted and buried with other fill materials for an unspecified period of time.

6. Sources of Waste - Unidentified

Date of Incident - Incident occured in 1971.

8. Location - Mayer Landfill, Springfield Township, Delaware Co., Pennsylvania

9. Status - The site was closed and covered some time between 1971 and August 1975.

10. Remedial Action Taken - Leachate collection and subsequent transport to a public treatment plant for treatment began either after the 1971 fire of after the 1974 fish kill. Leachate collection may still be occurring or may have been discontinued when the landfill was closed.

11. Legal Action Taken - None documented

12. Narrative - For an unspecified period of time the Mayer Landfill located in Delaware County, Pennsylvania, accepted all types of industrial wastes. Quantities of industrial wastes ranged from drums to tank car loads. Indications are that other types of fill materials were also accepted. The industrial wastes were probably co-mingled with these fill materials and compacted during disposal operations. At the time of the incident the surface of the landfill was approximately 100 feet above the original ground level. The area occupied by the landfill was not specified. The landfill site lies in the floodplain of Crum Creek.

In 1971 a drum exploded during compacting operations and caused a fire that burned for several days. The air around the landfill was polluted during the fire.[2] The compacting bulldozer was destroyed. There is no indication that any remedial action was taken by the landfill operators, or by the state, local, federal government as a result of this incident.

In 1973, and possibly earlier, it was noted that leachate from the landfill occasionally flowed into Crum Creek. There was also some evidence of groundwater contamination at the landfill site. A leachate sample collected on December 6, 1973 showed 0.360 ppm Ni. fish kill which occurred on June 4, 1974 was attributed to oil run-off from oiling the road leading to the site.

At some time, probably in 1974, surface leachate collection was begun. The leachate was treated at an unspecified public treatment plant. The landfill was closed and covered some time before August 1975.

REFERENCES

1. All information contained in this summary was obtained from handwritten notes from what was probably a telephone conversation on August 14, 1975 with Wayne Lyn of the Solid Waste Commission of the Pennsylvania Department of Environmental Resources. The EPA person who jotted down the information was not identified.

2. This statement was not part of the conversation with Lyn. Comes from unidentified EPA source.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 4

July 14, 1977

Air Pollution at Evaporation Ponds

1. Personal Damage - Noxious odors, eye and throat irritation.

2. Environmental Damage - Contamination of air by fumes from ponding of liquid organic waste

3. Economic Damage - Corrosive damage to homes

4. Cause of Problem - Fumes (organic vapors, acidic vapors, etc.) from the surface of industrial liquid waste evaporation ponds

5. Type and Quantity of Hazardous Waste - For years, unspecified (but large quantities) or a variety of industrial waste liquids have been disposed of via evaporation in ponds. Many of the constituents in the wastes are more volatile than water.

6. Source of Waste - Industrial and some municipal sources

7. Date of Incident -Numerous incidents occurring over a period of several years.

8. Location - San Francisco Bay Area

9. Status - Operations continue

10. Remedial Action Taken - None specified

11. Legal Action Taken - Numerous citations, usually by local Air Pollution Control Boards.

12. Narrative - Evaporation ponds have been used in certain areas of the country for many years for disposal of liquid and semi-solid waste of industrial origin. As an example of the kinds of air pollution associated with many of the disposal activities, some experiences with Industrial Tank, Inc., are given below.

    Industrial Tank, Inc. operates several evaporation pond sites in the San Francisco Bay Area. Three sites, the Martinez Site, the Antioch Site, and the Benicia Site, are discussed here.

    The Antioch site operated for many years. It is located in Contra Costa County, California, and was originally located in the center of a Superior Oil tank farm. Its purpose was to receive waste water containing substantial amounts of oil and recover as much of the waste oil as possible. This recovered oil was then sold to various sources and used in oiling roadways. The site consisted of a series of ponds through which the water-borne waste flowed. At some point in the ponding procedure skimming equipment removed the portion of the water which contained high concentrations of the oil. The final pond acted as an evaporation pond for the sludge material contained in the waste. This site operated in the manner described above for an unspecified number of years during which time Superior Oil abandoned the tank farm and sold part of the land to private individuals who received zoning variances and developed the area into a residential community. Some time after the subdivision was build residents began to complain of odor problems from the disposal activity. Many complaints to the Air Pollution Control Board were made. The citizens filed a one million dollar law suit against Industrial Tank's Antioch site for personal damage including damage to the houses of the home owners. These homes were suffering damage such as paint discoloration and peeling.

Apparently, the Antioch site had never received a permit to operate a Class I landfill but had operated for several years with the tacit approval of the California Water Quality Control Board. They did routinely send the analysis of water from observation wells around the perimeter of the site to the Water Quality Control Board. When the pressure from residents became intense, the Water Quality Control Board gave notice to the Antioch site that it should be closed. The first notice came in July 1973 and was deferred until January 1974. At this time the process of filling in the pond began. The method for filling was to add municipal refuse to the liquid in the ponds until they would be gradually filled with municipal refuse. The process of closing the site began in January of 1974 and continued for an unspecified period of time. It is not known whether the site has been completely closed at this time. During the process of closing the site one fire occurred July 1974. It appears that the fire may have been deliberately set. (This fire is the subject of a separate Air Hazardous Waste Damage Report.)

The Martinez site is an active site. It consists of four evaporation ponds. Two (A and D) are used in a biological treatment method. The other two (B and C) rely on evaporation as the disposal mechanism.

The biodegradation pond receives flock containing a large variety of unidentified material from oil company effluents. It is generally quite odorous. This flock is pumped into pond A and then periodically the more solid material is pumped into pond D where it is disced frequently. This allows for anaerobic degradation procedures. The efficency of the aerobic biodegradation process is questionable.

The remaining two evaporation ponds accept a wide variety of liquid organic waste. These include acids, bases, flourides, solvents, and organic oils. Some of the organic oils are recovered and burned in an incinerator owned and operated by Industrial Tank. The kinds and efficiencies of air pollution control equipment on this incinerator were not identified. The pH of the waste materials is adjusted in holding tanks prior to discharge to the ponds. The pH generally ranges from 6.8 to 7 before discharge in ponds. Once the materials are contained in the ponds the pH appears to gradually become more acidic.

Some biological activity does take place. These ponds are largely an anaerobic process since the lagoons are not aerated. Some of the materials produced as the wastes degrade under anaerobic, reducing conditions include hydrogen sulfide, organic sulfur compounds, nitrogen bases and possibly ammonium chloride. Occasionally blue smoke can be observed over a pond. It has been postulated that this occurs when ammonia evaporates from one pond, HCl evaporates from the adjacent pond, and the two are mixed by prevailing winds to form ammonium chloride. This does not always account for the blue smoke because the smoke has been observed when the winds are blowing the wrong way. In addition to these kinds of materials which are produced while the material is in the pond, many of the materials discharged to the ponds are volatile.

Numerous citations have been issued against the Martinez facility, and there have been complaints from near by residents in Martinez and Concord. In the summer time very bad odors commonly occur in the evening and are detectable many miles away. The composition and quantities of materials evaporating to the air from this site have not been determined. Occasionally certain wastes are slipped into a pond which cause severe odor problems. These are generally the ones which result in citations. There appears to be some degree of monitoring by the San Francisco Bay Area Air Pollution Control Board; however, the extent of this surveillance is unknown. Whatever the extent of the surveillance, contaminants to the air continue to be released. This site does have a permit to operate as a Class I hazardous waste disposal site.

The Benecia site is a Class I hazardous waste disposal site and accepts exclusively hazardous wastes, sludges, and other solids which may at some time be classified as Class I material. It does not accept any municipal refuse. This site, as is the case in the Martinez site, consists of a series of evaporation ponds. The principle difference between the two sites is that the odorous wastes are treated and handled at the Martinez site while the more non-odorous wastes are handled at the Benecia site. The Benecia site also has a sludge treatment area. The site was originally owned by J & J Disposal, Inc. and was subsequently purchased by Industrial Tank, Inc. To operate the site as a Class I disposal site, Industrial Tank, Inc. built a retaining wall along the bottom of the site. They accept plastic and acidic waste materials. For example, they accept wastes from Du Pont Chemical's titanium dioxide operation. The odor problems described for Martinez apply to Benecia as well although the odor problems appear to be slightly less.

REFERENCES

Case #21 of the table entitled "Public Health and Environmental Damage Assessment Inventory," completed by Bob Testani, OSW, EPA, undated. The source of the information was Dave Storm, California Department of Health.

2. Karen Slimak, Environmental Engineering Division, TRW, Inc. July 14-15, 1977. Report of Verbal Communications with Mr. Carl Schwartzer, Division of Vector and Solid Waste Control, California Department of Health.

VERBAL COMMUNICATION REPORT

Call From: Karen Slimak, TRW, Inc., Consulting to EPA (Contract #68-01-4644)

Call To: Mr. Carl Schwartzer
Vector and Solid Waste Control Division
California Department of Health
415-843-7900 X434

Date: July 14-15, 1977

Subject: Air Pollution Incidents at Industrial Tank, Inc. Evaporation Ponds

The following information regarding the air pollution incidents associated with Industrial Tank, Inc. was received from Mr. Carl Schwartzer via telephone conversation on July 14-15, 1977. Three sites operated by Industrial Tank were mentioned. These are the Martinez site, the Benecia site, and the Antioch site. The Martinez site is also known as the Baker site and the Vine Hill site; the Vine Hill name denotes the processing equipment used to blend the various waste materials and the Baker site refers to the evaporation pond area.

Antioch site (Contra Costa County, California);

- The Antioch facility is now either completely abandoned or in the process of being filled in and abandoned.

- The site during active operation was designed as an oil recovery facility. There were several ponds in a series. Waste oil was added to the first pond and allowed to flow through the pond system during which time surface skimming was accomplished with floatation equipment. One of the ponds was designed as a drop out pond for the sludge from the oil. All materials not skimmed from the surface were retained in the evaporation pond system. The recovered oil (with its relatively high water content) was sold for use as road oil.

- The Industrial Tank oil recovery facility operated for many years (exact number of years unspecified). The facility was initially surrounded by a Superior Oil tank farm. Superior Oil subsequently sold the property, it was rezoned for residential use and houses were built.

- Complaints from near-by residents began. They reached a peak in about 1972. At which time, a coalition of residents filed a one-million dollar suit against Industrial Tank. Industrial Tank counter-sued for three million dollars. There appeared to be some cooperation with local air pollution inspectors. The inspectors passed out forms for the residents to fill out rather than interviewing each complaintant and filling out the forms as required. Other efforts to harass the Industrial Tank facility included daily calls to Industrial Tank and to the Air Pollution Control Board concerning odors. This was apparently an activity of a few residents who took it upon themselves to call daily. The suits progressed to the point where depositions started to be taken, but then the lawyer for the citizens group dropped out. Eventually both suits were dropped.

- In 1973 the Water Quality Control Board decided to close the landfill. The site had apparently never received a Class I landfill permit but had been operating as a Class I site with the tacit approval of the Water Quality Control Board. Periodically samples from observation wells in the vicinity were submitted to the Water Quality Control Board. The notice for closure was received in July 1973 and deferred until January 1974 when waste oils were no longer accepted at the facility.

- The process of abandoning the site included gradually filling the pond with municipal refuse.

- When one of the ponds was approximately one-third filled with municipal refuse a fire occurred on the morning (1 a.m. through 5 a.m.) of July 5. The fire was apparently not started by spontaneous combustion of the fill material. Although the exact cause of the fire remains undetermined possibilities include fire crackers, hot charcoal in trash, and malicious mischief. The Fire Department determined that the fire started in the corner where the most recent garbage dumping had occurred. The size of the pond involved was approximately one-half acre with an undetermined depth. The fire flared twice in the 1 a.m. to 5 a.m. time period.

Martinez site:

- This is an active facility. It consists of four evaporation ponds. Two ponds are used for biodegradation of the materials from oil refineries. It is placed in pond A where anaerobic degradation takes place and the sludge from that pond is pumped into pond D where ~~it is disced almost~~ continually to allow for aerobic degradation. Probably the efficiency of ~~biodegradation is low because there is no mechnaism~~ for periodic removal of accumulated salt although there is a conveniently available area for draining the liquid. The two remaining ponds (B and C) receive wastes for evaporation. Anaerobic degradation occurs here.

- This site has received several citations from the local Air Pollution Control Authority. The frequency of citations and of complaints increases in the summer time when there are very bad odors. Some evenings the odors can be detected for many miles. The City of Concord is considering a suit against the facility.

- Occasionally a blue smoke can be observed over the pond. This is possibly ammonium chloride formed by the reaction of ammonia and hydrogen chloride gases from adjacent ponds. This does not always explain the appearance of the blue smoke because it has been observed when the winds were blowing the wrong way to allow for mixing of the two gases.

- There is some H_2S odor occasionally. Other odors are from chlorinated hydrocarbons.

- The pH of the material discharged into the pond is between 6.8 and 7 (this is to allow for protection of the pipes which convey the wastes to the pond); the pH probably increases in acidity with time. The ponds are largely anaerobic. (Reducing atmosphere produces H_2S and sulfate and also produces sulfide, organic sulfur compounds and nitrogen bases.) At the surface of the pond contact with air would allow the conversion of alkaline material containing CO_2 to sodium bi-carbonate.

- Materials accepted include acids, bases, flourides, solvents, organic oil. Some organic oils are recovered and burned in an incinerator.

- Recently they have installed a chlorinator for decomposition of cyanide containing waste.

- Quite a large percentage of the waste materials are significantly more volatile than water.

Benecia site (Salona County, California):

- The site accepts exclusively hazardous wastes, sludges, and other solids. No Class II materials such as municipal refuse are disposed of at the site.

- The site is a very poor location. It was originally operated by J.& J Disposal, but was shut down by the Water Quality Control Board. It was purchased by Industrial Tank who subsequently built a retaining wall along the lower edge of the facility at a cost of $750,000. The area is monitored periodically for signs of leachate from the landfill.

- Materials accepted include plastics, acids, and all of Du Pont's hydrochloric acid waste from its titanium dioxide operations.

- Currently their are few water related problems with the site; however, these have been dry years and possible problems may occur during wet years. The subsoil doesn't seem to fit some geological requirements.

- Some of the same types of wastes are accepted at both the Benecia and the Martinez facilities. The more odorous are treated in specially ventilated holding tanks, neutralized and routed to evaporation ponds. The more non-odorous material is disposed at the Benecia site.

- There is a sludge treatment process at the site.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 5

July 14, 1977

Fire at Hazardous Waste Landfill

1. Personal Damage - None

2. Environmental Damage - Contamination of air from fire at landfill

3. Economic Damage - None reported

4. Cause of Problem - The cause of the fire is undetermined. Possibilities include fire crackers, hot charcoal in refuse, malicious mischief.

5. Type and Quantity of Hazardous Waste - Primarily residue from waste oils. Quantities are unknown. Other combustible material was contained in municipal refuse.

6. Source of Waste - Unidentified; the waste came from several industrial and municipal sources.

7. Date of Incident - July 5, 1974; 1a.m. - 5a.m.

8. Location - Antioch site of Industrial Tank, Inc.

9. Status - Site is closed.

10. Remedial Action Taken - None directly related to the fire. The site was in the process of being closed at the time of the incident.

11. Legal Action Taken - None identified

12. Narrative - The Antioch disposal site of Industrial Tank, Inc. was primarily a waste oil recovery operation. It was a series of ponds through which oily water was passed. Large sized skimming equipment was used to remove the ~~oily water (for use as road~~ oil) from the surface of the pond. Up until 1973 this site apparently operated as a Class I landfill with the tacit approval of the California Water Quality Control Board. Although there is indication that there was not formal approval of the operation of this site as a Class I landfill, observation wells were routinely monitored by Industrial Tank and the results sent to the Water Quality Control Board on a routine basis. This continued until 1973 when public pressure against the landfill became quite vocal. At this time the state Water Quality Control Board gave notice to Industrial Tank, Inc. that the site would have to be closed. The initial notice of July 1973 was deferred until January 1974 when the site stopped accepting hazardous wastes.

    The procedure for closing the site involved gradual additions of municipal refuse to the site to absorb the water without causing overflowing of the pond. Once the pond area was completely filled with garbage it would be covered and abandoned. By July 1974 one pond whose dimensions were approximately 1/2 acre in area and several feet deep, was filled to approximately 1/3 capacity with municipal refuse. A fire occurred in the early morning of July 5. (This pond was originally designed as a drop out pond for sludge from the waste oil. At the water surface there was some oil which was skimmed with floatation equipment.) Fire burned from approximately 1 a.m. until 5 a.m. and flared at least twice during that time. Possibilities for the cause of the fire include fire crackers from the 4th of July celebration, hot charcoal present in some of the trash material, and malicious mischief from some of the near by residents. The actual cause of the blaze was not determined although the fire department did think that the fire started in the corner of the pond where they had been dumping the garbage. The procedure of filling the series of ponds continued without modification after the fire was put out. The exact time of final covering and abandonment of the site is not known.

REFERENCES

1. Case #21 of the Table entitled "Public Health and Environmental Damage Assessment Inventory," completed by Bob Testani, OSW, EPA, undated. His information source was Dave Storm, California Department of Health. There is no record of the communications with Storm.

2. Report of Communication of Karen Slimak, Environmental Engineering Division, TRW, Inc. with Mr. Carl Schwartzer, Division of Vector and Wastes, California Department of Health on July 14, 1977.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 6

July 12, 1977

Air Pollution from Disposal and Recovery of Lead Wastes, San Francisco, California

1. Personal Damage - Alkyl lead intoxication occurred at lead recovery facility. Toll collectors on a bridge became ill from vapors escaping from trucks hauling organic lead wastes. Hazard was created to workers at another reprocessing plant and to surrounding firms.

2. Environmental Damage - Contamination of air from escaping alkyl lead vapors.

3. Economic Damage - None reported

4. Cause of Problem - Evaporation of organic lead vapors from disposal sites, recovery facilities, and from transporting vehicles.

5. Type and Quantity of Hazardous Waste - The type is liquid, organic waste. The quantity of waste is unknown other than that approximately 50 tons of organic lead waste has been produced annually in the San Francisco Bay Area.

6. Source of Waste - Several unidentified manufacturers

7. Date of Incident - Problem has existed for several years

8. Location - San Francisco Bay Area

9. Status - Proper disposal and/or recovery of organic lead wastes is still a problem. Wastes are stored in a holding basin by one manufacuturer awaiting further instructions.

10. Remedial Action Taken - This series of incidents has been handled in a variety of ways; these include (a) temporary storage of the wastes awaiting further instructions, (b) a reprocessor returned the wastes to the original disposal site.

11. Legal Action Taken - At least one recovery plant was closed down.

12. Narrative - The disposal of organic lead wastes from the manufacture of alkyl lead has been a continuing problem for several years. Several of the associated incidents in the San Francisco Bay Area are related below:

    The annual production of organic lead waste from the manufacturing process for alkyl lead in the Bay Area has amounted to about 50 tons per year. Although the organic lead waste is now being stored in a holding basin at the manufacturing plant while capability for recovering the lead is developed, the waste was previously disposed of in ponds at one industrial waste disposal site. Those attempts of lead recovery resulted in alkyl lead intoxication of recovery plant employees. A later attempt to reprocess the lead wastes at another location created a hazard to employees at the plant, as well as a hazard to surrounding firms, as a result of air-borne alkyl lead vapor. Also, toll collectors on a bridge along the truck route to the new reprocessing facility became ill from the escaping vapor. After this second recovery plant was closed, some hazardous material remained on the property and created a health hazard. Finally, after much delay without achieving proper control, this material was returned to the original disposal site. Recently, with the detection of significant levels of alkyl lead in the air in the vicinity of another disposal facility, a new hazard has been identified. The source of this air-borne lead has not yet been confirmed because it cannot be accounted for at the disposal site.

In summary, material generated by one firm has been deposited in a disposal site which is operated by a second party and owned by a third. Responsibility for protection of the public under these conditions has been weak.

REFERENCES

1. Case #7 of the table entitled "Public Health and Environmental Damage Assessment Inventory". Information recorded by Bob Testani, OSW, EPA on December 16, 1975. His information came from Don Andreas, California Department of Public Health via Tim Fields, OSW, EPA.

2. 1973 Report to Congress, Disposal of Hazardous Wastes (SW-115) Appendix A, p.41.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 7

July 12, 1977

Air Pollution Incident at Pond Disposal Site

1. Personal Damage - Nausea was reported

2. Environmental Damage - Contamination of air resulted from the evaporation of volatile liquid wastes from pond surface

3. Economic Damage - At least one of the buildings downwind of the pond lost an undetermined number of working manhours from its employees due to the evacuation of the building.

4. Cause of Problem - Volatile odorous wastes evaporated from the surface of a disposal pond

5. Type and Quantity of Hazardous Waste - The material consisted of between 4,000 and 16,000 gallons of volatile odorous liquid wastes from the manufacture of allyl amines. Constituents included organohalogens such as crotyl chloride (C=C-C-Cl), amines, and C_5 - C_6 hydrocarbons.

6. Source of Waste - Shell Oil in San Francisco Bay area

7. Date of Incident - September 1975

8. Location - Richmond Disposal Site of Richmond Sanitary Service, Contra Costa County, California, Parent company - West Contra Costa Disposal, Inc.

9. Status - Pond was closed shortly after the incident due to water pollution problems. Pond may have reopened for certain restricted uses in May or June of 1977.

10. Remedial Action Taken - None

11. Legal Action Taken - Richmond Sanitary Services and Industrial Tank, Inc. (hauler) were cited for air pollution violations by the San Francisco Bay area Air Pollution Control. Other legal actions were considered and may have been carried out, these included criminal charges against the hauler.

12. Narrative - There were four firms involved in this incident. Shell Oil Company in the San Francisco Bay Area was the company who produced the waste. Industrial Tank, Inc. was contracted by Shell Oil to dispose of the waste, they were also the hauler of the waste. BKK Disposal was the southern California company which rejected the waste at its disposal site. Richmond Sanitary Services was the company which ultimately disposed of the waste material in its evaporation pond.

In September 1975, Shell Oil Company generated several thousand gallons of volatile liquid waste at its allyl amine plant in San Francisco Bay Area. The exact quantity of the waste is not known; however, the amount is between 4,000 and 16,000 gallons (1-4 truck loads). These wastes were all volatile material. The primary constituents were organohalogens such as crotyl chloride, amines, and short-chain hydrocarbons. This composition was reported by the manufacturer and was confirmed by analyses performed by the California Department of Health.

Arrangements were made with Industrial Tank, Inc. for the hauling and disposal of this waste material. The wastes were loaded into vacuum trucks and presumably hauled to an Industrial Tank facility. Industrial Tank, Inc. operates evaporation pond disposal sites in the Martinez and Antioch areas. It was determined that the wastes were not suited for pond disposal. The material was then transported in the vaccumn trucks to BKK Disposal in West Covina, California. The BKK Disposal site is a municipal refuse co-mixing operation typical of the southern California area.

BKK disposal rejected the material at the gate on the basis of an initial examination. The waste very odorous. BKK was especially sensitive to odorous waste at this time because it had been closed down by the town of West Covina for from 1-2 days in just the previous week. (At a later time the odors were proved not to be due to the BKK landfill.)

Industrial Tank, Inc. returned the material to the San Francisco area and sent it to the Richmond disposal site of Richmond Sanitary Services. The Richmond disposal site is primarily a sanitary landfill which handles the sanitary trash business of West Contra Costa Disposal. They also have one small evaporation pond. Richmond Sanitary Service accepted the waste and ran it into their evaporation pond.

The material floated to the top of the pond and evaporated. During the evaporation there was a visible plume (white mist typical of amines), very bad odors, and complaints of nausea from persons downwind.

REFERENCES

1. Case #19 (original case #) from the table entitled "Public Health and Environmental Damage Assessment Inventory" completed by Alice Giles and Bob Testani, OSW, EPA, January 28, 1976. The source of the information contained therein was Harvey Collins, Head, Vector Control, California Health Department. There is no record of the contact(s) with Collins in the EPA file.

2. Notes from a conversation between Dave Storm, California Department of Health and an unidentified person, presumably from EPA. The notes are undated.

3. Verbal communication report by Karen Slimak, Environmental Engineering Division, TRW, Inc. concerning telephone conversation on July 11, 1977 with Dr. Robert Stevens of the California Department of Health.

Where conflicting information occurred among these three sources, the verbal communication report was used.

VERBAL COMMUNICATION REPORT

Call From: Karen Slimak, TRW, Inc., Consulting to EPA (Contract #68-01-4645)

Call To: Dr. Robert Stevens
California Department of Health
415-843-7900 X434

Date: July 11, 1977

Subject: Air Pollution Incident at Richmond Disposal Site

The following information regarding the above incident which occurred in September 1975 was received from Dr. Robert Stevens.

- Some number of truck loads of wastes were involved. Exact amount is not known; between 4,000 and 16,000 gallons (1-4 truck loads)

- Wastes were produced by a Shell allyl amine plant

- Constituents (as reported by the manufacturer and as confirmed by analysis of California Department of Health) included very volalite organohalogens (e.g., crotyl chloride C=C-C-Cl) amines, and C_5 - C_6 hydrocarbons

- Industrial Tank Incorporated was contracted by Shell to dispose of the wastes

- ITI has evaporation ponds in Martinez and Antioch, but determined that the wastes were not suitable for ponding

- They shipped the material to BKK Disposal in West Covina, California. This is a municipal refuse co-mixing operation typical of the Southern California area.

- Dr. Stevens was at the BKK site in West Covina collecting samples the day the trucks arrived.

- BKK rejected the material at the gate on the basis of initial examination, the waste was very odiferous. BKK had been closed down by town of West Covina for from 1-2 days the previous week because of the odor problems (later odors proved not to be due to the landfill). Therefore BKK was very sensitive to odor problems at the time.

- Industrial Tank then returned the material to the San Francisco area and took it to Richmond Sanitary Services' Richmond Disposal Site. (Parent company - West Contra Costa Disposal Incorporated)

- Richmond Sanitary Services handles the Sanitary trash business for the parent company. They also have one small evaporation pond.

- Richmond Sanitary Services accepted the wastes and ran it into the evaporation pond.

- The material floated to the top and began evaporating

- There was a visible plume (white mist), no fire, very bad odors, and complaints of nausea from persons downwind. One or more buildings were evacuated including a Social Security building.

- There were unconfirmed reports that the plume didn't rise readily but hovered above ground for several hours, moved in various directions by prevailing wind before dissipation.

- There were reports that the plume was sighted 10-15 miles away in Atlameta.

- An air pollution citation was issued against Richmond Disposal and against Industrial Tank Inc. One Industrial Tank official was almost jailed in the incident.

- No remedial action was taken because this was a one-time incident and the material evaporated.

- Air pollution surveillence increased after the incident and more requirements were placed on testing wastes and on procedures for accepting wastes; volatiles were restricted

- Shortly after this incident the pond was closed because of leaks and because it got too full

- It has possibly reopened in 1977.

- For more information on the complaints of nausea, etc. contact Bob Gaynor,
  Bay Area Pollution Control District
  415-771-6000

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 8

July 22, 1977

Bulldozer Operator Nauseated from Fumes

1. Personal Damage - Bulldozer operator became nauseated

2. Environmental Damage - Contamination of air when wastes were uncovered; leaks from waste material into a local stream

3. Economic Damage - None documented

4. Cause of Problem - Fumes from wastes from lindane and benzene hexachloride manufacture uncovered during site preparation for a baseball field

5. Type and Quantity of Hazardous Waste - About 400 tons of BHC waste

6. Source of Waste - Unidentified pesticide manufacturer

7. Date of Incident - August 4, 1976

8. Location - Hamilton Township, Allegheny County, Pennsylvania

9. Status - Undetermined

10. Remedial Action Taken - Undetermined

11. Legal Action Taken - None

12. Narrative - Apparently, an unidentified pesticide manufacturer produced lindane/BHC on a site in Hamilton Township, PA. The operation ceased in about 1966. Subsequently, the site was deeded to the town.

    Recently, the town decided to construct a baseball field and a bulldozer operator became nauseated when he unearthed what was later shown to be BHC waste. Pennsylvania Department of Conservation (PDC) estimates over 400 tons of BHC waste is present. Further, there is a confirmed leak from the waste into a local stream.

    As of August, 1976 the State was undecided on the best course of action. The town did not have the funds to effect clean-up. The two options considered were containment of the waste on site with treatment of the leaking material or excavation and removal to a hazardous waste site. A PDC group was scheduled to survey the buried waste to determine its extent.

The PDC was provided with some specific information, obtained from TRW, on treatment of BHC waste by conversion to trichlorobenzene with calcium oxide. They may elect to use this method for treatment of the discharge.

REFERENCES

1. Harold R. Day, Pesticide Waste Management Division, EPA. August 1S, 19 6. Memo to Harry M. Trask, Pesticide Waste Management Division, EPA.

2. Case #65 from the table entitled "Public Health and Environmental Damage Assessment Inventory - Pennsylvania", completed by Bob Testani, OSW, EPA, September 7, 1976. Source of information was Bill Schremp, Region III, EPA.

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 9

July 19, 1977

Asbestos Air Pollution from Landfills

1. Personal Damage - Possible exposure of workers and their families to high levels of asbestos

2. Environmental Damage - None documented

3. Economic Damage - None documented

4. Cause of Problem - Unsatisfactory methods of disposal of hazardous waste containing asbestos from asbestos mine and mill

5. Type and Quantity of Hazardous Waste - Undetermined quantities of chrysotile asbestos in disposal area

6. Source of Waste - Pacific Asbestos Company, Copperopolis, California, Parent Company - H. K. Porter Corporation

7. Date of Incident - February - March, 1973

   Location - Copperopolis, California

9. Status - Unknown

10. Remedial Action Taken - None determined

11. Legal Action Taken - None determined

12. Narrative - The Pacific Asbestos Company operates a quarry - mill complex adjacent to the community of Copperopolis, California. Processing wastes are apparently disposed on site. The method for disposal is unsatisfactory and has resulted in complaints of exposure to the community of high levels of chrysotile asbestos.

    At the request of the International President of the Cement, Lime, and Gypsum Workers, the Industrial Union Department of the AFL/CIO conducted an investigation of worker and community resident exposure to asbestos. A medical and environmental science team headed by Professor Irving J. Selikoff visited the Copperopolis community and the Pacific Asbestos plant on March 9-10 to assess the adequacy of the method of disposal of material from the Pacific Asbestos plant as well as the levels of exposure of residents in the community and workers in the plant to chrysotile asbestos fibers.

The results of this investigation are unknown. There is no data on any remedial measures or any legal action taken.

REFERENCES

1. Case #8 from the table entitled "Public Health and Environmental Damage Assessment Inventory", completed by Bob Testani, OSW, EPA, undated. Source of information was Alan Cranston, Committee on Labor and Public Welfare, U.S. Senate (letter, March 1, 1973), and S.W. Samuels, Director Health Safety and Environmental Affairs, Union Department, AFL-CIO (memorandum, February 21, 1973).

HAZARDOUS WASTE DISPOSAL
DAMAGE REPORT NO. 10

July 20, 1977

Air Pollution from Waste Asbestos Piles

1. Personal Damage - Potential exists for asbestosis and mesothelioma among workers at asbestos mill and nearby residents.

2. Environmental Damage - Contamination of air (ambient levels 3.6 ng/m^3 above background; emission levels 108 to 1739 ng/m^3 above background) due to disposal activities and wind erosion at asbestos waste pile. Leachate from waste pile (Total solids: 580 mg/l; pH 11.1) contaminated nearby stream.

3. Economic Damage - None identified

4. Cause of Problem - Asbestos emissions from waste storage pile as a result of wind erosion and dumping activities. Periodic leachate from landfill.

5. Type and Quantity of Hazardous Waste - Approximately 1.5 million cubic yards of asbestos containing wastes; the waste pile is 50 feet high and covers 20 acres. Other waste constituents include calcium and magnesium carbonate.

6. Source of Waste - Various asbestos ~~manufacturing process and milk-of-~~ magnesia manufacture.

7. Date of Incident - The Nicolet Landfill (and associated asbestos emissions) began operation in about 1870 and continued until about 1975; Certainteed Products Landfill began operations sometime after January 1, 1970 and discontinued operations in March, 1972.

8. Location - Ambler Borough, Montgomery County, Pennsylvania

9. Status - The present status is unreported; both sites were required to complete closure and site abandonment procedures by May 1, 1974. However, appeals delayed this deadline until September 1975. As of January 1976 the site was neither covered nor removed.

10. Remedial Action Taken - As of early 1975, the Nicolet site was not fenced. Equipment to filter out the asbestos and concentrate the waste has been purchased. The resultant asbestos containing wastes will go to the Montgomery County Landfill.

11. Legal Action Taken

   - In 1973 Nicolet was ordered to cease and desist dumping, and to cover and stabilize the dumps.

- On February 19, 1974, Pennsylvania Department of Environmental Resources ordered Nicolet Industries, Inc. and Certain-teed Products Corporation to cease waste disposal operatons immediately and comply with landfill closure requirements by May 1, 1974.

- On February 10, 1975, Pennsylvania Department of Environmental Resources denied the Nicolet Industry permit for disposal and required that Nicolet cease operation of its solid waste disposal facility by August 1, 1975 and proceed with closure activities.

12. Narrative - In 1867 two Ambler, Pennsylvania companies, Keasley and Mattison (K & M) began manufacturing milk of magnesia and asbestos products and dumping wastes a short distance away at the intersection of Butler Avenue and Morris Road near the main section of the borough. The wastes then, as now, were primarily (~80%) magnesium carbonate and calcium carbonate. The site contains about 100,000 tons of magnesium. Asbestos concentration varies throughout the site depending on waste type encountered, e.g., asbestos dust - up to 40%, asbestos pipe - up to 12%, waste water sludge - ~2%.

Dumping has occurred at the site for a total of about 90 years. Much of the waste pile was due to K & M activities. In 1930 when Nicolet Industries, Inc. purchased the insulation and general products divisions of K & M they inherited the waste pile. In 1962 Certain-teed Products Corporation bought out the pipe manufacturing operation of K & M. Nicolet Industries, Inc. and Certain-teed Products Corporation are now joint owners of the pile. Certain-teed Products Corporation has added about 2700 tons of crushed asbestos pipe each year. Nicolet industries disposes of its asbestos waste in piles adjacent to the old pile at Butler Avenue and Morris Road.

The old pile contains approximately 1.5 million cubic yards of waste; its dimensions are approximately 50 feet high by 20-25 acres. A residential development and the Wissahickon Creek are nearby.

The locations of the active sites are shown in Figure 1. Current waste treatment and disposal processes include waste collection, settling ponds, lagoons, and disposal piles.

Waste generated as a dust (40 percent asbestos) from the sanding of monolithic board is collected in baghouses. The dust is transferred from the baghouse to containers where the material is wetted, covered, and transported to a settling pond about one kilometer away. The waste material is dumped into a section of the settling poind, mixed into a slurry, and pumped to the active disposal lagoon approximately 50 meters away. Other asbestos-containing waste generated at the plant empties into a wastewater system and is channeled to the settling pond.

Waste generated from machining the pipe ends is collected in a baghouse and recycled rather than being discarded as waste. Pipe scraps greater

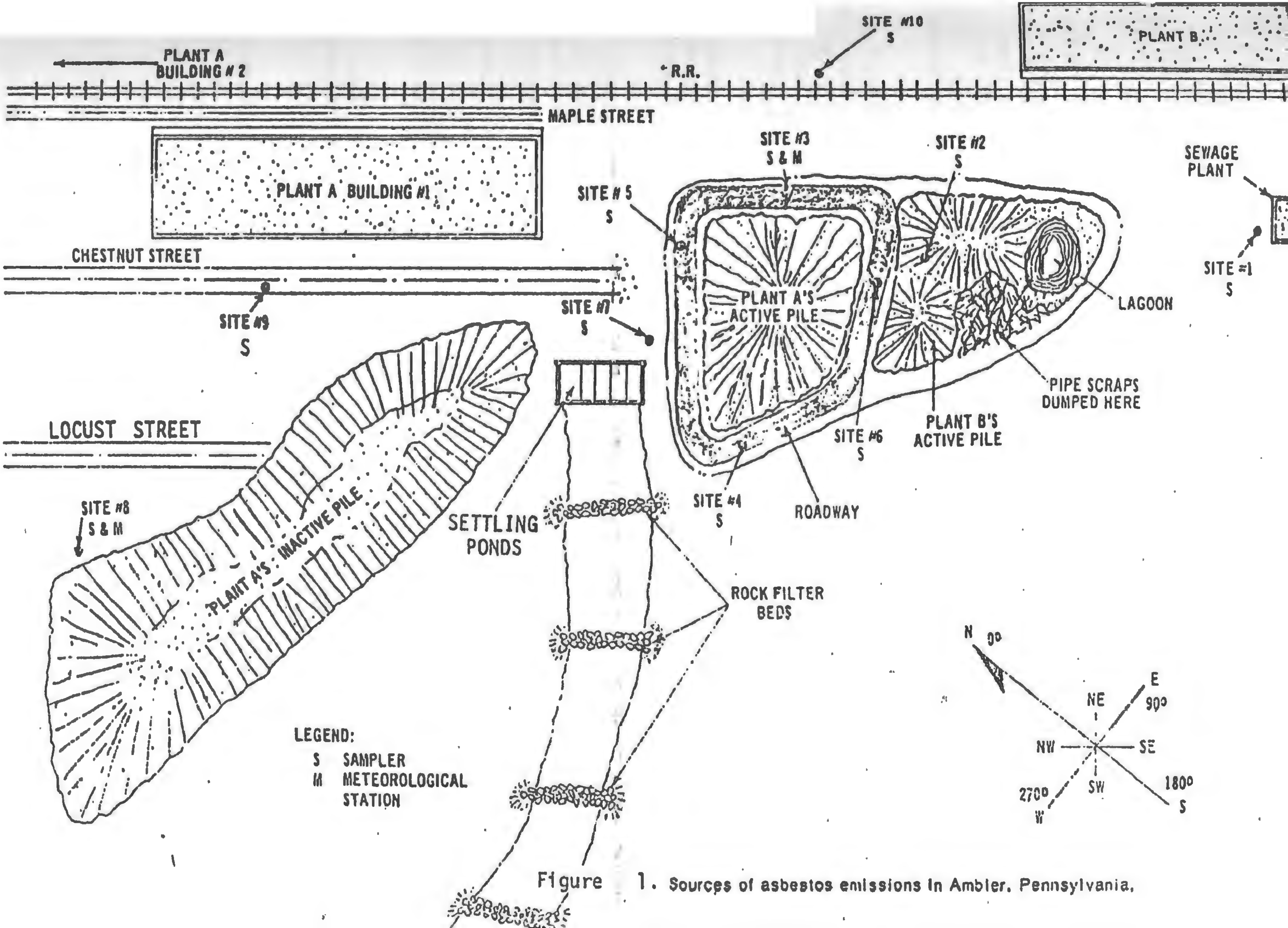

Figure 1. Sources of asbestos emissions in Ambler, Pennsylvania.

than 30 cm (ca. 12 inches) in diameter are not recycled, and this waste is transported to the disposal pile. A large amount of asbestos-containing sludge is created in the wastewater treatment operation. Tank trucks transport the slurried sludge to the disposal lagoon; each truck carries approximately 23,000 liters (ca. 6000 gallons) per load and empties into the lagoon at a rate of about 10 to 12 truck-loads per 6-week period.

After water evaporates from the disposal lagoon, portions of the lagoon have a dry, cracked crust. The top layer is light in color, has a relatively low density, and is fibrous. The fibers appear to be bound securely enough so that they are not released by wind action alone. The sides of the disposal site are about 46 cm higher than the level of the lagoon and form a roadway approximately 4.5 meters wide. Solid material is deposited and spread on this roadway when it becomes necessary to build up the sides of the lagoon.

When enough water has evaporated, the semidry waste is shoveled from the lagoon and piled onto the adjacent disposal area. A bulldozer then crushes the discarded pipe; the semidried sludge is mixed with the crushed pipe, and the mixture is spread uniformly on the disposal pile. The crushing operation is performed for approximately 1-1/2 days of an 8-week period.

There are actually two adjoining disposal sites. Site A is approximately 20 meters high, 90 meters wide, and 150 meters long (ca. 60 feet high, 300 feet wide, and 500 feet long), while Site B is approximately 6 meters high, 90 meters wide, and 210 meters long.

A waste disposal site located southwest of Plant A at the Nicolet facility has been inactive for about 4 years and covers approximately 40,000 m^2 (ca. 10 acres) (Figure 1). The type of waste material deposited at the site differs from the material currently being disposed of at the other two sites. Trees, grass, shrubs, and weeds cover approximately 75 to 90 precent of surface area, but little vegetation grows on the north bank of the pile, which borders one side of a playground and is close (within 15 meters) to occupied dwellings. This bank is approximately 180 meters long, approximately 15 meters high, and has a slope of about 60 degrees.

Over a period of years, starting in 1971, both Nicolet and Certain-teed have been challenged on state laws concerning solid waste management. Investigation has also determined that the landfill is causing a discharge of pollutants into the Wissahickon Creek.

On December 2, 1971, Nicolet Industries applied for permission to continue dumping (Permission required by Solid Waste Management Act of 1968). Pending approval, Nicolet continued to dump. On March 2, 1972 Certain-teed applied under the same Act. However, they discontinued dumping upon application.

Pressure to close the landfill due to high levels of asbestos air emissions began in about 1973. Concern was voiced by Dr. Irving Selikoff, Mt. Sinai Environmental Sciences, Jack Farmer, EPA, and others. An air monitoring program conducted by the U.S. Environmental Protection Agency in October, 1973, indicated ambient background levels of asbestos to be 6 ng/m^3. An asbestos level of 9.6 ng/m^3 was found at a playground near the largest waste pile. Values obtained near active disposal piles range from 114 to 1745 ng/m^3. It has been reported that citizens have been removing material from the piles for driveways.

In 1973 the Pennsylvania Department of Environmental Resources (DER) ordered Nicolet to cease and desist dumping, to cover and stabilize the dumps. The firm reapplied for a solid waste management permit. In February 1974, a disposal permit was denied by the Pennsylvania Department of Environmental Resources; Nicolet Industries and Certain-teed were directed to cease disposal activities immediately and cover and abandon the site by May 1974. In February 1974, a second application was denied and disposal operations were directed to cease in August 1975. As of November 1975 the Pennsylvania DER reported that Certain-teed Products was complying with the court order regarding dumping. Nicolet had complied in part, with one phase of their operations still producing asbestos wastes. Nicolet was exploring alternative remedies; however, the asbestos piles had been neither planted or removed.

Although the initial pressure which resulted in the permit denials was due to asbestos air emissions, justification for permit denial and site closure was given as water pollution due to leachate contamination of an adjacent stream. The DER orders did not mention the air emissions problem!

A similar asbestos waste pile exists at Hyde Park, Vermont. The pile dimensions were approximately 400 feet high, approximately 2600 feet long, approximately 1000 feet wide as of September 1973. At that time the site contained 20 million metric tons of tailings. The site had been in use for 15 years at that time. Percentages of chrysotile asbestos in samples of debris from the tailings pile ranged from 12.7 to 21.1. Ambient concentrations (away from the site) ranged from 3 to 13,600 ng/m^3; average concentration was about 1300 ng/m^3. Windblown emissions from the tailings pile averaged 500 ng/m^3. In this case emissions from mining, milling, and roadways probably contributed significantly to ambient concentrations.

REFERENCES

1. William K. Mandel. The Evening Bulletin. December 3, 1973. "Asbestos Hill is Hit as Health Hazard".

2. Leon T. Gonshor, Regional Coordinator, Pennsylvania DER. February 20, 1974. Letter to Daniel Synder, Region III Administrator, EPA.

3. Leon T. Gonshor, Regional Coordinator, Pennsylvania DER. February 20, 1975. Letter to Daniel Synder, Region III Administrator, EPA.

4. Alice Giles, Undated. Internal EPA summary of Ambler Incident, OSW, EPA.

5. U.S. Environmental Protection Agency, 1974. Background Information on National Emission Standards for Hazardous Air Pollutants - Proposed Ammendments to Standards for Asbestos and Mercury. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina (EPA - 450/2-74-009a).

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Resource Conservation and Recovery Act
Subtitle C-Hazardous Waste Management
Section 3004 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

DRAFT

BACKGROUND DOCUMENT

Section 250.45-2 Standards for Landfills

U.S. Environmental Protection Agency
Office of Solid Waste
December 15, 1978

TABLE OF CONTENTS

This document provides background information and support for regulations which have been designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft for comment. As new information is obtained, changes may be made in the regulations, as well as in the background material.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Timothy Fields, Jr.
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Office of Solid Waste
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I. Introduction

Section 3004 of the Resource Conservation and Recovery Act of 1976 (RCRA) mandates that the EPA Administrator promulgate regulations establishing standards applicable to owners and operators of facilities for the disposal of hazardous wastes as may be necessary to protect human health and the environment. Among other things, these standards are to include requirements respecting (1) the disposal of all such waste received by the facility pursuant to such operating methods, techniques, and practices as may be satisfactory to the Administrator, and (2) the location, design, and construction of such hazardous waste disposal facilities.

This document will be concerned specifically with the secure landfilling method of hazardous waste disposal. For the purpose of this discussion, a landfill is a facility which is engineered for the secure disposal of hazardous wastes involving the placement of such waste into the land surface, and involving covering of the hazardous waste so that human health and the air, groundwater and surface water is protected.

According to definitions given in Subtitle A, Section 1004 of RCRA, hazardous waste storage facilities must not leak or else the intended storage activity constitutes disposal. The pertinent definitions from the RCRA are as follows:

"The term 'storage,' when used in connection with hazardous waste, means the containment of hazardous waste, either on a temporary basis or for a period of years in such a manner as not to constitute disposal of such hazardous waste."

"The term 'disposal' means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters."

When used in this Subpart, the following terms have the meanings given in the Act:

"Administrator" - Sec. 1004(1)

"disposal" - Sec. 1004(3)

"Federal Agency" - Sec. 1004(4)

"hazardous waste management" -Sec. 1004(7)

"open dump" -Sec. 1004(14)

"person" - Sec. 1004(15)

"resource recovery" -Sec. 1004(22)

"sanitary landfill" - Sec. 1004(26)

"sludge" - Sec. 1004(26A)

"solid waste" - Sec. 1004(27)

"solid waste management" - Sec. 1004(28)

"solid waste management facility: - Sec. 1004(29)

"State" - Sec. 1004(31)

"storage" - Sec. 1004(33)

"treatment" - Sec. 1004(34)

Other terms used in this Subpart have the following meanings:

"Act" means the Resource Conservation and Recovery Act of 1976, Public Law 94-580.

"Active Fault Zone" means a land area which according to the weight of the geologic evidence, has a reasonable probability of being affected by movement along a fault to the extent that a hazardous waste facility would be damaged and there by pose a threat to human health and the environment.

"Active Portion" means that portion of a facility where treatment, storage, or disposal operations are being conducted. It includes the treated area of a landfarm and the active face of a landfill, but does not include those portions of a facility which have been closed in accordance with the facility closure plan and all applicable closure standards.

"Aquifer" means a geologic formation, group of formations, or part of a formation that is capable of yielding useable quantities of groundwater to wells or springs.

"Attenuation" means any decrease in the maximum concentration or total quantity of an applied chemical or biological constituent in a fixed time or distance traveled resulting from a physical, chemical, and/or biological reaction or transformation occurring in the zone of aeration or zone of saturation.

"Cell" means a portion of waste in a landfill which is isolated horizontally and vertically from other portions of waste in the landfill by means of a soil barrier which meets criteria specified in Section 25.45-2(b)(14).

"Chemical Fixation" means the treatment process involving reactions between the waste and certain chemicals, resulting in solids which encapsulate, immobilize or otherwise tie up hazardous components in the waste so as to minimize the leaching of hazardous components and render the waste nonhazardous or more suitable for disposal.

"Close Out" means the point in time at which facility owners/operators discontinue operation by ceasing to accept hazardous waste for treatment, storage, or disposal.

"Closed Portion" means that portion of a facility which has been closed in accordance with the facility closure plan and all applicable closure requirements in this Subpart.

"Closing Date" means the date which marks the end of a reporting quarter or reporting year.

"Closure" means the act of securing a facility pursuant to the requirements of Section 250.43-7.

"Closure Procedures" means the measures which must be taken to effect closure in accordance with the requirements of Section 250.43-7 by a facility owner/operator who no longer accepts hazardous waste for treatment, storage, or disposal.

"Container" means any portable enclosure in which a material can be stored, handled, transported, treated, or disposed.

"Contamination" means the degradation of naturally occuring water, air, or soil quality either directly or indirectly as a result of man's activities.

"Cover Material" means soil or other material that is used to cover hazardous waste.

"Direct Contact" means the physical intersection between the lowest part of a facility (e.g., the bottom of a landfill, a surface impoundment liner system or a natural in-place soil barrier, including leachate detection and removal systems) and a water table, a saturated zone, or an underground drinking water source, or between the active portion of a facility and any navigable water.

"Disposal Facility" means any facility which disposes of hazardous waste.

"Endangerment" means the introduction of a substance into groundwater so as to:

(i) cause the maximum allowable contaminant levels established in the National Primary Drinking Water standards in effect as of the date of promulgation of this Subpart to be exceeded in the groundwater; or

(ii) require additional treatment of the groundwater in order not to exceed the maximum contaminant levels established in any promulgated National Primary Drinking Water regulatons at the point such water is used for human consumption; or

(iii) Reserved (Note: Upon promulgation of revisions to the Primary Drinking Water Standards and National Secondary Drinking Water Standards and National Secondary Drinking Water Standards under the Safe Drinking Water Act and/of standards for other specific pollutants as may be appropriate).

"EPA Region" means the States and other jurisdictions in the ten EPA Regions as follows:

Region I - Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island.

Region II -New York, New Jersey, Commonwealth of Puerto Rico, and the U.S. Virgin Islands.

Region III - Pennsylvania, Deaware, Maryland, West Virginia, Virginia, and the District of Columbia.

Region IV - Kentucky, Tennessee, North Caorlina, Missiissippi, Alabama, Georgia, South Carolina, and Florida.

Region V	-	Minnesota, Wisconsin, Illinois, Michigan, Indiana, and Ohio.
Region VI	-	New Mexico, Oklahoma, Arkansas, Louisiana, and Texas.
Region VII	-	Nebraska, Kansas, Missouri, and Iowa.
Region VIII	-	Montana, Wyoming, North Dakota, South Dakota, Utah, and Colorado.
Region IX	-	California, Nevada, Arizona, Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.
Region X	-	Washington, Oregon, Idaho, and Alaska.

"Facility" means any land and appurtenances, theron and thereto, used for the treatment, storage, and/or disposal of hazardous waste.

"Final Cover" means cover material that is applied upon closure of a landfill and is permanently exposed at the surface.

"Five-Hundred-Year Flood" means a flood that has a 0.2 percent or one in 500 chance or recurring in any year. In any given 500 year interval, such a flood may not occur, or more than one such flood may occur.

"Flash Point" means the minimum temperature at which a liquid or solid gives off sufficient vapor to form an ignitable vapor-air mixture near the surface of the liquid or solid. An ignitable mixture is one that, when ignited, is capable of the initiation and propagation of flame away from the source of ignition. Propagation of Flame means the spread of the flame from layer to layer independent of the source of ignition.

"Groundwater" means water in the saturated zone beneath the land surface.

"Hazardous Waste" has the meaning given in Section 1004(5) of the act as further defined and identified in Subpart A.

"Hazardous Waste Facility Personnel" means all persons who work at a hazardous waste treatment, storage, or disposal facility, and whose actions or failure to act may result in damage to human health or the environment.

"Hazardous Waste Landfill" means an area in which hazardous waste is disposed of in accordance with the requirements of Secion 250.45-2.

"Hydraulic Gradient" means the change in hydraulic pressure per unit of distance in a given direction.

"Incompatible Waste" means a waste unsuitable for commingling with another waste or material, because the commingling might result in:

(i) Generation of extreme heat or pressure,

(II) Fire,

(iii) Explosion or violent reaction,

(iv) Formation of substances which are shock sensitive friction-sensitive, or otherwise have the potential of reacting violently,

(v) Formation of toxic (as defined in Subpart A) dusts, mists, fumes, gases, or other chemicals, and

(vi) Volatilization of ignitable or toxic chemicals due to heat generation, in such a manner that the likelihood of contamination of groundwater, or escape of the substances into the environment, is increased, or

(vii) Any other reactions which might result in not meeting the Air Human Health and Environment Standard.

"Leachate" means the liquid that has percolated through or drained from hazardous waste or other man emplaced materials and contains soluble, partially soluble, or miscible components removed from such waste.

"Leachate Collection and Removal System" means a system capable of collecting leachate and/or liquids generated within a hazardous waste landfill, and removing the leachate and/or liquids from the landfill. The system is placed or constructed above the landfill liner system.

"Leachate Detection System" means a gravity flow drainage system installed between the top and bottom liners of a surface impoundment capable of detecting any leachate that passes through the top liner.

"Leachate Detection and Removal System" means a system capable of detecting the presence of leachate and/or liquids beneath the bottom liner system of a landfill, and is capable of periodically removing leachate and/or liquids if found or known to be present.

"Leachate Monitoring System" means a system beneath a facility used to monitor water quality in the unsaturated zone (zone of aeration) as necessary to detect leaks from landfills and surface impoundments. (For example, a pressure-vacuum lysimeter may be used to monitor water quality in the zone of aeration.)

"Liner" means a layer of emplaced materials beneath a surface impoundment or landfill which serves to restrict the escape of waste or its constituents from the impoundment or landfill.

"Monitoring" means all procedures used to systematically inspect and collect data on operational parameters of the facility or on the quality of the air, groundwater, surface water, or soils.

"Monitoring Well" means a well used to obtain water samples for water quality analysis or to measure groundwater levels.

"Navigable Waters" means "waters of the United States, including the territorial seas". This term includes, but is not limited to:

(i) All waters which are presently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide, intermittent streams, and adjacent wetlands. "Wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, paririe potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

(ii) Tributaries of navigable waters of the United States, including adjacent wetlands;

(iii) Interstate waters, including wetlands; and

(iv) All other waters of the United States, such as intrastate lakes, rivers, streams, mud-flats, sandflats, and wetlands, the use, degradation or destruction of which would affect or could affect interstate commerce, including, but not limited to:

(A) Intrastate lakes, rivers, streams, and wetlands which are or could be used by interstate travelers for recreational or other purposes;

(B) Intrastate lakes, rivers, streams, and wetlands from which fish or shellfish are or could be taken and sold in interstate commerce; and

(C) Intrastate lakes, rivers, streams, and wetlands which are used or could be used for industrial purposes by industries in interstate commerce.

(v) All impoundments of waters of the United States otherwise defined as navigable waters under this paragraph.

"Non-Point Source" means a source from which pollutants emanate in an unconfined and unchannelled manner, including, but not limited to, the following:

(i) For non-point sources of water effluent, this includes those sources which are not controllabl through permits issued pursuant to Sections 301 and 402 of the Clean Water Act. Non-point source water pollutants are not traceable to a discrete identifiable origin, but result from natural processes, such as nonchannelled run-off, precipitation, drainage, or seepage.

(ii) For non-point sources of air contaminant emissions, this normally includes any land-fills, landfarms, surface impoundments, and basins.

"On-site" means on the same or geographically contiguous property. Two or more pieces of property which are geographically contiguous and are divided by public or private right(s)-of-way are considered a single site.

"Owner/Operator" means the person who owns the land on which a facility is located and/or the person who is responsible for the overall operation of the facility.

"Partial Closure Procedures" means the measures which must be taken by facility owners/operators who no longer accept hazardous waste for treatment, storage, or disposal on a specific portion of the site.

"Permitted hazardous waste management facility (or permitted facility)" means a hazardous waste Treatment, storage, or disposal facility that has received an EPA permit in accordance with the requirements of Subpart E or a permit from a State authorized in accordance with Subpart F.

"Point Source" means any discernible, confined, and discrete conveyance, including, but not limited to, the following:

(i) For point sources of water effluent, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated feeding operation, vessel, or other floating craft from which pollutants are or may be discharged; and

(ii) For point sources of air contaminant emissions, any stack, duct, or vent from which pollutants are or may be discharged.

"Post-Closure Care" means the monitoring and facility maintenance activities conducted after closure.

"Publicly Owned Treatment Works" or "POTW" means a treatment works as defined in Section 212 of the Clean Water Act (CWA), which is owned by a State or municipality (as defined by Section 502(4) of the CWA). This definition includes any sewers that convey wastewater to such a treatment works, but does not include pipes, sewers, or other conveyances not connected to a facility providing treatment. This term also means the municipality as defined in Section 502(4) of the CWA, which has jurisdiction over the indirect discharges to, and the discharges from, such a treatment works.

"Reactive Hazardous Waste" means hazardous waste defined by Section 250.13(c)(1) of Subpart A.

"Recharge Zone" means an area through which water enters an aquifer.

"Regional Administrator" means the Regional Administrator for the Environmental Protection Agency in which the facility concerned is located, or his designee.

"Run-off" means that portion of precipitation that drains over land as surface flow.

"Saturated Zone (Zone of Saturation)" means that part of the earth's crust in which all voids are filled with water.

"Spill" means any unplanned discharge or release of hazardous waste onto or into the land, air or water.

"Soil Barrier" means a layer of soil of a minimum of 1.5 meters (5 feet) in thickness with a permeability of 1×10^{-7} cm/sec or less which is used in construction of a landfill or a surface impoundment.

"Sole Soruce Aquifers" means those aquifers designated pursuant to Section 1424(e) of the Safe Drinking Water Act of 1974 (P.L. 93-523) which solely or principally supply drinking water to a large percentage of a populated area.

"Treatment Facility" means any facility which treate hazardous waste.

"True Vapor Pressure" means the pressure exerted when a solid and/or liquid is in equilibrium with its own vapor. The vapor pressure is a function of the substance and of the temperature.

"Unsaturated Zone (Zone of Aeration)" means the zone between the land surface and the nearest saturated zone, in which the interstices are occupied partially by air.

"United States" means the 50 States, District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

"Underground Drinking Water Source" (UDWS) means:

(l) an aquifer supplying drinking water for human consumption, or

(ii) an aquifer in which the groundwater contains less than 10,000 mg/l total dissolved solids; or

(iii) an aquifer designated as such by the **Administrator or a State.**

"Underground Non-Drinking Water Source" means an underground aquifer which is not a UDWS.

"Volative Waste" means waste with a true vapor pressure of greater than 78 mm Hw at $25^{o}C$.

"Water Table" means the upper surface of the zone of saturation in groundwaters in which the hydrostatic pressure is equal to atmospheric pressure.

It should be noted that certain aspects pertaining to the secure landfilling of hazardous wastes which come under the heading of General Facility Standards and apply to all treatment,storage and disposal facilities, will be addressed in other gackground documents. These include:

(1) General Site Selection

(2) Security

(3) Contingency Plan and Emergency Procedures

(4) Training

(5) Manifest System, Recordkeeping and Reporting

(6) Visual Inspections

(7) Closure and Post-Closure

(8) Groundwater and Leachate Monitoring

(9) Financial Requirements

II. Rationale for Regulation

The case for hazardous waste management legislation has been well stated in a recent EPA publication (1):

> Some of the primary findings of EPA's Report to Congress on Hazardous Waste Disposal, which was mandated by Section 212 of the Solid Waste Disposal Act as amended, are that current hazardous waste management practices are generally unacceptable, and that public health and welfare are unnecessarily threatened by the uncontrolled discharge of such waste materials into the environment, especially upon the land. It was also concluded that usage of the land for hazardous waste disposal is increasing due to the implementation of air and water pollution controls, and the limitation of disposal methods such as ocean dumping.
>
> The Clean Air Act (as amended), the Federal Water Pollution Control Act (as amended), and the Marine Protection, Research, and Sanctuaries Act (as amended), are curtailing the discharge of hazardous pollutants into the Nation's air and water. The basic objective of the latter is to prohibit the dumping of some materials, and strictly regulate the dumping of all materials (except dredge material controlled by Army Corps of Engineers). Increasing volumes of sludges, slurries, and concentrated liquids will therefore find their way to land disposal sites.

Few economic incentives exist to encourage waste generators to utilize environmentally acceptable disposal methods. Current methods frequently result in contamination of ground waters from leachates; surface waters from run-off and leachate; and air from evaporation, sublimation, or dust dispersal.

EPA files contain many examples of environmental damage from improper land disposal of hazardous waste.

An EPA ground water monitoring project entitled, "The Prevalence of Subsurface Migration of Hazardous Chemical Substances At Selected Industrial Waste Disposal Sites," has investigated the likelihood of groundwater contamination at hazardous waste land disposal sites. In this study, groundwaters at 50 land disposal sites located East of the Mississippi River and which received large quantities of industrial waste were sampled and analyzed. The sites selected are representative of typical industrial land disposal facilities, and are situated in a wide variety of geologic environments. No previous contamination of groundwater with hazardous substances had been reported before sampling, and waste disposal had been in progress for a minimum of 3 years. At 43 of the 50 sites migration of one or more hazardous constituents was confirmed according to project criteria. Twelve hazardous inorganic constituents were detected above background concentrations. The five most frequently occurring were selenium, barium, cyanide, copper, and nickel in that order. Organic substances that were identified included PCB's, chlorinated phenols, benzene and derivitives, and organic solvents.

At 26 sites, hazardous inorganic constituents in the water from one or more of the monitoring wells exceeded the EPA drinking water limits. Of the hazardous substances, selenium most frequently exceed drinking water limits, followed by arsenic, chromium, and lead.

Conclusions drawn from the study are:

1. Groundwater contamination at industrial land disposal sites is a common occurrence.
2. Hazardous substances from industrial waste land disposal sites are capable of migrating into and with groundwater.
3. Few hydrogeologic environments are suitable for land disposal of hazardous waste without some risk of groundwater contamination.
4. Continued development of programs for monitoring industrial waste land disposal sites is necessary to protect groundwater quality.
5. Most old industrial waste disposal sites, both active and abandoned, are located in geologic environments where groundwater is particularly susceptible to contamination.

6. Many waste disposal sites are located where the underlying aquifer system can act as a pipeline for discharge of hazardous substances to a surface-water body.

Numerous incidents of damage which resulted from improper land disposal are contained within EPA files.

Grasshopper bait, a pesticide containing arsenic trioxide, was being buried on a farm near Perham, Minnesota between 1934 and 1936. In 1972, 36 years later, a well was drilled near the burial site to supply water for employees in a newly built office facility. Eleven of the thirteen employees of the facility became ill from arsenic poisoning. Two required hospitilization and treatment. One lost the use of his legs for about six months due to severe neuropathy. Analysis of well water revealed arsenic levels of 21,000 ppb. (The USPHS drinking water standard is 50 ppb). The area of disposal was located twenty feet from the well. Estimated costs for solving the problem range from $2500 to $25,000.

In May 1974, three dead cattle were discovered on a power company's recently acquired farm property near Byran, Illinios, and pathological examination established that the cattle had died of cyanide poisoning. Further investigation revealed that the approximately 5-acre area, which is part of a large property set aside for a nuclear power plant, had been for several years a repository of large quantities of toxic industrial wastes. The former owner of the property used it to dispose of industrial waste his hauling company collected. The power company hired a consultant to study the environmental damage on the property and to recommend clean-up procedures. The subsequent study documented extensive harm to wildlife and vegetation. Nearby soils and surface and groundwaters were heavily contaminated with cyanide and chromium. It is not yet known when farm crops can safely be harvested on the affected property again.

Until approximately June 1970, Beech Creek, Waynesboro, Tennessee, was considered pure enough to be a source of drinking water. At that time, waste polychlorinated biphenyls (PCB) from a nearby plant began to be deposited in the Waynesboro city dump site. Dumping continued until April 1972. Apparently the waste, upon being off-loaded at the dump, was pushed into a spring branch that rose under the dump and then empties into Beech Creek. Shortly after depositing of such wastes began, an oily substance appeared in the Beech Creek waters. Dead fish, crawfish, and waterdogs were found, and supported wildlife also was being affected (e.g., two raccons were found dead). Beech Creek had been used for watering stock, fishing, drinking water, and recreation for decades. Presently, the creek seems to be affected for at least 10 miles (16.09 kilometers) from its source and the pollution is moving steadily downstream to the Tennessee River. Health officials have advised that the creek should be fenced off to prevent cattle from drinking the water.[3]

The City of Aurora, Illinois operated a dumpsite until 1965, at which time it was leased to a disposal company to operate as a sanitary landfill. From 1961 until 1972, residential, commercial, and industrial wastes were disposed of at the site. During the early months of 1966, nearby residents began complaining of odor problems with their drinking water. By the summer of 1966, a total of nine wells had been polluted by leachate; seven of them were totally unfit for any kind of use. All seven wells substantially exceeded USPHS standards for chlorides, total solids, and biological contaminants. Tests by the Illinois Department of Public Health and Illinois Geological Survey confirmed that the landfill was the source of the pollution. The owners of the contaminated wells sued the disposal company and were awarded $54,000 damages in a directed verdict. This was to cover legal expenses and the costs of hooking up with the city of North Aurora's waterlines. The cost to the State for its investigation was estimated to be $52,000.[4]

The Cedar Hill dump, in King County, Washington has been in operation for about ten years. For the last three years, it has operated as a sanitary landfill accepting industrial and hospital wastes in addition to municipal refuse from the Seattle area. Leachate from the landfill, high in iron and zinc, has been contaminating Mason Creek which passes below the site. The creek runs into Issa Creek and through the City of Issaquah, about two miles downstream from Cedar Hill. Contaminants in the leachate have fostered the growth of a slime mold (sphaerotilus) in the creek which has been killing salmon eggs and fry at the Issaquah State Fish Hatchery. The fungus covers the eggs and clogs the gills of the fry, depriving them of oxygen. Estimated losses at the Hatchery since 1973 amount to $280,000. Leachate run-off and infiltration at the landfill continue and could eventually affect nearby Sammamish Lake.

A landfill, in Lehigh County, Pennsylvania opened in 1967 on the site of an abandoned quarry, accepting trash and industrial wastes from Lehigh and Northampton Counties. Among the wastes dumped at the landfill was a wide variety of industrial organics. In October, 1970, a supplier of water for about 50 homes in North Whitehall Township, filed a complaint with the Pennsylvania Department of Environmental Resources for contamination of their water supplies by leachate from the landfill. Analysis of water from wells in March 1971 revealed the presence of 20 ppm trichloroethylene, as well as phenols and ethyl acetate. Although the landfill company reportedly stopped accepting liquid wastes in 1970, traces of organic contaminants still persist in the water. The water, though somewhat degraded, is considered potable and is used for drinking.

The city of Rockford, Illinois operated a landfill in a former sand and gravel pit from 1947 to 1972. The landfill received residential, commercial, and industrial wastes. Leaching of chemicals into the groundwater caused nine wells -- four industrial, four residential, and a public supply well -- to be contaminated. The industrial wells were abandoned in 1966, the residential wells in 1970, and public supply well in 1972. Contaminants found in levels over the USPHS standard were: total dissolved solids (800 ppm), iron (1.8 ppm), and manganese (0.71 ppm). The recommended USPHS drinking water standards for these substances are as follows: 500 ppm, 0.3 ppm, and 0.05 ppm. The industrial and residential wells affected were replaced by connecting to the city water system and a new well was drilled to replace the abandoned public well. The total cost of connecting the industrial and residential sites to city water, replacing the public water supply well, and placing a better cover on the landfill was estimated at $127,500. These expenditures did not include investigative and administrative costs, and did nothing to clean up the water.[4]

A landfill in Allegheny County, Pennsylvania, began waste disposal operations in Monroeville Borough in 1932. Besides municipal solid waste, the landfill accepted heavy metal-containing industrial sludges and at one time an estimated 15,000 gallons/day of waste water from steel mills.

Contamination of the groundwater and a tributary of Turtle Creek by an estimated 50,000 gallon/day of leachate initiated a lengthy court battle in December, 1970, involving the landfill, area residents, Monroeville Borough, Allegheny County, and the State of Pennsylvania. The landfill was ordered closed in March 1973. Subsequently, it reopened after installation of a leachate system. Nevertheless, as of March 1975, area residents continued to complain of untreated leachate bypassing the treatment plant, odors emanating from the site, insufficient cover material being used, and other alleged violations.[4]

A landfill in Egg Harbor Township, New Jersey, has been the depository of large quantities of organic and inorganic industrial wastes. In 1973, this landfill was ordered by the State not to accept any more industrial wastes since laboratory analysis of samples from nearby observation wells established the existence of a groundwater pollution problem involving several chemical contaminants. Lead concentrations in the observation wells have been analyzed up to 18 ppm. (The U.S. Public Health Service mandatory drinking water standard for lead is 0.05 ppm.) A municipal water supply well field, situated within 0.6 miles (1 kilometer) of the area of contamination, has not been affected; however, it is being regularly monitored because of the obvious threat.[4]

A chemical company in Will County, Illinois, disposed of unidentified solid chemical wastes in a landfill on its property for a number of years. In February 1974, area residents complained of a reddish discharge into the Des Plaines River from a tributary stream which drained off the chemical company property. Monitoring tests on the runoff from the site taken at the stream showed (in ppm): Fe 2600, Mn 1360, Ni 2.4 and sulfates 2200. BOD was over 10,600 ppm and COD above 46,670 ppm. The runoff wiped out several acres of foilage and vegetation downslope from the disposal area. As a result of regulatory action by the State, the following corrective actions were taken by the company: A treatment lagoon was clay-lined, the drainage pattern changed, the area reseeded, and the leachate collected in tank trucks and treated on-site.[4]

Improper disposal of hazardous wastes by and on the property of Hooker Chemical and Plastics Corporation in Montague, Michigan, probably began in the 1950's and continued until early 1970. Various drummed wastes, including hexachlorocyclopentadiene (C 5, 6) residues, fly ash, and brine sludge were deposited in several dump sites on the company's property. In addition, brine sludge combined with sediments from an equalization basin was disposed in a 15 acre on-site lagoon. The disposal areas and equilization pond cover approximately 30 acres and have ~~accommodated~~ accumulated about 400,000 cubic yards of wastes. As a result of this improper disposal, groundwater resources that supply drinking water for nearby residents were irreparably contaminated, along with as much as 1.2 million cubic yards of soil. Furthermore, White Lake, which discharges directly into Lake Michigan, has become polluted via inflow of contaminated groundwater.

~~Salisbury Labs,~~ A ~~a~~ chemical manufacturing company has been dumping As-containing wastes since 1953 at the LaBounty Dump Site along the Cedar River in South Charles City, Iowa. This chemical fill covers approximately 8.5 acres and contains an estimated 27,000,000 cubic feet of chemical sludge and underlying and surrounding soil. In addition to various forms of arsenic, the site also contains phenols, orthoni-troalinine, nitrobenzene, etc.

The situation poses a serious threat because the underlying fractioned limestone bedrock is where 70 percent of Iowa residents obtain their drinking and irrigation water. At one point (date ?) toxic~~s~~ chemicals from LaBounty were found in the drinking water at Waterloo, 50 miles downstream on the Cedar River.

The company ~~Salisbury~~ was ordered to close shop and cease all dumping at LaBounty by the Iowa D.E.Q. in December 1977. The order also requires:

(1) program of soil borings to locate, then remove As contamination;

(2) removal must begin by July 1, 1979;

(3) locate new dumpsite and have operative by July 1, 1979.

The estimated cost of removal of these toxic wastes is about $20 million.

The preceding damage incidents are just a few of the over 420 confirmed hazardous waste damage cases contained in damage assessment files of the EPA. This does not include numerous unestimated potential damage incidents across the U.S. which are still unknown or unconfirmed by EPA at present.

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III. Identification and Analysis of Regulatory Options

Option 1 - Performance standards on the design and operation of a hazardous waste landfill.

Advantages

- Regulations are easily enforced. Compliance could be checked by simple observation of the landfill facility.

Disadvantages

- Innovation is stifled. Improved technology cannot be implemented without changes in the regulations.
- Comprehensive regulations would be difficult to devise in the short time EPA has.
- Difficult to justify most design and operating standards without good data base.
- Compliance with design and operating standards will not ensure environmental protection.

Option 2 - Hazardous waste landfills shall use the best available and/or practical technology to ensure the protection of the public health and environment.

- Option 2 is modeled from EPA effluent discharge requirements of the Federal Water Pollution Control Act. These requirements are based on the quality of effluent discharges from existing facilities in the United States. Effluent discharge requirements vary with industry type. Establishment of these discharge requirements is initiated by making an inventory of existing industries with effluent discharges and determining the quality of each facility's discharge. An exemplary group of facilities is then selected for each industry type. This exemplary group is composed of those facilities having the highest quality discharge. Generally, the average discharge quality of each examplary group is adopted by the EPA as the effluent discharge standard for that industry type. These standards are considered to represent the "best practicable control technology." In some cases, a quality lower or higher than the examplary group average has been adopted as the standard. New facilities are usually required to practice the "best available technology." The "best available technology" generally represents the highest existing discharge quality for a given industry type. A similar type or inventory could be conducted for existing hazardous waste chemical landfills. The criteria for selecting an exemplary group of landfills might be the amount of leakage detected from the bottom of the facility. The "best practicable liner technology" and the "best available liner technology" could then be established based on leakage found at "examplary" landfills. The standard could then be the use of specific liner types based on their performance at existing facilities, i.e., their ability to not leak. The standard could perhaps vary for different hazardous waste types.

Advantages

- Once the "best available and/or practical" technology is defined enforcement is relatively simple. Compliance can be checked by observation.
- If the "best available and/or practical" technology is adequately defined, it is assured that a facility is doing everything possible to protect the public health and environment.

Disadvantages

- Defining the "best available and/or practical" technology will require a data base EPA does not yet have and will not have the time to acquire.
- Even if the "best available and/or practical technology is used at a landfill, the protection of the public health and environment is not ensured.

Option 3 - No performance standards on the design and operating of a hazardous waste landfill.

- In this case, hazardous waste landfills will be required to comply with emission standards by any methods they wish to devise. Guidelines concerned with operating and design practices may be supplied to permitting agencies to be used in determining the suitability of a landfill design for the disposal of hazardous wastes.

Advantages

- There is flexibility in the manner in which the landfill operates. New techniques and designs are not discouraged.
- Guidelines could be readily amended to adapt to changing technology.

- Protection of the environment is ensured if the emission standards are met.

Disadvantages

- Guidelines do not have the force of law. They are used at the discretion of permitting officials and may be applied unevenly.

Option 4 - Performance standards on the design and operation of a hazardous waste landfill with provision for deviating from the prescribed standards.

Advantages

- Eliminates inflexibility associated with specific performance type standards, encourages innovation.
- Easily enforceable and less discretionary.
- Specific and clearly defines duties which are not subject to broad interpretations.
- Standards carry the force of law.

Disadvantages

- Comprehensive standards difficult to devise in a short period of time.
- Difficult to justify most design and operating standards without good data base.

State Regulations

California

California has developed regulations concerning hazardous waste land disposal. These regulations specify that hazardous wastes may only be disposed of in Class I landfills. Standards for Class I landfills are listed in Section 2510 of the regulations. The design and operation standards are limited to specifying a liner impermeability and requiring drainage control structures. Environmentally safe operation is ensured by permitting only secure facilities as Class I sites. The strategy followed in California is most similar to Option 3.

Minnesota

The Minnesota Pollution Control Agency has recently compiled a set of proposed regulations concerning the management of hazardous wastes. These regulations do not include any design and operation standards and so, are similar to Option 3. There is a set of specifications requiring certain information be included with a permit application. The prime mechanism for ensuring environmental protection lies in permitting only those facilities which are secure.

New York

The New York State Department of Enviornmental Conservation has developed draft regulations dealing with solid waste management facilities. The New York regulations specify many aspects of the design and operation of hazardous waste landfills and so follow the strategy outlined in Option 1. Though variances can be granted these standards rigidly specify many of the operating features of a landfill. Regulation 360.8(b)(1)(VII), which concerns the cover and compaction of solid wastes, is an example of this type of standard.

An important feature of the New York regulations is regulation 360.8(b)(2) which specifies that all standards which apply to sanitary landfills must also apply to hazardous waste landfills. One problem may be that though the wastes disposed of in a hazardous waste landfill by definition have a greater potential to cause environmental damage, there may be operational practices desirable in a sanitary landfill but not necessary in a hazardous waste landfill. The use of a daily cover may be one example.

Pennsylvania

The Pennsylvania Department of Environmental Resources has recently drafted a set of proposed regulations for the management of solid waste.

These regulations are in large part design and operation oriented as is Option 1. Phase II of Section 75.38 specifies design and operating practices necessary to obtain a permit. In addition, paragraph (1) of Section 75.38, Phase II requires that hazardous waste landfills comply with the standards set for sanitary landfills, with certain exceptions. The design and operation regulations discuss many of the practices associated with secure landfilling such as the use of daily covers, final covers and liners.

Texas

Section 104 of the Industrial Solid Waste Management Regulation Order No. 75-1125-1 addresses the problem of hazardous waste disposal. The four regulations of this section are all performance standards and design and operating practices are not specified. Environmental protection is ensured by permitting only secure facilities and my monitoring to check compliance with performance standards. The Texas strategy is analogous to Option 3.

Summary and Discussion

The application of the four options is disucssed in terms of their suitability as a Federal regulatory framework to control the landfilling of hazardous waste. The advantage and disadvantages of each approach are discussed as are the rationale for choosing or not choosing a particular approach.

Option 2 was determined not to be a viable alternative for establishing landfill design and operating standards. The Agency recognizes that the state-of-the-art of predicting landfill discharges is poor, and thus the prudent course is to prescribe maximum containment while allowing for deviation with proof of non-degradation. The strategy used for regulating landfills in these proposed rules is that they should be designed, constructed and operated so as to achieve the maximum containment of wastes. The rationale for this strategy is two fold. Maximizing containment minimizes the escape of waste constituents and thus provides protection of human health and the environment. Although EPA recognizes that some escape of wastes may not present a hazard to the environment, the Agency does not know how to predict what designs will allow what release rates, nor does the Agency know what release rates are acceptable. Accordingly, landfills are required to be designed, constructed and operated such that discharges do not occur unless the facility owner/operator can demonstrate that the groundwater human health and environmental standard (EPA drinking water standards) is not exceeded via some alternative design.

Therefore, developing standards along or based on discharge requirements was not further considered.

Evaluation of landfilling practices on a case-by-case basis (Approach 3) is the ideal regulatory approach in terms of insuring that the permit is tailored to the site and takes into account site and waste specific parameters. This approach advantageously requires that the permitting official carefully scrutinize and assess each permit application, on its own merits, in an effort to determine the appropriate permit requirements.

A major drawback of Approach 3 is the excessive economic, manpower, and time requirements needed for implementation. Another problem is that if EPA does not promulgate specific standards then there will be no means by which to assess or compare the equivalency of State hazardous waste programs to the Federal program. It may be difficult for a State to even develop a comparable hazardous waste program without Federal standards to use as guidance.

Guidelines for controlling the landfilling of non-hazardous waste are used by some States as guidance to aid in evaluating permit applications for the landfilling of hazardous waste. Nonhazardous landfilling guidelines are often grossly inappropriate and inadequate for this purpose.

Three of the five States evaluated here use guidelines developed specifically for controlling the landfilling of hazardous waste. The guidelines specify minimum requirements, of either a process or performance type, and are incorporated into the permit. These guidelines, although lacking the force of law, are included in all permits except when certain site or waste-specific parameters dictate that a modification to the guideline(s) be made. Depending on the parameter in question, the guideline may be made more stringent, less stringent, or deleted. If made less stringent or deleted, the owner or operator of the facility may be required to demonstrate that the objective of the original guideline will still be achieved.

Professional judgement must frequently be exercised when modifying a guideline. This requires a considerable amount of expertise on the part of the permitting official. Finding and hiring individuals of the appropriate caliber may be a major limiting factor (of this approach) at both Federal and State levels.

The apparent popularity of Approach 3 with the States surveyed does not necessarily mean it was selected because it was the best approach. It is possible that selection of Approach 3 may have been based on it being the only available choice, rather than the best choice.

Approach 3, in spite of its popularity, was not selected by EPA as a framework for regulating landfilling. Excessive resource requirements and the lack of a means for assessing and comparing State programs to the Federal program make this approach impractical on a national scale.

Approach 1 involves the use of specific performance standards applicable to all landfills. Such standards specify the minimum requirements a facility must meet in order to obtain a permit. Performance standards include material restrictions; and location, design and operating requirements. Standards of this type essentially tell a facility owner/ operator: (1) what materials (hazardous wastes) are or are not acceptable for certain treatment, storage, and disposal practices, and (2) where to locate and how to design and operate a site. Performance standards find favor with facility owners/operators that are seeking regulatory guidance on material restrictions and site location, design and operation.

However, strict standards specify a desired result without specifying how to achieve it. Standards of this type are favored by facility owners/operators that have the necessary treatment, storage, and disposal expertise and want only to know what end result is desired by the regulatory agency.

As a result of its "cookbook" nature, Approach 1 would be easier to implement on a national scale and would utilize less resources than Approach 3. This approach also provides a basis for assessing the equivalency of State programs.

A major disadvantage of Approach 1 is its inflexibility. Even when an alternative method can be demonstrated to meet or exceed the objective of a set standard, there are no provisions for deviating from that standard. Because of this inflexibility, Approach 1 discourages the development of new and innovative technologies by industry.

Only one of the States surveyed used this approach to regulate the landfilling of hazardous waste. Its unpopularity is thought to result primarily from its inflexibility. The solution to this problem is to incorporate flexibility into an otherwise rigid standard; especially a standard that might not be suitable for all existing or future technologies. Because Approach 1, as presented, has no provision for flexibility, it was rejected for use as a regulatory framework. In lieu, a hybrid approach, Approach 4, was developed, and selected for use as a regulatory framework.

In developing Approach 4, emphasis was placed on maximizing the beneficial attributes of Approaches 1 and 3, and minimizing their inherent disadvantages.

In an effort to eliminate the inherent inflexibility associated with developing design and operating standards, many of the standards, where appropriate, are accompanied by notes. The notes which are performance oriented, provide deviation from the standard provided the facility owner or operator can demonstrate to the EPA Regional Administrator, prior to receiving a permit, that the proposed alternative method(s) meets the objective(s) of the standard. The Regional Administrator, therefore, has the discretion to permit the use of alternate but equivalent technologies on a case-by-case basis. This approach affords maximum flexibility, where possible, by allowing industry to either follow the standard or demonstrate the efficacy of an equivalent method.

Not all of the standards are accompsnied by notes, hence, some lack flexibility. Several of the proposed standards do not have notes because the Agency made a decision, based on the best data available, that it was not possible to deviate from the standard and still meet the human health and environmental objective (of the standard). Some of the landfilling standards are not accompanied by notes because they specify a desired result, e.g., preventing direct contact between the landfill and navigable water.

Implementation of Approach 4 on a national scale will impact upon economic and manpower resources to a much lesser extent than Approach 3. This is because Approach 4 is "cookbook" in nature, and when deivation from a standard is proposed, the burden of proof is upon the facility owner or operator. This attribute will keep judgmental decisions to minimum, thereby lessening the need for a workforce of the caliber required in Approach 3.

Approach 4 was selected for use as a framework to regulate the landfilling of hazardous waste because it: (1) lends flexibility in the form of notes to what would otherwise be rigid standards, (2) provides a means by which permit applications can be more easily evaluated, and (3) provides an objective basis for comparing the Federal program to State programs.

IV. Identification of Chosen Standards and Associated Rationale

The purpose of the hazardous waste landfill standards are to reduce the potential for damage to human health and the environment which can arise from improper disposal of hazardous waste.

The regulatory format which the Agency has chosen to implement in the regulation is one of specific design and operating standards, combined with notes which provide a basis for deviation from the standard. It is one which the Agency feels best protects the human health and the environment. It combines most all the advantage of the options discussed in Section III by sepecifically delinenting what is required of owners and operators regarding landfilling of hazardous waste, while at the same time, providing some flexibility through the mechanism of the note. However, not all of the standards are accompanied by notes. For some standards the Agency believes that it is not possible for the facility owner/operator to deviate from the standard and still protect human health and the environment.

The following regulations, with their associated rationale, have been proposed under Section 250.45-2, standards for hazardous waste landfills:

(a) Site Selection

(1) A landfill shall be located, designed constructed, and operated to prevent direct contact between the landfill and navigable water.

Navigable water should not be allowed to interact with hazardous waste deposited in a landfill, since it could allow the waste to escape to the environment. Additionally water, contacting the landfill could erode or otherwise deteriorate the structure. A regulation prohibiting direct contact between a landfill and navigable water would help prevent such problems. The prescedent set by the State of New Jersey and most other States, which have or are preparing hazardous waste disposal regulations, establishes the fact that such procedures are recognized good practice. The potential consequences of not having such a regulation (listed below in detail) provide the rationale for this regulation.

(1) Precedent set by the State of New Jersey. A portion of New Jersey's hydrologic criteria for site location includes a recommendation to prohibit the establishment of facilities in places where disposal of wastes could bring contact with surface water or navigable water.

(2) Consequences of not having such a regulation.

A. Direct contact would hasten the movement of hazardous wastes into surface and/or groundwater and away from the site.

B. Navigable water contacting the landfill has the potential to:

i) Infiltrate the landfill, form a leachate, create a hydraulic head which can eventually breach the landfill liner.

ii) Carry dissolved and undissolved hazardous constituents away from the site.

iii) Damage the landfill structure.

C. Direct contact will preclude the existence of an unsaturated zone under and around the landfill. This automatically eliminates any natural attenuation or buffering capacity that could exist in such an unsaturated zone. Additionally, the time to detect and rectify a problem before environmental damage can occur is reduced if not eliminated.

(2) A landfill shall be located designed, and constructed so that the the bottom of its liner system or natural in-place soil barrier is at least 1.5 meters (5 feet) above the historical high water table.

NOTE: The bottom of any liner system or natural in-place soil barrier may be located less than 1.5 meters (5 feet) above the historical high water table, provided the facility owner/operator can demonstrate, to the Regional Adminstrator, at the time a permit is issued persuant to Subpart E, that no direct contact will occur between the landfill and the water table, and a leachate monitoring system as required by Section 250.43-8 can be adequately maintained in the lesser space.

The objective of this regulation is to ensure that a sufficient distance exists between the bottom of the landfill and historical high water table that will allow for the emplacement of leachate monitoring equipment, if necessary, and to act as a buffer and provide reaction time for responding to an unacceptable discharge should one be detected.

The rationale for such a regulation is very similar to rationale (2) (A) and (C) of regulation (a) (1) of this section. Essentially the above regulation is attempting to ensure that a buffer zone or zone of natural attenuation exists between the landfill and groundwater. The presence of such a zone may make the difference between what would be a minor, reversible pollution problem a major irreversible one. The separation between the bottom of the landfill and aquifer will prevent the aquifer from becoming contaminated immediately in the event of a leak. Thus, if a monitoring system immediately beneath a landfill detects a leak some time will be available for implementing contingency plans before the aquifer becomes contaminated. The 1.5m buffer zone also provides for unpredictable fluctuations of the historical high water table, reducing the possibility of direct contact between groundwater and the bottom of the landfill. The exact distance needed is site specific and should be established on a case by case basis. Therefore the note, which is part of this regulation, prescribes the criteria for deviating from the standard. In allowing the owner/operator to demonstrate that no contact will occur between the landfill and the UDWS and maintaining adequate leachate detection capabilities between the landfill liner and the UDWS, the Agency has allowed for achievement of equivalent waste containment while encouraging technological innovation and advancement of current state-of-the-art treatement, storage and disposal practices.

A review of several state's regulations reveals a variation, between states, concerning the distance between a landfill and groundwater. New York requires 5 feet (1.5m) to groundwater and a liner, of unspecified thickness, with a permeability of 1×10^{-7} cm/sec. Illinois requires 10 feet (3m) of 1×10^{-8} cm/sec (permeability) clay between a landfill and groundwater. Other states, such as Oklahoma require different depths to groundwater depending upon whether or not there is leachate collection and the type of leachate collection system employed. The minimum depth to groundwater for a landfill with a compound leachate collection system (in Oklahoma) is less than 3 meters (10 feet) of "relatively impermeable soil". Guidelines developed by Texas state that the bottom of the landfill area should be well above the historical high groundwater table, suggesting a maximum of 50 feet but allowing this number to be reduced to 1/10 of that value (5 feet) if the site is located in massive relatively impermeable clay formations. Other States which specify a minimum depth to the water table are Minnesota and Iowa which specify 5 feet, and Washington and Pennsylvania both specifying 4 feet to the groundwater table.

Although 1.5 meters is conservative when compared with other States' requirements, when it is used in conjunction with other requirements in this section, it provides adequate protection. Essentially, regulation (b) (6) (iv) requiring that bulk liquids semi-solid and sludge not be landfilled; regulation (b) (11) requiring a 10 ft. (3m) thick liner of 1×10^{-7} cm/sec permeability (in addition to the 1.5m above groundwater requirement) and regulation (b) (13) requiring leachate collection, provide considerable protection of groundwater by themselves. The additional requirement of a 1.5m buffer zone is more important in terms of providing a margin of safety rather than being the main barrier to pollution of the groundwater by leachate.

(3) A landfill shall be at least 150 meters (500 feet) from any functioning public or private water supply, or livestock water supply.

NOTE: A landfill may be less than 150 meters (500 feet) from any functioning public or private water supply or livestock water supply, provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that:

(i) No direct contact will occur between the landfill and any functioning public or private water supply or livestock water supply;

(ii) No mixing of the landfill leachate (including) groundwater or surface water contaminated with leachate) with the public or private water supply or livestock water supply will occur; and

(iii) A groundwater monitoring system as required by Section 250.43-8 has been installed and is being adeqately maintained.

A review of several States' regulations reveals a dichotomy in the approach used to develop buffer zone regulations. Most states prefer regulating on a site-specific basis, the premise being that the distance needed between a landfill and water supply well is dependent upon site specific variables, such as soil permeability, groundwater flow and direction, groundwater quality and use, etc.

At least two states, Texas (State Department of Health Resources), and Wisconsin (Department of Natural Resources), prefer to specify a distance, 500 feet (150m) and 1250 feet (375m) respectively. The States' rationale behind specifying a number is that it provides a tangible point of reference and facilitates enforcement. Being cognizant that a specified distance may not be applicable in some situations, both States maintain a flexible attitude and allow for concessions to be made. For example, Wisconsin requires that special construction techniques be used for constructing wells within 1250 feet (375m) of a landfill. Texas allows wells within 500 feet (150m) of a landfill if certain site parameters can provide the equivalent of 500 feet protection.

The regulatory approach taken by EPA, inclusion of a note allowing deviation from the standard, incorporates the advantages of having a tangible reference point with the versatility of allowing for concessions to be made under special circumstances.

Although the conservative value of 150m was chosen, when it is used in conjunction with other requirements in this section, it provides adequate time for detecting and responding to a problem when one is detected.

Essentially, a distance of 150m is relied upon in terms of providing a margin of safety and is not expected to serve as the main barrier to pollution of a water supply well.

(b) Construction and Operation

(1) A landfill shall be located, designed, constructed, and operated to minimize erosion, landslides, and slumping.

Erosion, landslides and slumping are three geophysical forces that can potentially disrupt the environmental integrity of a landfill. The main objective of the above regulation is to ensure that such a disruption does not occur.

Being cognizant of the fact that few potential landfill sites will be free of such forces, the regulation was written to allow flexibility, i.e., if an ideal site could not be found, then engineering against such geophysical forces would be acceptable. It is germane to point out that locating a landfill in an area known to be subject to extensive erosion, landslides, and/or slumping will require that site improvements be made and/or special operational techniques be employed.

The potential consequences of not locating or designing against erosion, landslides and slumping are listed below:

1. Erosion

Erosion can deteriorate the structure of a landfill and increase the likelihood of water entering the site. Subsequent infiltration and development of hydraulic head can hasten the vertical migration of hazardous constituents from the site. Additionally, once surface water has entered the landfill, erosion can effect removal of ~~wastes~~ the soil cover material (which may be contaminated) and deposited wastes via suspension or solution. The ultimate result is polluted surface water runoff which requires collection and treatment.

2. Landslides

Landslides, along with floods and erosion are common changes due to weather, the nature of soils, and gravity. Each, however, can produce a change in a site, thereby directly affecting the rate at which contaminants reach the environment.

A landslide near or within a landfill can disturb its structural integrity. All environmental media could be adversely affected in the event of a landslide disrupting the containment system of a secure landfill.

Areas subject to or having had landslides are undesirable locations for siting a landfill because the loose unconsolidated soil that characterizes such an area would lack the necessary structural integrity needed to safely support a landfill.

3. Slumping

The slumping or subsidence of land beneath a landfill can:

A. breach the landfills containment system;

B. bring the bottom of the landfill and groundwater into closer proximity if not in direct contact; and

C. cause depressions in the surface of the landfill in which surface water can accumulate.

(2) A landfill shall be located, designed, constructed and operated. So that its liner system or natural in-place soil barrier is compatible with the wastes to be land-filled.

Among the first considerations in selcting a site for disposal of hazardous wastes, should be the compatibility of the structural components of the site with the wastes to be deposited. The possible re-actions between the soil liner and a waste can detrimentally affect the ability of a disposal site to isolate a waste and prevent its escape to the environment.

In addition to possible soil reactions, reaction of the waste with the filled material can result in serious consequences. In particular, disposal in landfill areas can result in decomposition of the filled material, with generation of toxic gases and possible ingnition of flammable gases produced in the landfill. A careful evaluation of disposal area compatibilities is essential to ensure adequate protection of the human health and the environment.

Natural in-place soil barriers (liners) consists of clay and fine grained soils. However, some natural liners are not compatible with some hazardous wastes. For example, some natural impermeable soils may fail when exposed to strong acids. Also, artificial liners and synthetic membranes may fail if not properly installed or constructed, or when exposed to some hydrocarbon solvents. Table 1 summarizes some of the advantages and disadvantages of several liner types.

It is evident that the compatibility of the waste with the liner should be the first consideration in selecting a site for disposal. Any structural damage to the liner due to incompatible reactions between the waste and liner of the cell can result in escape of the hazardous constituents to the environment, which could adversely affect the human health and wildlife as well as interact with other incompatible substances in the vicinity. The leakage or rupture of containerized hazardous wastes can also result in structural damage through interaction of the escaped material with the liner or with other escaping wastes. Another potential

TABLE 1

ADVANTAGES AND DISADVANTAGES OF SEVERAL LINERS

Alternatives	Advantages	Disadvantages
Natural Claycy Soil	Self-sealing elements provide adequate ground-water protection	Not available in all geographic regions. Exposure to certain acids and chemicals may cause failure
Bentonite Clay	Very low permeability provides ground-water protection	Failure may occur when exposed to acids and certain chemicals
Low-cost synthetic membranes	Most membranes have good tensile strength, low temperature flexibility and resistance to a number of chemical wastes, highly impermeability	Not recommended for retention of hydrocarbons and solvents. Data on long-term integrity is lacking
High-cost synthetic membranes	Extra thickness provides excellent resistance to a number of chemical wastes, highly impermeability	Not recommended for retention of hydrocarbon and solvents. Data on long-term integrity is lacking. High-cost may cause use to be economically infeasible
Paved asphalt with a tar cover	Provides firm structural support	Vulnerable to attack by certain hydrocarbon solvents
Paved asphalt with a synthetic membrane	Provides structural integrity and resistance to chemical attack	Vulnerable to attack by certain hydrocarbon solvents. Use of certain synthetic membranes could elevate cost
1.2 m (4 ft) layer of common clay	Low permeability specifications provide ground-water protection	Exposure to certain acids may cause failure. Not available in all geographic areas
Clay barrier with synthetic membrane	Structural integrity and self-sealing properties of clay provide a very high degree of ground-water protection	Expose to certain acids over a long-term period may cause failure. Clay is not available in all geographic regions. Use of certain synthetic membrane could elevate cost

consequence of such interaction is the formation or release of other hazardous substances to the air and water media.

Stone, et al, in their report entitled "Evaluation of Hazardous Waste Emplacement in Mined Openings", discussed the interaction of several rock types of different mineral constituents with aqueous solutions of varying pH. It was pointed out that in a given pH range some rocks release complexing agents which hold toxic metals in solution, while other exhibit thixotropic properties, and others dissolve or react and undergo unfavorable structural alterations, perhaps allowing the release of hazardous wastes to the environment.

These considerations are representative of the kinds of interaction which are possible between a waste and a landfill liner. However, there are many other parameters regarding liner-waste incompatibility besides pH which need to be considered in the evaluation of any disposal area for hazardous waste. Mere hindrance of hydraulic continuity is not a sufficient basis for determining the geological acceptability of a disposal site because of the many possible reactions of waste and the liner.

It is therefore imperative that the hazardous waste to be disposed is compatible with the disposal area and that such a determination be made before a waste is disposed so that incidents involving fires, explosions, formation of toxic fumes, and release of contaminants to the environment can be avoided.

(3) The exact location of each hazardous waste and the dimensions of each cell with respect to permanently surveyed bench marks shall be recorded. The contents of each cell shall also be recorded. These records shall be handled as specified in 250.43-5(b).

The exact location and contents of a particular landfill, with respect to surveyed bench marks, would provide beneficial and easily obtainable information. Surveyed bench marks will be required for laying out the design of the landfill, prior to ~~filling~~ operation. With the dimensions and bench marks determined for a particular landfill, a simple grid system could be utilized to record exact locations and contents of wastes.

Permanent records containing the exact location and the contents of each landfill will provide a means for tracking down sources of contamination in case of any damage incident resulting from the landfill operation. By knowing the exact location, quality, and quantity of a hazardous waste responsible for groundwater, surface water, or air contamination, the potential for further damage and methods of correction may be developed.

Besides facilitating remedies for damage incidents, recording the exact location and contents for a landfill would also aid in resource recovery efforts for a particular hazardous waste should it become economically feasible. Disposal in a landfill may prove to be only storage with time, should the particular waste become desirable to be recovered. This factor supports part of the basic philosophy of the RCRA legislation, that being resource recovery through treatment or re-use of wastes.

Permanent records for location and contents of landfills would also ensure that incompatible wastes have no chance of coming in contact with one another. They would protect filled and covered cells from being structurally disturbed from subsequent inadvertent landfilling in the immediate area.

(4) Wastes, containerized or non-containerized, that are incompatible shall be disposed of in separate landfill cells.

The wastes accepted at hazardous waste disposal facilities are usually hazardous by themselves. However, if a waste were to come in contact with another waste which is incompatible with it, the consequences often create a more acutely hazardous situation than that posed by the reactants themselves. Furthermore, wastes can contact other incompatible materials during handling at a facility resulting in the same consequences. The lack of accurate information about the wastes, and the often indiscriminate handling of the wastes contribute to the high risk of contact of potentially incompatible substances at hazardous waste landfills.

The chemical reactions which result from such contact can cause secondary consequences such as injury, intoxication, or death of workers, members of the public, wildlife, and domestic animals. They can also cause property and equipment damage, and contamination of air, water and land.

Persons involved in the handling and disposal of hazardous wastes should not create a situation whereby potentially incompatible wastes can come in contact with one another and result in: (1) heat generation, (2) pressure generation, (3) fire, (4) explosion or violent reaction, (5) formation of substances which are shock sensitive, friction sensitive, or otherwise have the potential of reacting violently, (6) dispersal of toxic dusts and mists due to an explosion or violent reaction, (7) formation of toxic fumes, gases, or other toxic chemicals, (8) volatilization of flammable or toxic chemicals due to heat generation, and (9) solubilization of toxic substances. These incompatible reactions are those that are considered most important to be controlled through the mandatory separation of incompatible wastes inorder to protect human health and the environment from their occurrences.

Many incidents have already occurred, some of which are documented in Appendix I. In each of the cases listed, incidents occurred during normal handling operations and were the results of lack of accurate information about the waste (Case History No. 5), indiscriminate disposal practices (Case Histories No. 1,3,4,6,7), and indiscriminate mixing during other handling operations (Case Histories No. 2,5). These incidents have shown that the above mentioned reactions are those that are most significant in the consideration of potentially incompatible hazardous waste and their separation.

Many documented cases provide the supporting rationale for the requirement for preventing contact of incompatible wastes and the contact of wastes with other incompatible materials within the landfill. The appropriate control method may prove to be both site and waste specific.

A variety of waste-control approaches for hazardous waste disposal have been adopted by the States. The California Department of Health restricts disposal of incompatible wastes in order to insure that they will not come into contact with one another to cause fire or explosion, to generate toxic fumes, or to create substances which are an even greater hazard. California's guidelines for handling of hazardous waste list incompatible wastes according to the potential consequences of their intermingling (See Table 2). Disposal standards require separation of these materials at storage and disposal sites. The Texas Water Quality Board has modeled its waste-classification regulation upon the California listing.

Maryland regulations identify designated hazardous substances in three classes based upon the gravity of risk to human health and the environment. Class I substances pose "a grave risk," Class II substances present a "major risk," while Class III substances are those that will pose a "substantial threat" under "certain conditions". The basis for classification is drawn principally from the requirement of the Water Pollution Control Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and RCRA.

Table 2

List of Potentially Incompatible Wastes

The mixing of a Group A waste with a Group B waste may have the potential consequence as noted.

Group 1-A	Group 1-B
Acetylene sludge	Acid sludge
Alkaline caustic liquids	Acid and water
Alkaline cleaner	Battery acid
Alkaline corrosive liquids	Chemical cleaners
Alkaline corrosive battery fluid	Electrolyte, acid
Caustic wastewater	Etching acid liquid or solvent
Lime sludge and other corrosive alkalies	Liquid cleaning compounds
Lime wastewater	Pickling liquor and other corrosive acids
Lime and water	Sludge acid
Spent caustic	Spent acid
	Spent mixed acid
	Spent sulfuric acid

Potential consequences: Heat generation, violent reaction.

. . . .

Group 2-A	Group 2-B
Asbestos waste and other toxic wastes	Cleaning solvents
Beryllium wastes	Data processing liquid
Unrinsed pesticide containers	Obsolete explosives
Waste pesticides	Petroleum waste
	Refinery waste
	Retrograde explosives
	Solvents
	Waste oil and other flammable and explosive wastes

Potential consequences: Release of toxic substances in case of fire or explosion.

. . . .

Group 3-A	Group 3-B
Aluminum	Any waste in Group 1-A or 1-B
Beryllium	
Calcium	
Lithium	
Magnesium	
Potassium	
Sodium	
Zinc powder and other reactive metals and metal hydrides	

Potential consequences: Fire or explosion; generation of flammable hydrogen gas.

. . . .

Group 4-A

Alcohols
Water

Group 4-B

Any concentrated waste in Groups 1-A
Calcium
Lithium
Metal hydrides
Potassium
Sodium
SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3, and other water-reactive wastes

Potential consequences: Fire, expl sion, or heat generation; generation of flammable or toxic gases.

. . . .

Group 5-A

Alcohols
Aldehydes
Halogenated hydrocarbons
Nitrated hydrocarbons and other reactive organic compounds and solvents
Unsaturated hydrocarbons

Group 5-B

Concentrated Group 1-A or 1-B wastes
Group 3-A wastes

Potential consequences: Fire, explosion or violent reaction.

. . . .

Group 6-A

Spent cyanide and sulfide solutions

Group 6-B

Group 1-B wastes

Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.

. . . .

Group 7-A

Chlorates and other strong oxidizers
Chlorine
Chlorites
Chromic acid
Hypochlorites
Nitrates
Nitric acid, fuming
Perchlorates
Permanganates
Peroxides

Group 7-B

Acetic acid and other organic acids
Concentrated mineral acids
Group 2-B wastes
Group 3-A wastes
Group 5-A wastes and other flammable and combustible wastes.

Potential consequences: Fire, explosion, or violent reaction.

Source: "Law, regulations and guidelines for handling of hazardous waste", California Department of Health, February 1975.

(5) Each container of liquid hazardous waste shall be surrounded by an amount of sorbent inert material capable of absorbing all of the liquid contents of the container.

The principal rationale behind this regulation is in line with a basic philosophy of landfilling hazardous waste, that philosophy being to operate a landfill so that no hydraulic head (hydrostatic pressure) is produced. By keeping free liquids out of a landfill, the potential for leachate production is reduced and thus, environmental damage resulting from that leachate is minimized. According to Darcy's Law, which pertains to the movement of water through a permeable medium, unless there is some hydraulic head produced there can be no flow out of the landfill. This is the desire containment condition favored in a secure hazardous waste landfill. When little or no leachate is produced, no hydraulic head develops, and because of Darcy's Law, the containment condition is realized.

Also, this regulation indirectly encourages the practice of pretreatment techniques prior to landfilling and the development of other acceptable methods of disposal of liquid wastes besides landfilling in containers. With Agency policy describing landfilling as the least environmentally acceptable method of liquid waste disposal, this regulation supports this philosophy by requiring the use of sorbent material around buried containers, thus increasing the cost of filling liquid wastes.

The sorbent materials serve to contain the waste liquid should its container be ruptured after burial. It must be realized that a container once it is buried in a landfill will not contain that waste forever. All buried containers will rupture or leak sooner or later and by providing sorbent material to hold the liquid waste leachate production would be reduced. A sorbent material such as lime may also act to neutralize the liquid waste if it is releasted.

The seepage of appreciable amounts of liquid waste or leachate may also cause a rise in the water table and the development of a groundwater mound. As the mound increases in size, the unsaturated zone becomes progressively thinner and thus the opportunity for natural attenuation is reduced. Sorbent material, again would retain liquid waste lost from ruptured containers and reduce the formation of this groundwater mound and the subsequent reduction in natural attenuation.

(6) The following hazardous waste shall not be disposed in a landfill:

(i) Ignitable waste, as defined in Section 250.13(a) of Subpart A;

(ii) Reactive waste, as defined in Section 250.13(c) of Subpart A;

(iii) Volatile waste;

Note: See Note in Section 250.45(c).

(iv) Bulk liquids, semi-solids, and sludges.

Note: Bulk liquids, semi-solids, and sludges may be disposed of at a landfill provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbant), or treated and/or stabilized in the landfill (e.g., mixed with municipal refuse at acceptable ratios) to reduce its liquid content or increase its solid content so that a non-flowing consistency is achieved to eliminate the presence of free liquids prior to final disposal in a landfill.

(i) Ignitable wastes, as defined in Section 250.13(a) of Subpart A.

The landfilling of wastes with a flash point of less than 60°C (140°F), defined as ignitable wastes, is considered an unsafe practice with potential threats to public health and the environment. The objective of this regulation is to reduce the potential for fires and the related adverse affects (e.g., explosions, air emissions).

During and after the disposal of flammable waste, there are many available external and internal energy sources which can raise temperatures of wastes to their flash points. Electrical energy in the form of sparks generated by landfill machinery and thermal energy resulting from the heat of neutralization (pH change) or from the decompostion of organic waste, are examples of potentially problematic heat sources.

Another concern is the fact that disposal sites often contain waste that initially are not hazardous, but which when burned, become so. Certain plastics for example, give off noxious fumes and a beryllium dust may become airborne by means of the fire. (It is important to identify flammable waste so that these wastes can be segregated from otherwise benign wastes.)

A pure liquid with a flash point less than 60^{o}C (140^{o}F) is a hazardous waste. The 60^{o}C (140^{o}F) breakpoint is suggested because temperatures of this order can be encountered during the disposal of wastes, particularly in hot climates. Heats of chemical reaction, solar radiation, or organic degradation can elevate ground temperatures well above 38^{o}C (100^{o}F). Further evidence in support of a 60^{o}C flash point include:

(1) The heat generated as wastes are mixed, including heat of neutralization, heat of reaction, and heat of mixing, all are exothermic but difficult to estimate the temperature of these reactions;

(2) The heat from dark objects absorbing sunlight in landfills can approach 49^{o}C (120^{o}F) in parts of the U.S.

(3) The heat from biodegration in landfills can reach 60^{o}C.

(4) Tempertures in composting operations can reach 70^{o}C (158^{o}F).

A flash point of 60^{o}C (140^{o}F) provides for an adequate margin of safety under such circumstances.

The possibility of landfilling certain wastes with a flash point less than 60°C (140°F), under certain situations could be considered safe. The notes accompaning this standard allows for deviation, thus landfilling of such a waste(s) may be acceptable if it can be shown that the disposal method (s) employed will not violate the human health and environmental standards and are approved by the Regional Administrator base on best available technology.

(ii) Reactive wastes, as defined in Section 250.13(c) of Subpart A.

The disposal of reactive wastes, as defined in Subpart A, in a hazardous waste landfill is considered an unsafe practice with respect to public health and the environment. A waste is reactive, according to Subpart A (250.13(c)(1), if it has any of the following properties:

Reactive Waste - A solid waste is a reactive waste if it:

(1) is normally unstable and readily undergoes violent chemical change without detonating; reacts violently with water, forms potential explosive mixtures with water, or generates toxic gases, vapors or fumes when mixed with water; or is a cyanide or sulfide bearing waste which can generate toxic gases, vapors or fumes when exposed to mildly acidic or basic conditions.

(ii) is capable of detonation or explosive reaction but requires a strong initiating source or which must be heated under confinement before initiation can take place, or which reacts explosively with water.

(iii) is readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

(iv) is a forbidden explosive as defined in 49 CFR 173.51, a Class A explosive as defined in 49 CFR 173.53, or a Class B explosive as defined in 49CFR 173.58.

Such wastes include pyrohoric substances, explosives, autopolymerizable material and oxidinizing agents. If it is not apparent whether a waste is a reactive waste under this section, then the methods cited in Section 250.13(c)(2) of Subpart A or equivalent methods can be used to determine if the waste is a reactive waste.

It is the intent of this regulation to minimize and/or eliminate the potnetial for the occurrence of incidents which may result in serious damange and/or adversely affect the public health and the environment.

According to the above criteria for reactive wastes, it can be readily seen that disposal of such waste may have the potential to cause serious and irreparable damage. There are numerous damage reports contained in the EPA files which document damage and injuries resulting from disposal of reactive wastes.

EPA recognizes that under certain situations and approved operating procedures, reactive wastes, as defined above, may be disposed of in a hazardous waste landfill in an acceptably safe manner, provided the methods employed will not violate human health and environmental standards (250.42-1,2,3) and are approved by the Regional Administrator, based on best available technology (See note Section 250.45(c)).

(iii) Volatile wastes

NOTE: See note in 250.45(c)

The objective of not allowing highly volatile wastes to be landfilled is to assure that hazardous waste disposal facilities (landfills) are operated such that the ambient air quality beyond the facility owner's property, due to emissions from the facility, does not adversely affect human health or the environment. Further discussion concerning standards regulating air quality from non-point emission sources can be found in the background document for the Control of Air Emissions.

Landfilling of highly volatile waste has the potential to create serious air pollution problems and for the occurance of incidents which may result in serious damage to and/or adversely affect the public health and the environment. There have been numerous damage incidents involving volatile wastes which are documented in EPA files. The majority of these incidents have occured as result of improper handling due to the lack of accurate information on the specific waste and, the often indiscriminate handling and disposal of such wastes. These factors contribute to the exceedingly high risk with the disposal of highly volatile wastes. Substances with high vapor pressures can cause, either alone or in conjunction with another substance, chemical reactions and reaction consequences which are often more reactive than the reactant(s) themselves (intense heat generation, pressure generation, fire, explosion, violent reaction, formation of latent reactive substances, dispersal of toxic substances, formation of toxic fumes, gases and other toxic chemicals and solubilization of toxic substances). These primary consequences can lead to secondary consequences such as injury, intoxication, or death of workers, members of the public, domestic animals and wildlife. Property and equipment damages as well as contamination of air, water and land can also be caused by the primary consequences. Examples of sepcific damage incidents resulting from disposal of volatile hazardous wastes can be found in the background document for the standards for the Control of Air Emissions.

The severity of these adverse consequences and the swiftness with which they can occur emphasize the necessity for adequate precautionary measures regarding the managment and disposal of highly volatile wastes.

A maximum vapor pressure of 78 mm of Hg at 25°C has been established, above which wastes could not be landfilled. Rationale supporting this number can be found in the background document, "Standards for the Control of Air Emissions."

The Agency recognizes that wastes with a vapor pressure below 78mm Hg at 25°C may be landfilled in a manner which would not adversely affect human health and the environment. The note accompanying this standard allows such deviation to occur if the owner/operator can demonstrate that non-point sources do not contribute any air contaminants to the atmosphere such that concentrations do not exceed limits based on those promulgated in 28 CFR 1910.1000 pursuant to the Occupational Safety and Health Act of 1970 (See 250.45(c) and Annex 2 of Subpart D). Comprehensive laboratory and field investigations by the owner/operator of a landfill will be requisite to demonstrating that certain volatile waste can be disposed of in an environmentally acceptable manner.

(iv) bulk liquids, semi-solids and sludges.

Note: Bulk liquids, semi-solids, and sludges may be disposed of at a landfill provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbant), or treated and/or stabilized in the landfill (e.g., mixed with municipal refuse at acceptable ratios) to reduce its liquid content or increase its solid content so that a non-flowing consistency is achieved to eliminate the presence of free liquids prior to final disposal in a landfill.

The landfilling of bulk liquids, semi-solids and sludges are considered contrary to the regulatory strategy put forth by the EPA. This strategy supports maximum containment of hazardous wastes and maximum protection of the public health and the environment.

Containment is directly affected by the liquid content of the waste materials. Increasing the liquid fraction will generally decrease the potential of containment.

Darcey's Law, which can be applied to define the rate of flow of groundwater, can also be applied to estimate how rapidly liquid contaminants move downward from the land surface to the saturated zone. Parameters which will affect rate of flow are the hydraulic conductivity of the material, fluid viscosity, material porosity, natural attenuation and the hydraulic head (hydrostatic pressure) created by the liquid. The rate of travel of a fluid is directly proportional to the amount of hydraulic head, i.e., the greater the hydraulic head, the greater the velocity of a liquid through a material, with all other parameters being kept equal. The disposal of bulk liquids, semi-solids and sludges into hazardous waste landfills will create a positive hydraulic head greater than what would be created by only direct precipitation. This would result in a situation where leaching of hazardous waste would be encouraged and cause a greater potential for ground water contamination.

The disposal of bulk liquids, semi-solids and sludges in hazardous waste landfills with, or being constructed with, leachate collection systems is also discouraged. The purpose of a leachate collection system is to collect and remove any leachate which happens to be generated from the disposal of hazardous wastes (which have only a small percentage of water by weight) and from direct precipitation. This is done to ensure maximum containment of the hazardous waste. The leachate which has been collected is a hazardous waste which is treated and discharged with appropriate NPDES permit or disposed of in the landfill. Recycling of the leachate through a landfill should accelerate the degradation of the organic fraction; however, the conservative mineral salts will be retained within the landfill mass. Some of these salts conceivably may be converted to low solubility compounds. Soluble salts, however, will continue to be susceptible to discharge from the landfill as the leachate volumes exceed the capacity of the barrier underlying the landfill.

In order to keep liquids and sludges out of hazardous waste landfills they must be treated and/or stabilized prior to or in the landfill to a non-flowing consistency, or they must be containerized and surrounded by sorbent material when buried.

Most landfills are designed without taking into account the nature of the waste that they are to contain. Modification or treatment of wastes prior to land burial can, in some cases, retard the production of leachate that would adversely affect the quality of ground waters and surface waters.

The appropriateness of a waste-modification method depends upon its technical effectiveness in preventing the leaching of toxic components and upon economic factors.

(7) Diversion structures (e.g., dikes, drainage ditches) shall be constructed such that surface water runoff will be prevented from entering the landfill.

Note: Diversion structures may not be necessary provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that the landfill facility is located so that the local topography will prevent surface water runoff from entering the facility.

Precipitation can create large amounts of surface water runoff which can enter or even flood a landfill. Landfills which are below surrounding grade are particularly vunerable since they can serve as sinks for the collection of rainfall or snowmelt runoff. This water would damage the physical structure of a landfill through erosion or carry away wastes in solution or suspension. Sufficient water may collect to allow overflow of hazardous materials to the surface water environment. Furthermore any water which is allowed on the surface of a landfill may percolate downward through wastes creating leachate and contributing to the static head within the site. To abate these potential environmental threats, every effort should be made to minimize runoff into landfills. This may be achieved by the construction of dikes or drainage ditches capable of diverting runoff water from the landfill. The diversion capacity of preventive structures should be based on a prediction of maximum storm frequency for the active life of the facility.

(8) Surface water which has been in contact with the active portions of a landfill shall be collected and treated or disposed of as hazardous waste in accordance with requirements in this Subpart unless it is analyzed

and found not to be a hazardous waste as identified or listed in Subpart A or it is collected and discharged into a navigable water in compliance with a NPDES permit issued under the Clean Water Act.

Runoff that comes in contact with the active face of the landfill may take some waste into solution or suspension. The quality of the contaminated water generated by this process cannot by easily predicted. Accordingly, it is safest to assume that the water will have been contaminated. Because the runoff cannot be easily controlled as a non-point source, collection and containment will be necessary. If water has been contaminated, the collected runoff can be treated and discharged. Water which has been shown to be uncontaminated, or which falls within limits established by the facilities NPDES permit, may be safely discharged directly.

(9) Where gases are generated within the landfill, a gas collection and control system shall be installed to control the vertical and horizontal escape of gases from the landfill.

NOTE: Gas collection and control system shall not be required provided the owner/operator can demonstrate, to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that gases will not be generated in the landfill or that gases generated will not be in violation of the air contaminant limits specified in the "Note" associated with Section 250.45(c) and will not creat a flammable or explosive atmosphere.

Landfills may contain or produce explosive, toxic or asphyxiating gases which may accumulate on site or migrate off-site. Products of waste decomposition, oxidation, volatilization, sublimation, or evaporation may include gases such as methane and hydrogen (explosive and asphyxiating), carbon monoxide and carbon dioxide (asphyxiating), chlorine (toxic), and various gases of chemical wastes (explosive, asphyxiating, or toxic).

Presence of any of these gases at a landfill, in sufficient concentration, can pose a serious threat to the health and welfare of site employees, users, and occupants of nearby structures. Explosions, asphyxiations, and poisonings resulting in injury and death have resulted from disposal site gases. In addition, property damage, groundwater contamination, and vegetation kills on-site and on adjacent lands have been caused by hazardous waste disposal gases. Techniques need to be implemented at landfills to avoid, prevent, or control the formation and migration of these gases.

There is need for the use of methods to prevent gas migration offsite and to prevent accumulation in on-site structures in harmful quantities. Frequently these measures are site-specific, and may include: control of incoming waste materials which may cause problems; location of the site away from occupied structures on-site to prevent migration; construction of barriers to gas migration at the landfill boundry; and the use of vents. Barriers to vertical migration consist of covering the landfill with low permeability soils or other materials. However, since all materials are somewhat permeable these barriers should be used in conjunction with vents. Vents may consist of gravel or open trenches and the use of porous or slotted pipes with or without pumps to stimulate gas flow either for dispersion into the atmosphere, or for concentration, destruction, or utilization, usually by combustion.

As previously mentioned, gas generation at hazardous waste landfills is frequently a site-specific situation which is generally dependent on the disposal of waste materials which may, by themselves or in combination with other wastes, cause gas generation and related problems. Therefore, this regulation is flexible enough to allow owners/operators of hazardous waste landfills not to install gas collection and control systems if they can demonstrate that gases will not be generated from wastes materials disposed in the landfill. Owners and operators may also choose to demonstrate that any gases generated would not contribute any air contaminant to the atmosphere in excess of limits set in 250.45(c) of Subpart D.

(10) A minimum of 15 centimeters (6 inches) of cover material shall be applied daily on active hazardous waste landfill. Active portions which will not have additional wastes placed on them for at least one week shall be covered with 30 centimeters (12 inches) of cover material.

NOTE: An owner/operator may use covers of different thicknesses and/or apply them at different frequencies if he can demonstrate to the Regional Administrator, at the time a permit is issure pursuant to Subpart E, that the possibility of fire or explosion or the harboring, feeding, and breeding of land burrowing animals and vectors will be controlled to an equivalent degree.

Cover material serves many purposes: (1) helps in disease vector and rodent control; (2) helps contain odor, litter, erosion, and air emissions; (3) enhances aesthetics; (4) lessens the chance and spread of fires; (5) reduces infiltration of rainwater and thereby decreases potential leachate generation and surface and groundwater contamination; and (6) enhances the site appearance and utilization after completion

Hazardous waste landfill operations plans should specify what soils are to be used as cover material, where they are to be obtained, and how they are to be placed over the waste in order to meet the aforementioned purposes. Cover materials used at a landfill is classes as daily, intermediate, and final; the classification depends on the thickness of soil used and by the length of time the cover is to exposed to the elements. In general, if the cover is to be exposed for more than 1 week but less than 1 year, intermediate cover should be used. If the cover is to be exposed less than one week, daily cover is sufficient, and if the cover is to be exposed longer than one year final cover should be used.

Final cover material should be well compacted.

DAILY COVER. The important control functions of daily cover are odor, vector, litter, fire, and moisture. Generally, a minimum compacted thickness of six inches of soil will perform these functions if it is applied at the end of each operating day. Using greater than six inches would waste soil cover and cause the landfill to be filled up more quickly decreasing its usable life. At the end of the operating day, the working face should also be covered, thus leaving no waste exposed. Subsequent grading may be desired to prevent ponding of rainwater and subsequent infiltration into the fill.

INTERMEDIATE COVER. Functions of intermediate cover are the same as daily cover but include gas control and possibly service as a roadbase. It is applied in the same manner as daily cover, but the minimum compacted depth recommended is one-foot (30 cm.). Periodic grading and maintenance may be necessary to repair erosion damage, to prevent ponding of water, and to fill cracks and depressions caused by moisture loss and settlement of the fill. The 30cm dept for intermediate cover was determined to be sufficient to withstand the added stresses of prolonges erosions and infiltration for a period of one year and still maintain adequate protective cover over the fill.

While the quantity of cover soil applied is important, the quality of the material is even more important. No one soil type appears to fulfill the requirement for impermeability. Clean sands are readily permeable, silts are difficult to manipulate, and clays have a tendency to shrink and crack if they lack moisture content. A mixture of these soils, however, can provide an adequate cover material. See the background document for Closure and Post-Closure Care (Section 250.43-7) for the development of suitable soils for cover.

The Agency realizes that the application for cover materials at the above specified frequencies and thickness may not be applicable at all landfills in every waste disposal situation. Therefore if owners/operators of hazardous waste landfills can demonstrate successfully that the possibility of fire or explosion, harboring, feeding and breeding of land burrowing animals and disease vectors; or that the human health and environment are controlled and protected to an equivalent degree, then covers of different thickness and/or frequencies may be employed.

(11) In areas where evaporation exceeds precipitation by 20 inches or more and where natural geologic conditions allow, a landfill shall have a natural in-place soil barrier on the entire bottom and sides of the landfill. This barrier shall be at least 3 meters (10 feet) in thickness and consist of natural in-place soil which has a

permeability of less than or equal to 1 X 10^{-7} cm/sec. and meets the requirements of Section 250.45(b) (14).

Note: A natural in-place soil barrier using natural in-place soils of different thicknessess and permeabilities may be used, provided the barrier has a thickness greater than or equal to 1.5 meters (5 feet), and provided that the owner/operator of the landfill can demonstrate to the Regional Administrator, at the time a permit is issued prusuant to Subpart E, that it will provide equivalent containment of leachate.

(12) An owner/operator of a landfill using the design in paragraph (b)(11) or any similar design which does not have a leachate collection system shall demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that liquids will not accumulate in the landfill to the extent that they may be discharged to the surface or to groundwater.

Any contaminant deposited on the ground surface is in position where it can easily enter the geologic environment of soils and unconsolidated or solid rocks, as long as they contain pore spaces or other openings. Liquid contaminants and solid contaminants that undergo leaching by water from precipitation can infiltrate where the soils are sufficiently permeable, to percolate downward through the unsaturated material to the water table.

The relative inaccessibility of the groundwater for monitoring dicatate emphasis on preventative control measures to protect usable drinking water supplies. Normal groundwater monitoring procedures involve limited sampling locations in the presumed direction of flow. Selection of monitoring locations and definition of flow direction techniques are not fool-proof. A very real possibility of "missing" ground-water pollution through normal monitoring and sampling techniques, therefore, exists. Furthermore, corrective techniques for groundwater pollution, once identified, are not well established. It is this situation which supports concentration on protection of groundwater via preventive techniques and requirements; i.e., criteria for contaminant containment.

The factors that relate to the containment characteristics of the site include soil thichkness, soil permeability, sieve analysis, liquid limit, Unified Soil Classification, and depth to water table. The containment time will vary with changes in the thickness of clay, depth to water, and hydraulic conductivity of the material above the water table. It is preferred that liquids be combined with absorbent material, although it is unlikely that all free liquids can be absorbed.

Leachate produced by water migrating through the deposited hazardous waste presents a treat of both ground and surface water contamination. Under moist climatic conditions, when precipitation exceeds evaporation, the production and migration of leachate is encouraged. For this reason, landfills using this natural design (without leachate collection) must be located in areas where evaporation exceeds precipitation annually by 20 inches. An excess of 20 inches of evaporation was chosen because such a number limits the use of this natural design to areas known to be very dry with naturally deep water table levels. Generally, these areas include parts of Arizona, New Mexico, Texas, Utah, Nevada, California, Colorado, and isolated areas of Wyoming and Montana. (See figure 1). If this standard was written without the 20 inch excess evaporation limit (i.e., as evaporation exceeds precipitation) the area in which this design could be used would include the majority of the continental U. S. west of the Mississippi River which, the Agency believes, would not be adequate in order to protect public health and the environment.

The types of information concerning soil properties sought by State regulatory agencies reflects a preference for tight clay soils with no sand or gravel seams and a hydraulic conductivity of less than 1 x 10^{-7} cm/sec.

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For Figure 1

Map U.S. showing general areas where evaporation exceeds precipitation by 20 inches.

The regulatory philosophy prevailing in the U.S. today favors maximum containment, and the States are using two different types of regulatory approaches to achieve this.

Some States specify minimum vertical distances to the water table, minimum permeabilities, minimum overburden thickness, and the soil or rock material criteria that must be met at sites. Other States regulate sites according to containment time characteristics.

There is a strong preference in many States for the use of natural in-place materials for lining sites and, generally, states specify lining as a condition for a permit. Hazardous waste land disposal facilities in California are required to have in-place soil liners with a permeability of 1×10^{-8} cm/sec regardless of the soil thickness. Illinois requires 10 feet of 1×10^{-8} cm/sec of in-place clay-rich soil for landfill liners. Pennsylvania is somewhat less stringent, but more explicit in their landfill liner requirements; where natural soil conditions allow, 2 feet (or a thickness determined by permitting official) of 1×10^{-7} cm/sec of clay-rich soils shall be required. The strictest landfill requirements are those in the State Ohio, which requires 25 feet of in-place clay-rich soils with a permeability of 1×10^{-8} cm/sec. Other States, Texas, New York, Minnesota and New Jersey, specify liner permeabilities of less than or equal to 1×10^{-7} cm/sec.

The criteria chosen by the EPA are most like the State of Illinois' liner thickness and permeability requirements. The requirements, however, have been scaled to apply on a national level. This is due to the lack of extensive clay-rich soil deposits available in the U. S. with permeabilities of less than or equal to 1 x 10^{-8} cm/sec.

The intent of this standard was to allow the use of a landfill design in areas where natural in-place soils would be sufficient to meet the specified containment requirements without leachate collection. Therefore, they must be located in very dry climates.

Sites meeting the necessary geologic and climatic condition for maximum waste containment without leachate collection could also pose a problem of accumulating liquids which might overflow to the surface or create leaks to the groundwater due to excessive hydraulic head, with the unlikely occurrance of unnaturally heavy rains. Thus, the owners/operators must demonstrate that such a situation will not occur if the site is to be used for the landfilling of hazardous wastes.

The availability of natural sites that will satisfy the above requirements may be difficult to find. In such situations the EPA standards provide needed flexibility by allowing other combinations of soil thickness that will achieve equivalent containment and/or allowing usage of synthetic membranes and leachate collection systems, specified under 250.45-2(b)(13) of this section.

(13) In areas where climatic and natural geologic conditions do not allow meeting the requirements of paragraph (b)(11), a landfill shall have either one of the following liner systems covering the entire bottom and sides of the landfill:

(i) Design I

The liner system shall have a slope of at least 1 percent at all points to one or more leachate collection sumps, (which meet the specifications in paragraph (b)(17)), so that leachate formed in the landfill will flow by gravity into the leachate collection sump(s) from which the leachate can be removed and treated or disposed of as specified herein. The liner system shall consist of:

(A) A soil liner which is at least 1.5 meters (5 feet) in thickness and composed of natural in-place soil or emplaced soil which has a permeability less than or equal to 1 x 10-7 cm/sec and meets the requirements of paragraph (b)(14); and

(B) A leachate collection and removal system overlying the soil liner which is at least 30 centimeters (12 inches) in thickness and composed of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sump(s).

(ii) Design II

The liner system shall have a slope of at least 1 percent at all points and be connected at all low points to one or more leachate collection sumps (which meet the specifications of paragraph (b)(17)), so that leachate formed in the landfill will flow by gravity into the leachate collection sump(s) from which the leachate can be removed and treated or disposed of as specified herein. The landfill liner system shall consist of:

(A) A leachate detection and removal system, placed on the natural base of the landfill, which shall consist of a minimum of 15 centimeters (6 inches) of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sumps;

(B) A membrane liner system overlying the leachate detection and removal system composed of a 15 centimeter (6 inch) layer of clean permeable sand or soil overlaid with a synthetic membrane liner which meets the specifications in paragraph (b)(15) and which is overlaid with a 15 centimeter (6 inch) layer of clean permeable sand or soil;

(C) A soil liner overlying the membrane liner system which is at least 1 meter (3 feet) in thickness and composed of soil which has a permeability less than or equal to 1 x 10^{-7} cm/sec and meets the requirements of paragraph (b)(14); and

(D) A leachate collection and removal system overlying the soil liner which is at least 30 centimeters (12 inches) in thickness and composed of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sumps.

Note: A landfill may use a different liner system than the two described above provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that the alternate liner system includes a liner and a leachate collection and removal system that provides equivalent or greater leachate containment, collection, and removal.

The objective of this standard is to provide maximum protection for human health and the environment at landfill sites where climatic and natural geologic conditions do not allow use of the liner design specified in 250.45-2(b)(11), and also to provide flexibility in design and construction of liner systems.

In establishing the rationale for standard 250.45-2(b)(11) the need for protecting the natural groundwater system beneath the landfill was discussed at length and therefore will not be addressed here. However, the emphasis on the protection of groundwater and underground drinking water sources through maximum waste containment is basic to the landfill designs discussed here.

The standard as stated above allows for the use of either of two basic disigns for the construction of a landfill liner system in conjunction with a leachàte collection system(s). These designs are designated, Design I and Design II.

Design I requires a soil barrier (liner) of at least 1.5 meters in thickness composed of natural in-place soil or imported amended, recompacted or reworked soils with a permeability of 1×10^{-7} cm/sec. The in-place soil or emplaced soil liners must also meet the requirements of 250.45-2(b)(14).

The liner type, thickness and permeability criteria specified in this standard for this design follows the strong preference in many States for the use of natural materials for lining sites. Hazardous waste disposal sites in Oklahoma must have a clay liner at least 1.5 meters (5 feet) thick, while New Jersey will permit the use of natural and/or man-made materials for lining as long as a maximum hydraulic conductivity of 1×10^{-7} cm/sec can be maintained. Other States with hazardous waste regulations and/or guidelines which specify liner thickness and permeability in conjunction with leachate collection and removal are Texas, New York, Minnesota, Ohio, and Pennsylvania. All of the above States require a maximum permeability of 1×10^{-7} cm/sec for soil liners. Soil liner thickness addressed by these States range from 1.5 meters (5 feet) to not specifying a thickness for liner material. The EPA has chosen to specify liner thickness to ensure adequate waste containment and to provide for leachate attentuation within the soil liner.

Design II is a more complex design involving a double liner system with leachate collection and removal. The liner system for Design II consists of a 1 meter (3 feet) soil liner with a permeability of 1×10^{-7} cm/sec., which meets the requirements of 250.45-2(b)(14). The soil liner overlies a synthetic membrane liner which meets the specifications in 250.45-2(b)(17) and is protected on both sides with a minimum of 14 cm (6 inches) of clean sand or soil. In addition to the leachate collection and removal system required to be constructed on tip of the liner systems of Design I and Design II, a leachate detection and removal system will be required beneath the membrane liner of Design II.

The Agency believes that use of Design II will afford the greatest degree of waste containment and groundwater protection of the designs described in these standards. It combines the attneuation and self-sealing properties of a soil/clay liner with the synthetic membrane's capacity for resistance to a number of chemical wastes and very low permeability. The use of synthetic membranes, by themselves is not an acceptable practice. The Agency feels that there is, at present, inadequate information available on the long-term reliability of synthetic membranes, used by themselves, for waste containment in landfills. Once a landfill liner is constructed and in place and waste materials are disposed of within the fill, and if the liner system fails to contain the waste; the retrieval and repair of that liner is extremely costly and hazardous if not an impossible task due to the nature and volume of the wastes within the fill. Thus deleterious effects to the groundwater may result.

The construction of an impermeable liner should be closely supervised. In particular, the installation of a manufactured liner requires (1) prior removal of all sharp stones and similar objects to prevent puncture and (2) application of a protective soil cover after the liner is in place to prevent damage from landfill machinery. Table 3 summarizes the advantages and disadvantages of several liner types. EPA has adopted standards which stipulate that liners may be natural or (when natural conditions are not favorable) man-made, or a combination of both; and must have a thickness of at least 1.5 meters (5 feet) when used in conjunction with leachate collection, and have a permeability of less than or equal to 1×10^{-7} cm/sec.

Natural Clayey Soil	Self-sealing elements provide adequate ground-water protection	Not available in all geographic regions. Exposure to certain acids and chemicals may cause failure
Bentonite Clay	Very low permeability provides ground-water protection	Failure may occur when exposed to acids and certain chemicals
Low-cost synthetic membranes	Most membranes have good tensile strength, low temperature flexibility and resistance to a number of chemical wastes, highly impermeability	Not recommended for retention of hydrocarbons and solvents. Data on long-term integrity is lacking
High-cost synthetic membranes	Extra thickness provides excellent resistance to a number of chemical wastes, highly impermeability	Not recommended for retention of hydrocarbon and solvents. Data on long-term integrity is lacking. High-cost may cause use to be economically infeasible
Paved asphalt with a tar cover	Provides firm structural support	Vulnerable to attack by certain hydrocarbon solvents
Paved asphalt with a synthetic membrane	Provides structural integrity and resistance to chemical attack	Vulnerable to attack by certain hydrocarbon solvents. Use of certain synthetic membranes could elevate cost
1.2 m (4 ft) layer of common clay	Low permeability specifications provide ground-water protection	Exposure to certain acids may cause failure. Not available in all geographic areas
Clay barrier with synthetic membrane	Structural integrity and self-seating properties of clay provide a very high degree of ground-water protection	Expose to certain acids over a long-term period may cause failure. Clay is not available in all geographic regions. Use of certain synthetic membrane could elevate cost

As discussed above liners may be natural or man-made, or a combination of both. Natural impermeable barriers consist of clay and fine-grained soils; man-made liners range from asphaltic compositions to concrete compositions to various synthetic polymeric membranes. The selection of liners may be determined by the type of leachable material to be disposed. Some liners are not compatible with some hazardous wastes. For example, ethylene propylene rubber would probably fail when used with a waste containing hydrocarbons. In addition, natural impermeable soils may fail when exposed to strong acids.

Texas has established guidelines for the use of soil barriers or liners at sites receiving hazardous wastes. Man-made liner material should be at least 30 mils thick, be of reinforced material, and be used in conjunction with soil protection to minimize the possibility of puncturing the liner.

Pennsylvania regulations stipulate that the disposer must submit data indicating the miscibility of any proposed liner membrane relative to an exposure of not less than 100 hours with the wastes to be disposed. Disposal sites constructed without man-made liners must have renovating soil between the waste and any sidewill. The State will determine the thickness of the renovating soil layer based upon the groundwater and surface water contamination potential of the wastes. The State agency also specifies that the leachate-collection system be designed to handle the amount of leachate generated over the active life of the site and up to 10 years after its closure.

Containment is of course directly affected by the liquid content of the waste materials. Increasing the liquid fraction will generally decrease the potential of containment. Natural attenuation by the soil and rock through which the waste pass will also affect the quality of the leachate reaching the ground and surface water. In general, attenuation mechanisms become more effective as hydraulic conductivity decreases in a given section of soil. It is EPA policy to eliminate the disposal and generation with subsequent collection and removal of all free-liquids in hazardous waste landfills. This is to be required in order to minimize the creation of a hydraulic head which would result in an increase in hydraulic conductivity and have deleterious effects to the liner.

As discussed, leachate produced by water migrating through the deposited hazardous waste presents the threat of both ground and surface water contamination. Leachate travels to the bottom of a landfill under normal circumstances. For this reason, additional protection and control can be achieved by the installation of a leachate collection and removal system. If leachate were detected, the collection system would allow it to be pumped out. The collection system should be monitored regularly for the quantity and quality of leachate produced.

This standard requires that ~~those~~ hazardous waste landfills be designed to include a leachate collection and removal system to be constructed on top of the liner system in order to intercept and remove leachate generated within the fill. A minimum acceptable leachate collection and removal system, is specified in these standards. Since the leachate collection and removal system is located on top of the liner system, the liner must have a slope at all points of at least 1 percent and drain to one or more leachate collection sumps. Leachate must be able to flow by gravity to the sumps from which the leachate can be removed and treated or disposed properly. A minimum of

30 cm (12 inches) of highly permeable soil or gravel, which will allow leachate to move rapidly to the collection sump(s) must be placed over the soil liner. Perforated pipes could also be added within the soil/gravel layer to enhance the collection and movement of liquids. The purpose and need for such a system in a landfill where free liquids are generated has been previously discussed. A system such as the one described here is a very minor part of the total cost of a secure landfill and the benefit of its use to the containment of waste and protection of groundwater can not be over emphasized.

Although leachate collection and treatment is called for by the majority of State regulatory agencies, the method of treatment is rarely prescribed. "Disposal Site Design and Operation Information," prepared by the California State Water Resources Control Board, summarizes the technical difficulties States may encounter in this respect by observing that "Treatment of this high organic and mineral content liquid is difficult. Discharge to a sewerage system usually is not possible because landfills normally are long distances from the nearest connection points. Use of evaporation ponds is practical only if the quantity of leachate collection is less than the evaporation potential of the ponding areas. Recycling of the leachate through a landfill should accelerate the degradation of the organic fraction; however, the conservative mineral salts will be retained within the landfill mass. Some of these salts conceivably may be converted to low solubility componds. Soluble salts, however, will continue to be susceptible to discharge from the landfill as the leachate volumes exceed the capacity of the barrier underlying the landfill." (5)

The federal effluent standards program applies to all generators of hazardous waste that dispose of material to surface waters. Storage, treatment, or disposal in lagoons, landfills, or spreading grounds is not covered. Some States have included discharges to the ground in their effluent program. EPA has not yet developed surface water effluent guidelines for the commercial hazardous waste management facility, but some States, New York and Washington, for example, are developing effluent standards on a case by case basis for the commercial treater of hazardous waste.

(14) The soils used in a soil liner and natural in-place soil barrier shall meet the following minimum criteria:

(i) Be classified under the Unified Soil Classification System CL, CH, SC, and OH (ASTM Standard D2487-69,

(ii) Allow greater than 30 percent passage through a No. 200 sieve (ASTM Test D1140),

(iii) Have a liquid limit equal to or greater than 30 units (ASTM Test D423),

(iv) Have plasticity equal to a greater than 15 units (ASTM Test D424),

(v) Have a pH of 7.0 or higher (Annex 5), and

(vi) Have a permeability not adversely affected by anticipated waste.

NOTE: Soil not meeting the above criteria may be used provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that such soil will provide equivalent or greater structural stability and waste containment and attenuation, and will not be adversely affected by the anticipated waste.

The objective of requiring landfill soil liners and natural in-place soil barriers to meet the criteria listed above is to provide for maximum structural stability, containment and attenuation (retention) of the hazardous waste constituents, and provide soils that will not be adversely affected by the anticipated waste.

The specifications concerning soil properties used by State regulatory agencies reflect a preference for tight, fine grain clay soils with no sand and gravel seams. The California Department of Health's soil criteria, as specified in "Draft Minimum Standards for Hazardous Waste Management," are used in varying detail by other states. Of these criteria, soil types of CL, CH, OH or sometimes SC per the Unified Soil Classification System, passage of not less than 30 percent (by wt.) through a standard US. No. 200 sieve, a liquid limit of not less than 30 units using ASTM Test D423, plasticity index of not less than 15 units based on ASTM Test D424, are addressed in regulations or guidelines for Hazardous Waste Management by Illinois, Oklahoma, Texas, New York, Pennsylvania and Minnesota.

Essentially the soil types selected are characteristic of inorganic clays, organic clays, clayey sands, sixty clays, sandy clays, lean clays and fat clays, all of which are fine grained soils.

Fine-grained soils are characterized by extremely large specific surface, i.e., area per unit weight. Clays have both internal as well as external surfaces. Their specific surface can reach $800m^2$ per gram.

Because of greater specific surfaces, finer soil materials have greater attenuating characteristics than courser material. In general, there is less migration of leachate as soil texture becomes finer.

Thus, where possible, it is advantageous to locate surface impoundments in thick, relatively impermeable formations such as massive clay beds. Where this is not possible, then the soils with a high clay and silt content (i.e., fine-grained soils) should be sought According to the Unified Soil Classification System, the boundary between coarse-grained and fine-grained soils is taken to be the 200-mesh sieve (0.074 mm), i.e.) 30 percent of the soil (by weight passing through such sieve.

Thus, the percentage of the soil passing through 200-mesh sieve is one of the indicators of the presence or absence of the clay or silt, to be used to determine the suitability of the soil to serve as a barrier to hazardous waste movement into the environment.

The objectives for requiring a liquid limit not less than 30 units and plasticity index not less than 15 units, are to assure the consistency, workability and firmness (i.e., compressibility, dry strength, shearing resistance, etc.) of the soils intended as liners or barriers to the passage of hazardous wastes and ~~for~~ leachates from landfills.

The "liquid limit," "plasticity limit" and "plasticity index" are the most useful indicators of the engineering behavior of clay soils. The above limits, also termed Atterberg limits, are defined by the water content required to produce specific degrees of consistency that are measured in the laboratory.

The "liquid limit" (upper plastic limit) is the point at which soil becomes semifluid. In operational terms, the liquid limit is defined as the water content at which a trapezoid grove of specific shape, cut in moist soil held in a special cup is closed after 25 taps on a hard rubber plate (ASTM Test D423).

The "plastic limit" (lower plastic limit) is defined as the water content at which soil begins to crumble on being rolled into a thread 1/8 inch 3 mm) in diameter (ASTM Test D424). It represents the lowest water content at which soil can be deformed readily without cracking.

The "plastic index," a difference between the liquid and plastic limits, is the range of water content of the soil at which plastic behavior occurs. It is also an indicator of the plasticity or "clayeyness" of the soil.

It has been observed (A. Casagrande) that many properties of clays and silts, such as their dry strength, their compressibility, their reaction to the shaking test, and their consistency near the plastic limit, can be correlated with the Atterberg limits by means of the so-called plasticity chart.[6] According to the chart, clays with liquid limits less than 30 are considered to be of "low" plasticity. Those with liquid limits between 30 and 50 exhibit "medium" plasticity and those above 50 exhibit "high" plasticity. The plasticity index is useful in estimating the dry strength and compressibility of the soil. The soils with plastic index less than 10 have low compressibility. Those with plastic index between 10 and 20 exhibit medium compressibility and those above 20 high compressibility.

Since the consistency of the soil, its workability, compressibility and dry strength are critical for construction and environmentally sound operation of hazardous waste landfills, both "liquid limit" and "plastic index" are important factors in determination of the soil suitability for such construction.

The requirement under (v) that soil liners have a pH of 7.0 or higher is required because of the greater attenuation ability of soils at higher pH values and the ability of high pH soils to inhibit the reaction of wastes with a low pH (acid). The Texas Department of Water Resources has also set a similar pH requirement of no less than 7 for soils to be used as liners or natural in-place soil barriers.

It is required under (vi) that the premeability of soil liners should not be adversely affected by the anticipated wastes. The rationale for this is the fact that clay liners, although suitable for the majority of hazardous wastes, are not compatible with certain wastes. For example, natural impermeable soils may fail when exposed to strong acids and strong alkaline waste may cause clay liners to swell. Therefore, the wastes that are not compatible with soil liners should not be deposited into such landfills. The rationale concerning waste compatibility with the liner is given in (b)(4) of this section.

(15) Synthetic membrane liners shall meet the following criteria:

(i) Be of adequate strength and thickness to insure mechanical integrity and have a minimum thickness of 20 mils;

(ii) Be compatible with the waste to be landfilled;

(iii) Be resistant to attack from soil bacteria and fungus;

(iv) Have ample weather resistance to withstand the stress of extreme heat, freezing, and thawing;

(v) Have adequate tensile strength to elongate sufficiently and withstand the stress of installation or use of machinery and equipment;

(vi) Be of iniform thickness, free from thin spots, cracks, tears, blisters, and foreign particles;

(vii) Be placed on a stable base; and

(viii) Have a permeability less than or equal to 1×10^{-12} cm/sec or it's equivalent.

Liners should be of adequate strength and thickness to insure mechanical integrity of the liner. The failure to provide liners of adequate mechanical strength and thickness could result in liner failure (e.g., rupture, puncture, laceration, and development of cracks) with subsequent seepage of hazardous wastes into the environment.

The thickness of synthetic membranes used as liners and their mechanical strength are closely related, i.e., the thicker the liner, the higher mechanical strength which can be anticipated.

For the purpose of these regulations a minimum thickness of 20 mils was chosen for membrane thickness in hazardous waste landfills. This thickness was chosen because the Agency believes that when used in conjunction with other criteria specified in Design II (see rationale for 250.45-2 (b)(13) Design II) and the specified minimum criteria for the use of synthetic membranes, that adequate waste containment and ground water protection will be realized.

Among the first consideration in selecting a liner for hazardous waste landfill is the compatibility with the hazardous wastes to be contained. The possible reactions between the liner and wastes can detrimentally affect the ability of the landfill to contain such wastes and prevent their seepage to the environment.

The compatibility criteria for synthetic membranes used as liners are similar to those specified in the rationale for 250.45-2 (b)(14)(i).

The exposure of synthetic membranes used in landfills to soil bacteria and fungi; has been known to, and could, adversely affect the durability and impermeability of such liners. For this reason, synthetic membranes which have properties which resist such attack should only be used.

Synthetic membranes used as liners should have ample weather resistance to withstand the stresses associated with wetting and drying, freezing and thawing as dictated by the geographical location of the landfill site.

Synthetic liner materials without adequate tensile strength may rupture during installation or be affected by continous use of machinery and equipment required for the operation of the landfill. Liner material should also resist laceration, abrasion and puncture from matter contained in the waste it will hold, all of which could decrease the durability of the liner.

The physical quality of the membrane liner is also of concern. Thin spots, cracks, tears, blisters, foreign particles and pin holes resulting from its manufacture and/or subsequent handling prior to installation could adversely affect durability and permeability of the liners.

The installation of a manufactured liner requires prior preparation of the base. The base should be stable so that settling or other movement after liner installation does not tear or weaken the liner through stretching. The improper installation of even the best material will defeat the purpose of the lining.

The Agency recognizes that the state-of-the-art of predicting landfill discharge is poor, and thus the prudent course is to prescribe maximum containment of hazardous waste.

Maximum containment minimizes the escape of hazardous waste constituents, and thus provides protection of human health and the environment.

To better attain containment of hazardous waste constituents in landfills there is a definite need for flexible impervious lining materials of long life. Data available on flexible polymeric membranes

(CPE, PVC, Hypalon, EPDM, ER) have indicated their permeability is less than 10^{-12} cm/sec.[7] However, since these flexible synthetic materials are composed of resin and a very slowly extractable plasticizer, there will be changes over long periods of time, with gradual stiffening of the material due to loss of this plasticizer. For example, even if all the plasticizer were removed from PVC, a process which is estimated to take more than 100 years, the basic resin still has 30 to 50 percent elongation. Over time the permeability of these materials is also believed to be reduced from its initial state. However, exposure test of these various polymeric membranes to conditions similar to those encountered in hazardous wastes landfills for periods exceeding 1 year, have so far, showed no effect on permeability.[8]

For these reasons the Agency feels that there is, at present, inadequate information available on long-term reliability of synthetic polymeric membranes used as liners, by themselves, for waste containment in landfills (Refer to 250.45-2 (14) for recommended landfill design using synthetic membranes).

The Agency has received comment on the ability, availability, and reliability of standard tests to measure a permeability as low as 1 x 10^{-12} cm/sec. Although this does present some difficulty in terms of long test periods and careful laboratory technique, a method is presented in ASTM, Test 3079.

Test methods are also being developed under EPA contract. Also, the standard is written as 1 x 10^{-12} cm/sec or its equivalent.

This was done so that the permeability of the membrane liner does not necessarily have to be expressed in cm/sec but in any units as long as the permeabilities are equivalent to 10^{-12} cm/sec or less.

(16) A landfill overlying an underground drinking water source shall have groundwater monitoring systems and a leachate monitoring system as specified in 250.43-8.

One of the most severe causes of groundwater contamination in the USA is leakage of wastes from unlined and lined hazardous waste landfills. Pollution problems such as these can be reduced if landfills are lined by impermeable clay, or clay and/or synthetic membrane liners. However, all liners are prone to failure, due to incompatibility with contained wastes, mechanical failure, improper installation, etc., resulting in hazardous waste seepage into the environment.

The objective of the above regulation is to detect and correct any liner failure or goundwater contamination before more serious problems can develop.

Monitoring requirements for hazardous waste surface impoundments over usable aquifers, under 250.43-8 specify monitoring in zone of saturation, applicable to all facilities constructed after the effective date of this regulation.

The objectives and rationale for requiring monitoring in the zone of saturation are the same as specified in the background document for Groundwate andLeachate monitoring section 250.43-8 of Subpart D.

(17) A leachate collection sump (as required in the liner systems specified in paragraph (b)(13) shall be designed and constructed:

(i) of materials both compatible with and impermeable to the leachate formed in the landfill;

(ii) so that the sump is accessible for removal of leachate if the sump pump becomes inoperative and/or the stand pipe for removal of leachate become damaged; and

(iii) with a volume equal to our greater than three-months expected volume of leachate but no less than 1000 gallons.

(18) The owner/operator shall remove leachate from a leachate collection sump as frequently as necessary to maintain gravity flow in the leachate collection and removal system and shall check the leachate collection sump at least monthly to assure compliance with this requirement.

The purpose of these standards is to specify minimum criteria for collection and removal of leachate from the hazardous waste landfill. This is done to minimize any hydraulic pressure which would be created in the landfill due to excess liquids (leachate) (see pages 80-82, rationale for 250.45-2 (b) (6) (iv)) which could cause the liner to fail.

Leachate is drained from the hazardous waste landfill via gravity to the collection sump. Because of the hazardous nature of the leachate and the possibility that it could remain in the sump up to one month before removal, the sump must be constructed of materials which would prevent the escape of leachate before removal. Therefore, the sump must be constructed using materials which are both impervious to and compatible with the leachate.

Because hazardous waste landfills are designed and constructed below the surface of the ground leachate collection sumps are required. The sump pump are access (stand pipe) for mechanical or physical removal of leachate is possible. If, however, either the sump pump or the stand pipe becomes mechanically or physically damaged so that removal of leachate by these means are not possible then there must be a means of leachate removal.

Since leachate collection and removal system specified in these standards is of gravity flow the leachate collection sump must be drained as necessary so that the leachate in the sump does not back up in to the system such that gravity flow into the sump is restricted.

(19) Landfill liner systems and natural in-place soil barriers shall not be placed over earth materials exhibiting a permeability of greater than 1 x 10^{-4} cm/sec.

The object of this standard is to restrict the siting of hazardous waste landfills in areas where soil permeability will not restrict the flow of waste constituents to groundwater or UDWS in the event of a liner failure. This provision provides an extra margin of safety at such facilities where the release of unknown quantities wastes of unknown quality might present a hazard to public health and the environment.

A precedent for such a standard exist in the State of New York which restricts hazardous waste facilities from being located in areas exhibiting a soil permeability greater than 1 x 10^{-5} cm/sec. This Agency is establishing a permeability not to exceed 1 x 10^{-4} cm/sec because of the availability of such soil on a National level, and that such a permeability, in conjunction with containment criteria, will be adequate to meet the objectives of the human health and environmental objectives of these regulations.

Closure

(1) At closure, the owner/operator of a landfill shall place a final cover over the landfill. This final cover shall consist of at least 15 centimeters (6 inches) of soil with a permeability less than or equal to 1×10^{-7} cm/sec which meets the criteria of Section 250.45-2 (b)(14), underlying 45 centimeters (18 inches) of soil capable of supporting indigenous vegetation. The top 15 centimeters (6 inches) of this cover shall be topsoil.

NOTE: A final cover using different thicknesses and permeabilities may be used provided the owner/operator can demonstrate to the Regional Administrator that it will provide equivalent control of infiltration of water, equivalent control of sublimation or evaporation of harmful pollutants into the air, and equivalent erosion control. The owner/operator must also demonstrate that the final cover will support indigenous vegatation.

The selection of clay as the recommended cover material was partially based on a report by Geraghty and Miller, "Site Location and Water Quality, Protective Requirements for Hazardous Waste Management Facilities"; and a Report by U.S. EPA, "Sanitary landfill design and operation".

In table 3 , various soil types are ranked according to their performance of certain cover functions. Clay is given a rating of "excellent" for the prevention of emergence of flies, minimization of moisture, minimization of gas venting and control of blowing paper and providing a pleasing appearance. For the support of vegetation it is rated "fair to good." It received "poor" ratings for the prevention of burrowing and tunneling by rodents and venting decomposition. However, other soil types did not receive as many "excellent" ratings for the performance of the various functions.

The cover depth requirement for clay is designed to provide a impermeable clay cap which will resist erosion, inhibit infiltration of rainwater and prevent sublimation of harmful pollutants into the air. A cover of top soil is necessary in order to sustain vegetative growth and to maintain the clay cap. More than 2 feet of cover may be necessary depending on the soil type and the anticipated use of the completed landfill. For example, if trees are to be planted a minimum of three feet or more of soil capable of supporting vegetation will be necessary

TABLE 3
SUITABILITY OF VARIOUS SOIL TYPES FOR USE AS LANDFILL COVER MATERIAL[9]

	Soil Type[1/]					
[illegible]on	Clean Gravel	Clayey-Silty Gravel	Clean Sand	Clayey-Silty Sand	Silt	Clay
[illegible]ts rodents [illegible]rrowing [illegible]neling	G	F-G	G	P	P	P
[illegible] flies from [illegible]ng	P	F	P	G	G	E[2/]
[illegible]zes moisture [illegible]ng fill	P	F-G	P	G-E	G-E	E[2/]
[illegible]zes gas [illegible]g through	P	F-G	P	G-E	G-E	E[2/]
[illegible]es pleasing [illegible]nce and con- [illegible]lowing paper	E	E	E	E	E	E
[illegible]ts vegetation	P	G	P-F	E	G-E	F-G
[illegible]ecomposition	E	P	G	P	P	P

[illegible]xcellent; G, good; F, fair; P, poor.

[illegible]pt when cracks extend through cover.

[illegible] if well drained.

to prevent the roots from breching the impermeable clay cap and entering the hazardous waste.

A permeability of less than 1 x 10^{-7} cm/sec was selected, based in part on a Corps of Engineers study, "Cover Materials for Solid and Hazardous Waste." Different Unified Soil Classification System soil types are ranked according to their performance of specific cover functions. The clays are ranked very high, "inorganic clays of high plasticity, fat clays" are ranked number one for effectiveness in impeding water percolation and gas migration. Inorganic clays of low to medium platicity, gravelly clays, sandy clays, silty clays, and lean clays are ranked second for effectiveness in impeding water percolation and gas migration. Inorganic silts, micaceous or diatomaceous fine sandy or silty soils and elastic silts were ranked third for impeding water percolation. Out of these possibilities, the 10^{-7} cm/sec figure was chosen because it appears effective to minimize infiltration and these types of soils are more easily found than others which are less permeable.

Clays were chosen for the following reasons. They are very fine in texture thereby making them more cohesive and more impermeable even though they commonly contain small to moderate amounts of silt and sand.

Clay soils vary greatly in their physical properties, which depend not only on the small particle size but on the type of clay minerals and soil water content. When dry, a clay soil can be almost as hard and tough as rock and can support heavy loads. When wet, a clay soil swells and its permeability is very low.

Six inches was determined to be the minimum thickness required to provide an impermeable cap over the fill while not wasting valuable clay. Eighteen inches of additional soil is necessary to, (1) prevent the clay cap from drying out and cracking and (2) sustain vegetative cover.

(2) Where trees or other deep-rooted vegetation are to be planted on the completed fill, the final cover shall consist of 15 centimeters (6 inches) soil layer specified in paragraph (c)(1) underlying at least 1 meter (3 feet) of soil capable of supporting the deep rooted vegetation and indigenous vegetation.

NOTE: The upper layer soil thickness for deep-rooted vegetation may be less than 1 meter (3 feet) provided the owner/operator can demonstrate to the Regional Administrator that the roots of the vegetation will not penetrate the 6-inch clay cover.

The 3 feet of soil requirement as well as the other depteh of soil layer requirements are based on EPA's recommendations for sanitary landfills, as described in, "Sanitary Landfill Design and Operation." The objectives for cover of sanitary landfills are the same as for hazardous waste landfills, i.e., maintenance of cover functions and the subsequent isolation of wastes from the environment.

(3) The final grade of the final cover shall not exceed 33 percent. Where final grades exceed 10 percent, horizontal terraces shall be constructed. Terraces shall be of sufficient width and height to withstand a 24-hour, 25 year storm. A terrace shall be placed at every 10 feet of rise in elevation when the slope is less than 20 percent and at every 20 feet of rise in elevation when the slope is greater than 20 percent.

NOTE: The final grade may be of different design and slope provided the owner/operator can demonstrate to the Regional Administrator that water will not pool on the final cover and that erosion will be minimized.

Grading is important in order to encourage runoff and minimize infiltration and erosion. The general topographic layout of the completed landfill surface should be controlled by carefully locating waste cells. The final cover should then be compacted and graded to inhibit the ponding of water on the landfill surface because any standing water will create hydraulic head encouraging infiltration into the fill. These values for grading were selected because they are minimum grades necessary to inhibit ponding and also minimize the effects of erosion by runoff. Preferably, topsoil from the site should be stockpiled and reserved for support vegetation indiginous to that area. The topsoil should not be highly compacted since it will be seeded.

Post-Close-Out

(1) During the post-closure period, which shall continue at the landfill for a period of at least 20 years (see 250.43-7), the owner/operator of the landfill:

(i) Shall maintain the soil integrity, slope, and vegetative cover of the final cover and all diversion and drainage structures;

(ii) Shall maintain the groundwater and leachate monitoring systems and collect and analyze samples from these systems in the manner and frequency specified in Section 250.43-8;

(iii) Shall maintain survey bench marks;

(iv) Shall maintain and monitor the gas collection and control system where such a system is installed to control the vertical and horizontal excape of gases; and

(v) Shall restrict access to the landfill as appropriate for its post-closure use.

NOTE: The owner or operator of a landfill may request that certain post-closure requirements be discontinued earlier than 20 years after closure. The facility owner or operator shall submit information to the Regional Administrator to indicate that such post-closure care need not continue; (e.g., no leaks have been detected, technology has advanced, alternate disposal techniques are to be employed).

The Regional Administrator shall have the discretion to discontinue one or more of these post close-out requirements.

At hazardous waste landfills, where wastes are not removed or rendered non-hazardous during site closure, there remains a potential,long-term threat that hazardous constituents could find their way off-site and pose a substantial threat to human health and the environment. During the active operation of a landfill these proposed standards for landfilling have specified specific design and operating methods which, if compiled with, will substantially minimize the potential for escape of hazardous waste constituents. Some of these design and operating methods must also continue during post-closure until such a time that it can be demonstrated that the landfill no longer presents a threat to human health and the environment.

Soil integrity, slope and vegetative cover of the final cover and all diversion and drainage structures must be maintained in order to eliminate the possibility of infilteration of surface waters which would increase the hydraulic head within the landfill, which would in turn increase the likelihood of hazardous constituents entering the environment.

Groundwater and leachate monitoring systems must be maintained to indicate as early as possible the potential movement of contaminants, so as to predict, as early as possible, the potential for endangerment of the groundwater or the impact on specified groundwater quality. The fundamental objective of monitoring landfill sites is to serve as a back up to the waste containment structures and/or devices.

The maintenance of survey bench marks during the post-closure period will enable the location of specific waste types if it were to become necessary and/or feasible to remove or further isolate such waste or portion of the landfill. This could occur if waste constituents were found in samples analyzed from the groundwater and/or leachate monitoring systems above background concentratioes. Also, the location of wastes in the landfill could be beneficial if it were determined or technology developed for a particular waste to be re-used or recycled.

Gas collection and control systems, in those landfills where installed, must also be maintained during the post-closure period. Gases have the potential to generate in the landfill for long periods of time

, therefore the venting and control of such gases must be maintained to reduce the risk of fire and explosion and to reduce air contamination.

At landfills, because of the presence of hazardous waste, site access must be restricted. However, the degree of restriction will be determined by the proposed post-closure use as approved by the Regional Administrator.

If the owner/operator of the landfill felt that certain aspects of or all of the post-closure care and maintence for a particular site need not continue for 20 years, he must demonstrate that such care is not necessary to protect human health and the environment (e.g., no leaks have been detected, technology has advanced, alternative disposal or treatment techniques are to be employed). The Agency feels that such an avenue for deviation must be available for flexibility in regulation to stimulate the development of treatment and disposal technology. Also flexibility is needed because not all disposal sites present the same potential threat to human health and the environment.

(2) No buildings intended for habitation shall be constructed over landfills where radioactive wastes as defined in Subpart A have been disposed.

Radioactive wastes are very persistant and contact with them is extremely dangerous. Excavation is required for the construction of a building and this would create the possibility of exposure of the radioactive material to the environment creating a hazard to public health and the environment.

The radiation associated with landfilled radioactive hazardous waste, is low level, but capable of causing chronic effects resulting from extended exposures. The exposure would be greatest immediately over the landfill and could be extensive if a building were constructed over the landfill where people were likely to spend considerable amounts of time.

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Appendix I - Case Histories

1. <u>Formation of Toxic Gas in Sanitary Landfill</u>

In Los Angeles County, a tank truck emptied several thousand gallons of cyanide waste onto refuse at a sanitary landfill. Another truck subsequently deposited several thousand gallons of acid waste at the same location. Reaction between the acid and the cyanide evolved large amounts of toxic hydrogen cyanide gas. A potential disaster was averted when a local chlorine dealer was quickly called to oxidize the cyanide with chlorine solution.

2. <u>Formation of Toxic Gas in Excavated Site</u>

A load of acidic aluminum sulfate was inadvertently discharged into an excavation already containing some sulfide waste. Hydrogen sulfide was released and the truck driver died in his cab at the landfill site.

3. <u>Formation of Toxic Gas at a Landfill</u>

At a sanitary landfill near Dundalk, Maryland, a 2,000-gallon liquid industrial waste load containing iron sulfude, sodium sulfide, sodium carbonate and sodium thiosulfate, along with smaller quantities of organic compounds was discharged into a depression atop an earth-covered area of the fill. When it reached eight to ten feet below the point of discharge, the liquid started to bubble and fume blue smoke. The smoke cloud quickly engulfed the truck driver and disabled him. Several nearby workers rushed to his aid and were also felled. During the clean-up operation, one of the county firefighters also collapsed. All six of the injured were hospitalized and treated for hydrogen sulfide poisoning. It was not determined whether the generation of hydrogen sulfide was due to the instability of the waste or the incompatibility of the waste with some of the landfill materials although the pH of the waste was measured to be 13 before it left the plant.

4. <u>Fire, Dispersal of Toxic Dusts from Leaky Containers</u>
At a dump in Contra Cost County, California, a large number of drums containing solvents were deposited in a landfill. In the immediate area were leaky containers of concentrated mineral acids and several bags containing beryllium wastes in dust form. The operators failed to cover the waste at the end of the day. The acids reacted with the solvents during the night, ignited them and started a large chemical fire. There was possible dispersion of

beryllium dust into the environment. Inhalation, ingestion or contact with beryllium dust by personnel could have led to serious health consequences.

5. Volatilization of Toxic Chemicals Due to Heat Generation from Ruptured, Buried Containers

A load of empty pesticide containers was delivered to a disposal site in Fresno County, California. Unknown to the site operator, several full drums of an acetone methanol mixture were included in the load. When the load was compacted by a bulldozer, the barreled waste ignited, engulfing the bulldozer in flames. The operator escaped unharmed, but the machine was seriously damaged. The ensuing fire, which also involved dispersion of pestidice wastes, was extinguished by firemen. The firemen were examined to ensure they had not been harmed by exposure to pesticide dusts.

6. Formation of Water Soluble Toxic Substances from Ruptured Drums

In Riverside County, California, several drums of phosphorus oxychloride, phosphorus thiochloride and thionyl choloride were improperly dropped off at a dump. Later during a flood, the drums were unearthed, ruptured, and washed downstream. They released hydrogen chloride gas and contaminated the water.

7. Fire at a Disposal Site

A disposal site in central California accepted a load of solid dichromate salts and dumped it in a pit along with pesticide formulations and empty pesticide containers. For several days thereafter, small fires erupted in the pit due to the oxidation of the pesticide formulations by the dichromate. Fortunately, the site personnel were able to extinguish these fires before they burned out of control. There were no injuries, or property or equipment damage.

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BD-27

Resource Conservation and Recovery Act

Subtitle C - Hazardous Waste Management

Section 3004 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

Draft

BACKGROUND DOCUMENT

Section 250.45-3 Standards for Surface Impoundments

U.S. Environmental Protection Agency

Office of Solid Waste

December 15, 1978

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being issued as a draft to support the proposed regulation. As new information is obtained, changes may be made in the regulations as well as in this background material.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling:

Comments in writing may be made to:

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I. Introduction

A. RCRA Mandate and Authority

B. Definition of Area being Regulated and Other Key Words.

II. Rationale for Regulation

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I. Introduction

A. RCRA Mandate and Authority

Section 3004 of the Resource Conservation and Recovery Act of 1976 (RCRA) madates that the EPA Administrator promulgate regulations establishing standards applicable to owners and operators of facilities for the treatment, storage and disposal of hazardous wastes as may be necessary to protect human health and the environment. Among other things, these standards are to include requirements respecting 1) the treatment, storage or disposal of all such waste received by the facility pursuant to such operating methods, techniques, and practices as may be satisfactory to the Administrator, and 2) the location, design, construction operation and maintenance of such hazardous waste treatment, storage, or disposal facilities.

B. Definition of Area being Regulated and Other Key Words

For the purpose of the regulation. "Surface Impoundment" means a natural topographic depression, artificial excavation, or dike arrangement with the following characteristics: (i) it is used primarily for holding, treatment, or disposal of waste; (ii) it may be constructed above, below, or partially in the ground or in navigable waters (e.g., wetlands); and (iii) it may or may not have a permeable bottom and/or sides. Examples include holding ponds and aeration ponds.

The other pertinent definitions are as follows:

(1) "Active Fault Zone" means a land area which, according to the weight of the geologic evidence, has a reasonable probability of being affected by movement along a fault to the extent that a hazardous waste facility would be damaged and thereby pose a threat to human health and the environment.

(2) "Administrator - See Section 1004(1).

(3) "Aquifer" means a geologic formation, group of formations, or part of a formation that is capable of yielding useable quantities of groundwater to wells or springs.

(4) "Attenuation" means any decrease in the maximum concentration or total quantity of an applied chemical or biological constituent in a fixed time or distance traveled resulting from a physical, chemical, and/or biological reaction or transformation occurring in the zone of aeration or zone of saturation.

(5) "Close out" means the point in time at which facility owners/operators discontinue operation by ceasing to accept hazardous waste for treatment, storage, or disposal.

(6) "Closure" means the act of securing a facility pursuant to the requirements of Section 250.43-7.

(7) "Closure Procedures" means the measures which must be taken to effect closure in accordance with the requirements of Section 250.43-7 by a facility owner/operator who no longer accepts hazardous waste for treatment, storage, or disposal.

(8) "Coastal High Hazard Area" means the area subject to high velocity waters, including, but not limited to, hurricane wave wash or tsunamis as designated on Flood Insurance Rate Maps (FIRM) as zone V1-30.

(9) "Contamination" means the degradation of naturally occurring water, air, or soil quality either directly or indirectly as a result of man's activities.

(10) "Direct Contact" means the physical intersection between the lowest part of a facility (e.g., the bottom of a landfill, a surface impoundment liner system or a natural in-place soil barrier, including leachate detection/removal systems) and water table, a saturated zone, or an underground drinking water source, or between the active portion of a facility and any navigable water.

(11) "Disposal Facility" means any facility which disposes of hazardous waste.

(12) "Endangerment" means the introduction of a substance into groundwater so as to:

(i) cause the maximum allowable contaminant levels established in the National Primary Drinking Water standards in effect as of the date of promulgation of this Subpart to be exceeded in the groundwater; or

(ii) require additional treatment of the groundwater in order not to exceed the maximum contaminant levels established in any promulgated National Primary Drinking Water regulations at the point such water is used for human consumption; or

(iii) Reserved (Note: Upon promulgation of revisions to the Primary Drinking Water Standards and National Secondary Drinking Water Standards under the Safe Drinking Water Act and/or standards for other specific pollutants as may be appropriate).

(13) "EPA" means the U.S. Environmental Protection Agency.

(14) "EPA Region" means the States and other jurisdictions in the ten EPA Regions as follows:

Region I - Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island.

Region II - New York, New Jersey, Commonwealth of Puerto Rico, and the U.S. Virgin Islands.

Region III - Pennsylvania, Delaware, Maryland, West Virginia, Virginia, and the District of Columbia.

Region IV - Kentucky, Tennessee, North Carolina, Mississippi, Alabama, Georgia, South Carolina, and Florida.

Region V - Minnesota, Wisconsin, Illinois, Michigan, Indiana, and Ohio.

Region VI - New Mexico, Oklahoma, Arkansas, Louisiana, and Texas.

Region VII - Nebraska, Kansas, Missouri, and Iowa.

Region VIII - Montana, Wyoming, North Dakota, South Dakota, Utah, and Colorado.

Region IX - California, Nevada, Arizona, Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Region X - Washington, Oregon, Idaho, and Alaska.

(15) "Facility" means any land and appurtenances, thereon and thereto, used for the treatment, storage, and/or disposal of hazardous waste.

(16) "Final Cover" means cover material that is applied upon closure of a landfill and is permanently exposed at the surface.

(17) "Five-Hundred-Year Flood" means a flood that has a 0.2 percent or one in 500 chance of recurring in any year. In any given 500 year interval, such a flood may not occur, or more than one such flood may occur.

(18) "Floodplain" means the lowland and relatively flat areas adjoining inland and costal areas of the mainland and off-shore islands, including, at a minimum, areas subject to a one percent or greater chance of flooding in any given year.

(19) "Freeboard" means the vertical distance between the average maximum level of the surface of waste in a surface impoundment, basin, open tank, or other containment and the top of the dike or sides of an impoundment, basin open tank, or other containment.

(20) "Fugitive Emissions" means air contaminant emissions which are not planned and emanate from sources other than stacks, ducts or vents or from non-point emission sources.

(21) "Groundwater" means water in the saturated zone beneath the land surface.

(22) "Hazardous Waste" has the meaning given in Section 1004(5) of the Act as further defined and identified in Subpart A.

(23) "Hazardous Waste Facility Personnel" means all persons who work at a hazardous waste treatment, storage or disposal facility, and whose actions or failure to act may result in damage to human health or the environment.

(24) "Hazardous Waste Landfill" means an area in which hazardous waste is disposed of in accordance with the requirements of Section 250.45-2.

(25) "Hydraulic Gradient" means the change in hydraulic pressure per unit of distance in a given direction.

(26) "Incompatible Waste" means a waste unsuitable for commingling with another waste or material, because the commingling might result in:

(i) Generation of extreme heat or pressure,

(ii) Fire,

(iii) Explosion or violent reaction,

(iv) Formation of substances which are shock sensitive friction-sensitive, or otherwise have the potential of reacting violently,

(v) Formation of toxic (as defined in Subpart A) dusts, mists, fumes, gases, or other chemicals, and

(vi) Volatilization of ignitable or toxic chemicals due to heat generation, in such a manner that the likelihood of contamination of groundwater, or escape of the substances into the environment, is increased, or

(Vii) Any other reactions which might result in not meeting the Air Human Health and Environmental Standard. (See Appendix I for more details.)

(27) "Leachate" means the liquid that has percolated through or drained from hazardous waste or other man emplaced materials and contains soluble, partially soluble, or miscible components removed from such waste.

(28) "Leachate Detection System" means a gravity flow drainage system installed between the top and bottom liners of a surface impoundment capable of detecting any leachate that passes through the top liner.

(29) "Liner" means a layer of emplaced materials beneath a surface impoundment or landfill which serves to restrict the escape of waste or its constituents from the impoundment or landfill.

(30) "Monitoring" means all procedures used to systematically inspect and collect data on operational parameters of the facility or on the quality of the air, groundwater, surface water, or soils.

(31) "Monitoring Well" means a well used to obtain water samples for water quality analysis or to measure groundwater levels.

(32) "Navigable Waters" means "waters of the United States, including the territorial seas". This term includes but is not limited to:

(i) All waters which are presently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide, intermittent streams, and adjacent wetlands. "Wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands, generally include swamps, marshes, bogs, and similar areas such as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

(ii) Tributaries of navigable waters of the United States, including adjacent wetlands;

(iii) Interstate waters, including wetlands; and

(iv) All other waters, of the United States, such as intrastate lakes, rivers, streams, mudflats, sandflats, and wetlands, the use, degradation or destruction of which would affect or could affect interstate commerce, including, but not limited to:

(A) Intrastate lakes, rivers, streams, and wetlands which are or could be used by interstate travelers for recreational or other purposes;

(B) Intrastate lakes, rivers, streams, and wetlands from which fish or shellfish are or could be taken and sold in interstate commerce; and

(C) Intrastate lakes, rivers, streams, and wetlands which are used or could be used for industrial purposes by industries in interstate commerce.

(v) All impoundments of waters of the United States otherwise defined as navigable waters under this paragraph.

(33) "Non-Point Source" means a source from which pollutants emanate in an unconfined and unchannelled manner, including, but not limited to, the following:

(i) For non-point sources of water effluent, this includes those sources which are not controllable through permits issued pursuant to Sections 301 and 402 of the Clean Water Act. Non-point source water pollutants are not traceable to a discrete identifiable origin, but result from natural processes, such as nonchannelled run-off, precipitation, drainage, or seepage.

(ii) For non-point sources of air contaminant emissions, this normally includes any landfills, landfarms, surface impoundments, and basins.

(34) "Owner/Operator" means the person who owns the land on which a facility is located and/or the person who is responsible for the overall operation of the facility.

(35) "Partial Closure Procedures" means the measures which must be taken by facility owners/operators who no longer accept hazardous waste for treatment, storage, or disposal on a specific portion of the site.

(36) "Permitted Hazardous Waste Management Facility (or Permitted Facility)" means a hazardous waste treatment, storage, or disposal facility that has received EPA permit

in accordance with Subpart E, or a permit from a State authorized in accordance with Subpart F.

(37) "Point Source" means any discernible, confined, and discrete conveyance, including, but not limited to, the following:

(i) For point sources of water effluent, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated feeding operation, vessel, or other floating craft from which pollutants are or may be discharged; and

(ii) For point sources of air contaminant emissions, any stack, duct, or vent from which pollutants are or may be discharged.

(38) "Post-Closure Care" means the monitoring and facility maintenance activities conducted after closure.

(39) "Reactive Hazardous Waste" means hazardous waste defined by Section 250.13(c)(1) of Subpart A.

(40) "Recharge Zone" means an area through which water enters an aquifer.

(41) "Representative Sample" means a sample having average characteristics of all groundwater in the aquifer beneath the facility.

(42) "Run-off" means that portion of precipitation that drains over land as surface flow.

(43) "Saturated Zone (Zone of Saturation)" means that part of the earth's crust in which all voids are filled with water.

(44) "Spill" means any unplanned discharge or release of hazardous waste onto or into the land, air or water.

(45) Soil Barrier" means a layer of soil of a minimum of 1.5 meters (5 feet) in thickness with a permeability of 1×10^{-7} cm/sec or less which is used in construction of a landfill or a surface impoundment.

(46) "Sole Source Aquifers" means those aquifers designated pursuant to Section 1424(e) of the Safe Drinking Water Act of 1974 (P.L. 93-523) which solely or principally supply drinking water to a large percentage of a populated area.

(47) "Storage Facility" means any facility which stores hazardous waste, except for generators who store their own waste on-site for less than 90 days for subsequent transport off-site, in accordance with regulations in Subpart B.

(48) "Treatment Facility" means any facility which treats hazardous waste.

(49) "True Vapor Pressure" means the pressure exerted when a solid and/or liquid is in equilibrium with its own vapor. The vapor pressure is a function of the substance and of the temperature.

(50) "24-Hour, 25-Year Storm" means a storm of 24-hour duration with a probable recurrence interval of once in twenty-five years as defined by the National Weather Service in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States", May 1961, and subsequent amendments, or equivalent regional or State rainfall probability information developed therefrom.

(51) "Unsaturated Zone (Zone of Aeration)" means the zone between the land surface and the nearest saturated zone,

in which the interstices are occupied partially by air.

(52) "United States" means the 50 States, District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

(53) "Underground Drinking Water Source" (UDWS) means:

(i) an aquifer supplying drinking water for human consumption, or

(ii) an aquifer in which the groundwater contains less than 10,000 mg/l total dissolved solids; or

(iii) an aquifer designated as such by the Administrator or a State.

(54) "Underground Non-Drinking Water Source" means an underground aquifer which is not a UDWS.

(55) "Volatile Waste" means waste with a true vapor pressure of greater than 78 mm Hg at 25^{o}C.

(56) "Water Table" means the upper surface of the zone of saturation in groundwater in which the hydrostatic pressure is equal to atmospheric pressure.

(57) "Wetlands" means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do or would support, a prevalence of vegetation typically adapted for life in saturated or seasonally saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas, such as sloughs, potholes, wet meadows, r~~e~~iver outflows, mudflats, and natural ponds.

II. Rationale for Regulation

A. Actual Damage Incidents

The treatment and disposal of hazardous wastes in a properly located, designed, constructed, operated and maintained surface impoundments could be an acceptable, environmentally sound waste management practice. However, numerous incidents of damage have occured because of the inproper location, design, construction, operation or maintenance of such facilities.

A few examples of such incidents are described below:

o A copper reclamation company operating in a mid-Atlantic State from 1965 to 1969 bought industrial wastes from other plants, extracted copper, and then stored the remaining liquids in 11 cement lagoons. Three of these lagoons developed open seams on the bottom from which toxic pollutants seeped into an adjacent creek, which became lifeless. Also, the plant grounds became reddish green with sulfuric acid wastes. The county and State, after prolonged litigation, finally had an injunction issued to have all wastes properly treated. Rather than face this expense, the company abandoned the site, leaving the lagoons filled with 3 1/2 million gallons of toxic wastes, and leaving rusting drums of toxic materials strewn about the property. In April 1970, heavy rains threatened to wash much of the toxic wastes in the lagoons into the Delaware River via the adjacent creek. When overflow reached 25 gallons a minute, county officials were forced to have the disposal site sandbagged and a dirt dike built to prevent further overflow. Had the lagoons continued to overflow, the Trenton water supply downstream would have been rendered unusable. Because of this danger, and a steady underground seepage from three of the lagoons, the State was forced to assume the expense of cleaning up the site. At a cost of $400,000 the wastes were neutralized and the ocean dumped in 1971. Although the waste no longer poses a threat to surrounding areas, the original plant site is still contaminated and devoid of vegetation.[1]

- Four private wells in an eastern state were contaminated with phenols in late 1972. The phenols had leached from unlined disposal lagoons of a fiberglass manufacturing operation. In January 1973, the phenol concentration in one of the wells was 1.64 ppm. (The U.S. Public Health Service recommended drinking water standard for phenols is 0.001 ppm). As a remedial measure, the leaking lagoons have been emptied and lined disposal lagoons have been installed. Recently, one of the affected wells still had a phenol concentration of 0.138 ppm.[2]

- On September 27, 1972, heavy rains broke the earthen dike of a former refinery waste lagoon which is currently owned by Pleasant Township. The released sludge entered the Allegheny River and killed about 450,000 fish with an estimated value of $75,000 along a 60-mile stretch. Analysis of the discharge entering the river at that time indicated the following: pH 1.7; COD 116,112 ppm; iron 507.3 ppm; sulfates 56.5 ppm. To stop the leak, the town built up the lagoon bank and also has been adding clean fill as available. Monitoring wells dug near the lagoon show that the groundwater quality still is degraded.[3]

o Chromium from a waste lagoon of a New Jersey company contaminated a municipal well, at least one domestic well, and a nearby stream in the 1960's. The company had been in operation for about ten years before the problem was recognized in 1970. At that time, a total chromium concentration of 150 ppm was measured in one of the wells 700 feet away from the waste lagoon. The source of contamination has been eliminated, but the plume of polluted groundwater is still there. The former municipal drinking water well is currently used for industrial purposes only.[4]

o Nitrate and nitrite contamination in several wells at the Bangor Annex naval installation in Kitsap County, Washington, was discovered in March 1971 during routine sampling. The Navy then began a program of monitoring 39 wells, 33 of which are off the Annex. As a result, it was found that the shallow perched aquifer underlying the area contained RDX and TNT in concentrations of 5.2 ppm and 13 ppm, respectively. The contaminants were also found to have penetrated the soil underlying this aquifer to a depth approximately 260 feet above the main aquifer. The contamination source was an unlined settling basin used to discharge wastewater from the washing of spent bomb casings, after removal of the insoluble solids. As a remedial measure, the upper six inches of residue was removed and incinerated in 1971, and the basin backfilled with four feet of soil. An estimated 9,000 pounds of RDX still remain in the soil of the basins.

The U.S.G.S. has released a final report on its study of the problem which recommends that the site be covered with an impermeable material and drainage controlled on the upgradient side. Currently, 11 wells are still monitored in an operation which has cost the Navy $150,000, so far. Final costs are estimated to approach a million dollars.[5]

o On October 27, 1968, a waste storage lagoon on the plant site of a Pennsylvania refining company broke, spilling waste sludge containing oils, acid wastes, and alkyl benzene sulfonate into the south branch of Bear Creek, killing an estimated 4.5 million fish valued at $108,000. Because the company was in poor financial condition, only a little over $20,000 in fines were levied to cover the damage.[8]

o Arsenic compounds, the by-products of pharmaceutical manufacturing operations, were discharged into sludge lagoons behind a Pennsylvania plant prior to 1966, when Rohm and Hass Company purchased the facilities. By 1966, the groundwater in the vicinity of the plant was contaminated with arsenic. The groundwater in the area discharges into Tupehocken Creek which downstream contributes to Philadelphia's water supply. Despite persistent pumping of the groundwater to reduce the arsenic level, analysis of the creek water revealed an arsenic concentration of 0.094 ppm in February 1975. This is significantly higher than the 0.010 ppm arsenic analyzed upstream from the plant site. Arsenic from the groundwater is also seeping into the Myerstown municipal sewer lines and entering the treatment plant. Arsenic has been detected at a concentration of 0.285 ppm in the sewage effluent, which now will require upgraded treatment to reduce this level. It has not yet been determined who will have to bear the cost for upgrading the treatment of the sewage effluent. Rohm and Haas Company wishes to resolve the arsenic problem by having the lagoons cleaned out and the wastes disposed of adequately. The manner of technical implementation is presently under study. Wastes currently being generated are stored in 55-gallon drums with polyethylene plastic liners.[7]

- On June 10, 1967, a dike containing an alkaline waste lagoon for a steam generating plant at Carbo, Virginia, collasped and released approximately 400 acre-feet (493,400 cubic meters) of fly ash waste into the Clinch River. The resulting contaminant slug moved at a rate of 1 mile per hour (1.6 kilometers per hour) for several days until it reached Norris Lake in Tennessee, whereupon it is estimated to have killed 216,200 fish. All food organisms in the 4-mile (6.43-kilometer) stretch of river immediately below Carbo were completely eliminated.[8]

- On December 7, 1971, at a chemical plant site in Fort Meade, Florida, a portion of a dike forming a waste pond ruptured, releasing an estimated 2 billion gallons (7.58 billion liters) of slime composed of phosphatic clays and insoluble halides into Whidden Creek. Flow patterns of the creek led to subsequent contamination of the Peace River and the estuarine area of Charlotte Harbor. The water of Charlotte Harbor took on a thick milky white appearance. Along the river, signs of life were diminshed, dead fish were sighted, and normal surface fish activity was absent. No living organisms were found in Whidden Creek downstream of the spill or in the Peace River at a point 8 miles downstream of Whidden Creek. Clam and crab gills were coated with the milky substance, and in general all benthic aquatic life was affected in some way.[9]

o A holding pond and tanks at a chemical manufacturing plant in Saltville, Virginia, failed, spilling chlorine, hypochlorites, and ammonia into the north fork of the Holston River. River water samples showed concentration levels at 0.5 part per million hypochlorite and 17.0 parts per million of fixed ammonia. Dead fish were sighted along the path of the flow in the river.

o Annual production of organic lead waste from manufacturing processes for alkyl lead in the San Francisco Bay area amounts to 50 tons (45.4 metric tons). This waste was previously disposed of in ponds at one industrial waste disposal site. Attempts to process this waste for recovery resulted in alkyl lead intoxication of plant employees affected, but employees of firms in the surrounding area were exposed to an airborne alkyl lead vapor hazard. Toll collectors on a bridge along the truck route to the plant became ill from escaping vapors from transport trucks. Currently, the manufacturers that generate organic lead waste are storing this material in holding basins at the plants pending development of an acceptable recovery process."

The damage incidents described above plus at least twenty other similar cases contained in the EPA files clearly indicate, that improperly located designed, constructed, operated or maintained hazardous waste surface impoundments can pollute usable aquifers, surface waters and the air, creating public health and environmental hazard. Thus a need exists to regulate the location, design, construction and operation of hazardous waste surface impoundments.

The environmental media most endangered by surface impoundments are: the groundwater-specifically underground drinking water sources; surface water and the air.

Regulatory methods/options for protecting underground drinking water sources and surface waters described in the following section of this document. Regulatory methods for protecting the air quality at hazardous waste surface impoundments are discussed in separate background document - "Air Human Health and Environmental Standard".

III. Identification of Existing Regulatory Methods

Regulatory methods used by States with the most progressive hazardous waste management for preventing groundwater and surface water contamination by leakage or overflow of hazardous waste surface impoundments are identified and briefly summarized below:

(1) Texas - According to Technical Guidelines No. 4 - Ponds and Lagoons, published by the Texas Water Quality Board, the pollution potential of a pond depends on the following factors: (1) the composition and reactivity of the waste material; (2) the physical state or form of the wastes; (3) the geological and hydrological parameters of the site; and (4) construction, operation and maintenance of the facility. Pertinent portions of the Texas Water Quality Board guidelines are cited below:

Wastes - "The waste/wastes to be treated/disposed of should be classified in accordance with the Texas Water Quality Board's guideline on "Waste Classification". In addition, it is necessary to determine, by testing, the effect of the wastes to be contained within the pond on the soils or lining materials to be utilized in the construction of the pond. The object of such testing is to determine if the wastes have any detrimental effect (causing dissolution, increasing the permeability, etc.) on the soils or lining material utilized as barriers to prevent the wastes or leachates from the wastes from seeping from the pond. No waste/ wastes that has a significant detrimental effect on the materials being used as barriers to movement of wastes from the pond should be disposed of in the pond.

Due to the higher degree of mobility of the liquid wastes, they present a somewhat greater hazard or pollution potential than do the more viscous, high solids content sludges. Greater care must be exercised when handling (loading or unloading) the liquid wastes, since spills involving these materials would be more likely to result in their rapid conveyance to area waters. All ponds, regardless of their content, should always have adequate freeboard. Ponds containing liquids, as opposed to sludges, may be subject to stricter freeboard requirements due to the possibility of wave action within the ponds being generated by strong winds, thus possibly allowing wastewaters to be washed over the pond dike."

Geology - "When possible, ponds should be located in thick, relatively impermeable formations such as massive clay beds. Where this is not possible, then soils with a high clay and silt content should be sought. Those earth materials classified under the Unified Soil Classification as CL, CH, OH, and sometimes SC are normally suitable for use as liners or barriers to the passage of wastes or leachates. Each pond-site location, its construction and operating procedures will be evaluated individually, but if natural in-place soils or imported, amended, recompacted or reworked soils are to be utilized as barriers or liners for the ponds, then the following suggested parameters should be met:"

TABLE I

Parameter	Waste Classification			
	IA	IB	II	III
In-place soil thickness or	4'	3'	3'	-
Compacted soil liner thickness	3'	2'	2'	-
Permeability* (in cm/sec)	$1x10^{-7}$	$1x10^{-7}$	$1x10^{-7}$	-
% Passing No. 200 Sieve	30	30	30	-
Liquid Limit	30	30	30	-
Plasticity Index	15	15	15	-
Artificial liner thickness	30mil	20mil	20mil	-

*Permeability is to be determined with the waste if liquid, and with the liquid phase if semisolid."

Hydrology - "When possible, the bottom of the pond should be well above the historical high groundwater table. Floodplains, shorelands, and groundwater recharge areas should be avoided. Significant hydraulic connection (surface or subsurface) between the site and surface and/or groundwaters should be absent. Each pond-site location will be considered/evaluated individually but as a rule, the following suggested parameters should be met."

TABLE II

Parameter	Waste Classification			
	IA	IB	II	III
Monitor Well	Yes	Yes	Yes	-
Leachate Collection	Yes	-	-	-
Secondary Dikes+	Yes	-	-	-
Freeboard	2'	1.5'	1.5'	-
Depth to Water Table*	50'	10'	10'	-
If site is below 50-year floodwater elevation	X	Z	Z	-
If site is above 50-year floodwater elevation	Z	Z	Z	-

X = operator should provide surface water diversion dikes with a minimum height equal to two (2) feet above the 50-year floodwater elevation around the perimeter of the disposal site.

Z = operator should provide surface water diversion structurers capable of diverting all rainfall runoff from a 24-hour, 25-year storm.

\+ Secondary dikes would normally not be necessary when the primary dikes are well engineered, constructed and maintained.

*If pond is located in massive relatively impermeable formation, these numbers could possibly be reduced to 1/10 of those listed.

Construction - "One of two common methods are recommended for pond or lagoon constraction: (1) the "above - ground" pond/ lagoon; and (2) the "below - ground" pond/lagoon.

- "Above-ground" ponds/lagoons are recommended for use in areas with high groundwater table conditions. If class IA (hazardous) wastes are to be retained in above-ground ponds and the primary dikes are poorly engineered or unstable/inadequate, then secondary or back-up dikes are to be constructed around the primary dikes in order to prevent exit of wastes from the facility if the primary dikes break. Other methods to prevent the escape of wastes into area waters may also be used.

- "Below-ground" ponds/lagoons are recommended for use in areas where the groundwater table is not close to the surface. In below-ground ponds containing Class IA (hazardous) wastes where waste level is above ground level, a secondary or back-up dikes are to be constructed around the primary dikes if the primary dikes are poorly engineered or unstable/ inadequate. These secondary dikes should be constructed to insure that the area within is capable of retaining a minimum of 1.25 times the volume of waste material retained above ground level within the primary dikes. Again, methods other than back-up dikes may be used to prevent escape of wastes into area waters.

"Above" - and "below-ground" ponds/lagoons are not required to be lined if the underlying soil is relatively impermeable ($\leq 10^{-7}$ cm/sec) and of sufficient thickness to inhibit seepage of wastes from the pond into the groundwater. If these conditions are not met, then the ponds should be lined.

Dikes for all ponds are to be "keyed" into the underlying soil to promote a good seal between the ground and the dike bottom in order to prevent lateral migration/seepage of wastes through the base of the dike."

Operation - "Regardless of the type of pond facility constructed it must be operated in such a manner so as to serve its intended purpose without posing a water pollution threat. Maintaining proper freeboard, accepting only those wastes which are compatible with and not detrimental to the pond lining, and taking care not to rupture the liner are just a few of the things that the operator must be constantly concerned with. Other potentially harmful or undesirable conditions such as foul odors, oil slicks on pond surface, or fires, are to be minimized or eliminated if possible."

The following suggestions are made regarding the maintenance of storage pond dikes:

- Construction - "all earthen dikes should be constructed of a clay-rich soil capable of achieving a coefficient of permeability of at least 1.0×10^{-7} cm/sec or less when compacted t0 95% standard proctor at optimum moisture content.

Dikes should usually (subject to soil and equipment types) be constructed in lifts a maximum of nine (9) inches thick. The surface between lifts should be sacrificed to insure a good seal between each lift.

o Stabilization and Maintenance - "In order to minimize the erosion of earthen dikes by wind and water, it is suggested that where practical all earthen dikes be stabilized by establishing a protective "cover" such as, but not limited to, grass, shell, rock, etc., over the top and sides of the exposed portions of the dikes. In addition, the dikes should be periodically inspected for the purpose of detecting and correcting any deterioration of the dikes. All needed maintenance or corrective action necessary to restore the dike to its original condition should be accomplished expeditiously due to the possible serious consequences".

(2) Oklahoma - According to the guidelines published by Oklahoma State Department of Health, Chapter IV.; "Ponds and Lagoons", treatment and disposal of industrial wastes in properly located, constructed, maintained and operated "ponds or lagoons" is considered to be an acceptable, environmentally sound waste

management practice. To assist operators in accomplishing the treatment and/or disposal of wastes in ponds and lagoon in such a manner as to preclude contamination of groundwater and surface water supplies, the Oklahoma State Department of Health published detailed guidelines for location, constraction, operation and maintenance of such facilities. Pertinent portions of these guidelines are as follows:

Wastes - No waste/wastes that has a significant detrimental effect on the materials being used as barriers to movement of wastes from the pond/lagoon should be disposed of in such facilities. It is, therefore, desirable to determine by testing the effect of the wastes to be contained on the soils or lining materials to be utilized in the construction of ponds or lagoons. Greater care must be exercised when handling the liquid wastes because they present a somewhat greater hazard of pollution potential than do the more viscous, high solid content sludges (e.i. spills involving liquids would more rapidly convey to area waters; possibility of wave action within a pond/lagoon generated by strong winds may result in stricter freebord requirements).

Geology - "Whenever possible ponds and lagoons should be located in thick, relatively impermeable formations such as massive clay beds. Where this is not possible, then soils with a high clay and silt content should be sought." "The soil characteristics shall be continuous for a distance of at least ten (10) feet in all directions vertically and laterally of the actual disposal area.

a. Fine-grained soils generally falling into group classification CH, OH, or CL per the Unified Soil Classification System.

b. Maximum permeability coefficient of 10^{-7} cm/sec, or less permeable.

c. Consideration will also be given to particle size distribution, liquid limit and plasticity index, pH, dispersion, etc.

If the natural or undisturbed soil at a proposed Industrial Waste disposal site would not be adequate to contain the waste deposited therein, an impervious liner of reconstituted natural or specific clays or artificial materials may be used. The following minimum criteria shall apply to such liners.

Clay liners

a. Be at least five (5) feet thick.

b. Be reconstituted and compacted on a substantially stable base.

c. After compaction, have a maximum permeability coefficient of 10^{-8} cm/sec, or less permeable.

Artificial liners

a. Be non-reactive to waste materials.

b. Be placed on a stable-type base."

Hydrology - "Whenever possible the bottom of the disposal area should be well above the historical high groundwater table. Floodplains, shorelands, and groundwater recharge areas should be avoided. Significant hydraulic connection (surface and subsurface) between the site and standing or flowing surface water should be absent. Each disposal site will be considered/evaluated individually but as a rule, the following suggested parameters should be met:

Parameter	Controlled Industrial Waste
Monitor Well	Yes
Leachate Collection	Yes
Secondary Dikes	Yes
Freeboard	3'
Depth to Water Table	50'

In addition, it is generally desireable to provide for temporary impoundment of all runoff that might be contaminated by spills, dike failures, or other unusual problems. By providing this extra level of protection, contamination runoff can be restricted to the site proper, without the risk of such runoff immediately entering creeks, rivers, etc."

Construction - "One of two common methods are recommended for pond or lagoon construction: (1) the "above-ground" pond/lagoon, and (2) the "below-ground" pond/lagoon.

- The "above-ground" method of pond and lagoon construct~~able~~ion is recommended for use in areeas with high groundwater table conditions. Because the waste level in such ponds will obviously be at some distance above ground level, a secondary or back-up dikes are recommended around the primary dike in order to prevent exit of wastes from the facility in the event the primary dike is breached. However, methods other than back-up dikes may be utilized to prevent escape of wastes into area waters.

o The "below-ground" pond and lagoon construction is recommended for use in areas where the groundwater table is not close to the surface. In situations where "Controlled Industrial Wastes" (hazardous wastes) are retained above ground level secondary or back-up dikes are recommended around the primary dikes to prevent exit of the wastes from the facility in the event the primary dike is breached.

Secondary dikes, for both types of pond/lagoon construction, should be designed and constructed to insure that the area within a secondary dike is capable of retaining a minimum of 1.25 times the volume of waste material retained above ground level within the primary dikes.

"Above" - and "below-ground" ponds/lagoons are not required to be lined if the underlying soil is relatively impermeable (10^{-7} cm/sec) and of sufficient thickness to prevent seepage of wastes from pond or lagoon into the ground water. If these conditions are not met, then the ponds are to be lined.

Dikes for all ponds are to be "keyed" into the underlying soil to promote a good seal between the ground and the dike bottom in order to prevent lateral migration/seepage of wastes through the base of the dike."

Operation - "Regardless of the type of pond facility constructed it must be operated in such a manner so as to serve its intended purpose without posing a water pollution threat.

Maintaining proper freeboard, accepting only those wastes which are compatible with and not detrimental to the pond lining, and taking care not to rupture the liner are just a few of the things that the operator must be constantly concerned with. Other potentially harmful or undesirable conditions such as foul odors, oil slicks on pond surface, or fires, should be minimized or eliminated if possible.

(3) California - According to the regulations published by the State Water Resources Control Board, both disposal sites and wastes have been categorized. Wastes which consist of or contain toxic substances are classified as Group I wastes. "Hazardous Wastes" are included in this group. The only classes of disposal sites which can accept Group I wastes, including hazardous wastes, are described below:

Class I - There must be no possibility of discharge of pollutant substances to usable waters. Artificial barriers may be used for control of lateral wastes movement only. Usable groundwater may underlie the site, but only under extreme cases and where natural geological conditions prevent movement of the wastes to the water and provide protection for the active life of the site. Inundation and washout must not occur. All waste groups may be received.

Limited Class I - A special case of Class I site is established where a threat of inundation by greater than a 100-year flood exists. A limitation is placed on the type and amount of Group 1 wastes that may be accepted.

Class II-1 - These sites may overlie or may be adjacent to usable groundwater. Artificial barriers may be used for both vertical and lateral waste confinement in the absence of natural conditions. Protection from a 100-year frequency flood must be provided. Group 2 and 3 wastes can be accepted and under special conditions, certain Group 1 materials may be accepted.

Most hazardous waste impoundments (ponds/lagoons), therefore, must be in areas where the natural geologic setting protects groundwater quality. Artificial liners are not considered adequate to provide groundwater protection from all Class I wastes.

Regarding surface water protection, Class I sites may have artificial barriers to control lateral waste movement. The modifications made to enable lateral control of waste migration must be in a manner acceptable to a regional board. The impermeable conditions established should meet all of the following criteria if the barrier is comprised of soil, or provide equivalent impermeable conditions if comprised of approved synthetic materials:

a. Permeability of 10^{-8} cm/sec, or less permeable.

b. CL, CH or OH soils per Unified Soil Classification System.

c. Not less than 30% by weight passes a No. 200 sieve (U.S. Standard).

d. Liquid limit of not less than 30 (ASTM Test D423).

e. Plasticity index of not less than 15 (ASTM Test D424).

f. Permeability is not adversely affected by chemical or physical reaction with the anticipated wastes.

Sites made suitable for use by man-made physical barriers shall not be located where improper operation or maintenance of such structures could permit the waste, leachate, or gases to contact usable ground or surface water. The integrity of waste containment structures must be maintained. Excavations made as part of the site operation should not result in removal of portions of confinement barriers without prior evaluation of the effect on containment features. Waste disposal facilities utilizing mechanical equipment such as pumps must be designed to prevent overflows due to malfunction of the equipment. Inundation and washout must not occur. The State suggests that freeboard should be established to prevent overflow under the greatest anticipated 24-hour or 6-day rainfall and wind conditons, whichever is more restrictive. Sites which meet all the criteria for Class I sites except they are subject to inundation by a tide or a flood of greater than 100-year frequency may be considered by the regional board as a limited Class I disposal site.

(4) Pennsylvania - Impoundments (ponds/lagoons) are regulated by the Bureau of Water Quality Management within the Department of

Environmental Resources. According to the regulations: "No person or municipality shall operate, maintain or use or permit the operation, maintenance or use of an impoundment for the production processing, storage, treatment or disposal of polluting substances, unless such impoundment is structurally sound, impermeable, protected from unauthorized acts of third parties and is maintained so that a freeboard of at least two (2) feet remains at all times". Except where impoundment is already approved under an existing permit, a permit from the Department is required approving the location, construction, use, operation and maintenance of the pond or lagoon.

According to the general policy, the "impermeability" is a coefficient of permeability. If natural deposits are used, they must have a uniform thickness of greater than 2 feet and must have a permeability of less than $1x10^{-7}$ cm/sec. If the uniform thickness is greater than 4 feet and there is an upward groundwater flow, the permeability may be increased to $1x10^{-6}$ cm/sec or less. Synthetic liners of membrane type must have a minimum thickness of 20 mils and a natural permeability of less than $1x10^{-7}$ cm/sec.

(5) New York - The State of New York has its own groundwater quality standards and a facility discharging to groundwaterd must have a permit. For a hazardous waste surface impoundments to obtain such a permit, it must have an impervious lining and all leachate

and runoff from the impoundment must be collected and treated adequately. No formal guidelines or criteria for permitting facilities have been adopted, and each impoundment is judged individually.

(6) Maryland - By July 1, 1977, all hazardous waste surface impoundment in Maryland will have to obtain an interim permit. These permits will be issued on a case-by-case basis, though these facilities will not be allowed to leak. The Maryland Department of Natural Resources, which is in charge of hazardous waste surface impoundments in Maryland, has no formal guidelines or criteria for use in permitting these facilities. However, permitting officials will use standards and/or guidelines already established by other organizations for pond design. Such organizations include the U.S. Soil Conservation Service and the American Society of Civil Engineers.

(7) Oregon - Industrial waste surface impoundments in Oregon are required to be permitted. To be permitted, an impoundment must be designed so as to be watertight; thus, a liner is usually required. The design adequacy of each impoundment is judged on a case-by-case basis, and no formal guidelines are used.

(8) Ohio - Ohio does not have nay published regulations pertaining to hazardous waste management facilities, nor is there a permit program for such facilities. The Director of the Ohio Environmental

Protection Agency, however, can issue an order requiring facilities. to take certain environmentally protective measures (i.e. clay liners in ponds, etc.)

(9) Illinois - Has no uniform program requiring hazardous waste surface impoundments linings.

IV. Analysis of Regulatory Options

The damage incidents described in Part II of this document clearly outlined the pollution potential associated with hazardous waste surface impoundments. However, the treatment, storage or disposal of hazardous wastes in properly located, designed, constructed, operated and maintained surface impoundments could be an acceptable, economical and environmentally sound waste management practice.

Surface water pollution problems, relative to the hazardous waste surface impoundments, are usually results of breaks in the dikes or overtopping, with subsequent spilling over of hazardous wastes to the surface waters. Such incidents have resulted in water contamination, fish kills and degradation of the stream.

The movement of hazardous wastes through surface impoundment into the groundwater can also cause human health and environmental damage. The groundwater has little assimilation capacity compared to the surface water. The rate of movement of groundwater is extremely low relative to surface water. Unlike streams, which can rebound from pollution conditions in few years, ground water does not experience the flushing action of a stream flow, nor does it experience the purifying effects of air, light or aerobic biological activity. Instead it flows very slowly, receives less dilution, has essentially no oxygen to degrade pollutants under aerobic conditions, and flows through a medium where surface tension tends to hold pollutants in a "plume" instead of dispersing them. Since the potential for the groundwater to recover from a polluted condition is very low, a high degree of groundwater protection should be provided by the regulations.

Generally, the pollution potential of hazardous waste surface impoundments depend on a number of things such as:

1. Site location (e.g., geological, hydrological parameters of site, geographical location, etc.).
2. Composition, reactivity and physical state or form of wastes to be contained.
3. Design and construction of the facility.
4. Operation and maintenance at the facility.
5. Closing procedures and post closure care.

All of these factors should be given careful consideration if impoundments are to be utilized without creating a threat to the public health and environment.

From the description of various state regulations in Part III of this document, it is clear that there are several alternative regulatory options that can be adopted for regulation of hazardous waste surface impoundments.

In accordance with EPA regulatory strategy, Part 250, Subpart D of the regulations includes two types of performance Standards (under Section 250.42), and design and operating standards (Sections 250.43 through 250.45). The design and operating standards, which cover general facilities standards, storage standards, and treatment and disposal standards, are designed to protect public health and the environment and, therefore, to achieve compliance with the Health and Environmental Standards under most situations. The Health and Environmental Standards are meant to be overriding standards to supersede the design and operating standards.

Under this regulatory structure, it is intended that the design and operating standards will be the principal regulatory criteria used to manage the treatment, storage and disposal of hazardous wastes. Where there is a reason to believe that design and operating standards will not achieve compliance with the Health and Environmental Standards, it is intended that the both will be used as the basis for regulatory action.

Following the foregoing rationale, the design and operating standards are designed to provide protection of public health and the environment for most situations.

In achieving this purpose, however, this standard may, in some instances, unnecessarily over-regulate some situations. Additionally, being based on the current state-of-art of treatment, storage and disposal practices, the standards may preclude technological inovation and advancement of the state-of-the-art. In recognition of this problem, some of the design and operating standards include notes, which prescribe the criteria for deviation from such standards. In all cases, the basis for deviation is achievement of equivalent containment or destruction of the hazardous wastes. It is believed, that the above approach will prevent over-regulation without sacrificing public health and environmental protection, and will permit application of new technology which would not otherwise be permitted by the specificity of the design and operating standards.

The Analysis of human health and environmental protection provided by each standard is presented in Section V of this background document.

V. Identification of Chosen Regulation and Associated Rationale

(a) Site Selection.

Standard: (1) Surface impoundments shall be located, designed, constructed, and operated to prevent direct contact between the surface impoundment and navigable water.

Rationale: Surface water should not be allowed to interact with hazardous waste deposited in the surface impoundment, since it could allow the wastes to escape to the environment. Additionally, water contacting the surface impoundment structure could erode or otherwise deteriorate its structural integrity. A regulation prohibiting direct contact between surface impoundments and surface water would prevent such problems.

A. The precedents set by the State of Texas and Oklahoma established the fact that such procedures are recognized good practices. Portion of Texas, and Oklahoma's hydrologic criteria for a hazardous waste "pond/lagoon" site location requires that significant "hydraulic" connection (surface or subsurface) between the site and standing or flowing surface water should be absent.

B. Consequences of not having such a regulation are listed below:

(i) Direct contact (surface or subsurface) with surface water would hasten the movement of hazardous wastes into surface water and away from the site. This is especially significant for surface impoundments since wastes contained in such facilities are either liquids or semi-liquids with hazardous components either in soluble or in readily soluble form.

(ii) Surface water contacting the surface impoundment has a potential to:

(a) carry dissolved and undissolved hazardous components away from the site,

(b) infiltrate the impoundment and damage its structural integrity (e.g., damage liners, break dikes).

Standard:(2) A surface impoundment shall be located, designed, and constructed so that the bottom of its liner system or natural in-place soil barrier is at least 1.5 meters (5 feet) above the historical high water table.

Note: The bottom of any liner system or natural in-place soil barrier may be located less than 1.5 meters (5 feet) above the historical high water table provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that no direct contact will occur between the surface impoundment and the water table, and a leachate monitoring system as required in Section 250.43-8 can be adequately installed and maintained in the lesser space.

Rationale: The objective of this regulation is to insure that a sufficient distance exists between the bottom of any surface impoundment and groundwater that will prevent direct contact between the impoundment and the aquifer; will allow for the emplacement of the leachate monitoring system as required under Section 250.43-8, and provide reaction time for responding to an unacceptable discharge should one be detected.

Essentially, the above regulation is intended to ensure that a buffer zone of natural attenuation exsits between the surface impoundment and groundwater. The presence of such a zone may make a difference between what would be a minor, reversible pollution problem and a major irreversible one.

The separation between the bottom of the impoundment and the aquifer will prevent the aquifer from becoming contaminated immediately in the event of failure of the liner system. ~~failure~~. Thus, if a leak is detected, some time will be available for implementing contingency plans before the aquifer becomes contaminated. It will also provide room for the emplacement of the leachate monitoring equipment, where required by design specifications. Furthermore, the buffer zone provides for unpredictable fluctuations of the groundwater level, reducing the possibility of direct contact between the groundwater and impoundment liner system, especially in the case of artificial liners.

The parameters for hazardous waste "ponds and lagoons" in Texas and Oklahoma specify the depth to the groundwater table as 50 feet unless the "pond and lagoon" is located in a massive, relatively impermeable formation, where the distance could possibly be reduced to 5 feet. Other states such as: Maryland, New York, Pennsylvania, Oregon and Ohio have no formal guidelines or criteria in this area; however, they seem to be more conservative in their approach.

It may be advantageous to require a greater distance to the groundwater table as an added precaution. This would, however, automatically exclude a number of potential and existing sites around the Gulf Coast and elsewhere, because of naturally high groundwater conditions. Since surface impoundments are an essential part of industrial wastewater treatment for the industry in these areas, standards preventing their use would cause a serious impact on industry. Additionally, there is no definitive evidence that a separation of 5 feet, or greater, is needed for human health and environmental protection.

When the 5-foot requirement is used in conjunction with design and construction criteria under Standard (c)(3) and (c)(4), and other requirements of this section, it should satisfy all above-stated objectives of the regulation and in the same time provide more flexible approach.

Furthermore, the above regulation is accompanied with a note which prescribes the criteria for deviating from the standard. The basis for the deviation allowed is the achievement of equivalent separation between the impoundment and the water table, and the adequate installation of a leachate monitoring system.

Consequences of not having such regulation are listed below:

(i) Direct subsurface contact with groundwater would hasten the movement of hazardous wastes into groundwater. This is especially significant for surface impoundment, since waste contained in such facilities are either liquids or semi-liquids with hazardous components either in soluble or in readily-soluble form.

(ii) Direct contact with groundwater will preclude the existence of an unsaturated zone under and around the surface impoundment. This automatically eliminates any natural attenuation or buffering capacity that could exist in such an unsaturated zone. Additionally, the time to detect and correct a problem before environmental damage can occur is reduced if not eliminated.

(iii) Direct contact with groundwater will preclude installation of leachate monitoring equipment required under (c)(3) of this Section, thus preventing early detection of the liner system failure.

The precednets set by the State of Oklahoma and Texas established the fact that such procedures are recognized good practices. Portion of Texas' and Oklahoma's hydrologic criteria for hazardous waste "pond/lagoon" site location requires that significant "hydraulic" connection (subsurface) between the site and groundwater should be absent.

Standard: (3) A surface impoundment shall be located at least 150 meters (500 feet) from any functioning public or private water supply or livestock water supply.

Note: A surface impoundment may be located less than 150 meters (500 feet) from any functioning public or private water supply or livestock water supply provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that:

(i) No direct contact will occur between the surface impoundment and any functioning public or private water supply or livestock water supply;

(ii) No mixing of the leachate (including groundwater or surface water contaminated with leachate) with the public or private water supply or livestock water supply will occur; and

(iii) A groundwater monitoring system as required by Section 250.43-8 has been installed and is being adequately maintained.

Rationale: Because groundwater is a major source of drinking water, and drinking water can have a direct effect upon public health, a buffer zone between the surface impoundment sites and water supply wells is desirable. A buffer zone of 150 m (500 feet) between impoundment site borders and drinking water supplies provides a margin of safety that will allow for detecting and responding to a groundwater problem before neighboring drinking water supplies can be affected.

A review of several state regulations, in respect to the general site selection, reveals a difference in their approach used to develop buffer zone regulations. Most states prefer to regulate on the site specific basis, the premise being that the distance needed between the surface impoundment and water supply well is dependent.

At least two states, Texas (State Department of Health Resources) and Wisconsin (Department of Natural Resources), prefer to specify a distance, 500 feet (150 m) and 1250 feet (375 m), respectively. The states' rationale behind specifying number is that it provides a tangible point of reference and facilitates enforcement. Being cognizant that a specified distance may not be applicable in some situations, both states maintain a flexible attitude and allow for concessions to be made. For example, Wisconsin requires special construction techniques to be used for construction wells with 1250 feet (375 m) of a site; Texas allows wells within 500 feet (150 m) if certain site parameters can provide the equivalent of 500 feet (150 m) of protection.

The regulatory approach taken by EPA similarly incorporates the advantages of having a tangible reference point, with the versatility of allowing for concessions to be made under special circumstances.

Although the conservative value of 150 m (500 feet) was chosen, when it is used in conjunction with other requirements in this section, it provides adequate time for detecting and responding to a problem when one is detected.

Essentially, a distance of 150 m (500 feet) is relied upon in terms of providing a margin of safety and is not expected to serve as the main barrier to pollution of a water supply well.

Standard: (4) Surface impoundments shall be located or designed, constructed, and operated to minimize landslides, slumping, and erosion.

Rationale: Erosion, landslides and slumping are three geophysical forces that can potentially disrupt the enviromental integrity of a surface impoundment. The main object of the above regulation is to ensure that such a disruption does not occur.

Being cognizant of the fact that few potential sites will be free of such forces, the regulation was written to allow flexibility, i.e., if an ideal site could not be found then engineering against such geophysical forces would be acceptable. It is germane to point out that locating surface impoundment in an area known to be subject to extensive erosion, landslides, and/or slumping will require that site improvements be made and/or operational techniques be employed.

The potential consequences of not locating or designing against erosion, landslides and slumping are listed below:

1. Erosion

   Erosion can deteriorate the structural stability of the pond or lagoon. Exposed portions of earthen dikes are especially susceptible to erosion. Subsequent infiltration or breaching of the dikes can hasten the movement of hazardous constituents from the site. The ultimate result is polluted surface runoff which requires collection and treatment to prevent surface water contamination.

2. Landslides

   Landslides, along with floods and erosion, are common occurrences caused by weather, the nature of soils, and gravity. Each, however, can produce a change in a site, thereby directly affecting the rate at which contaminants reach the environment.

A landslide near or within a site can disturb its structural integrity. All environmental media could be adversely affected in the event of a landslide, thus disrupting the containment system of a surface impoundment. Areas subject to, or having had landslides are undesirable locations for siting surface impoundments because the loose unconsolidated soil that characterizes such an area would lack the necessary structural integrity needed to safely support such facilities.

3. Slumping

The slumping or subsidence of land beneath a surface impoundment can:

A. Disturb structural integrity of the impoundment,

B. Breach the containment system of such facilities,

C. Bring the bottom of the surface impoundment and groundwater into closer proximity if not direct contact.

(b) <u>Hazardous waste Suitable for Surface Impoundments</u>

<u>Standard</u>: (1) A surface impoundment shall not be used to contain hazardous waste which is:

(i) Detrimental to any material being used as a barrier to the waste movement from the surface impoundment,

(ii) Ignitable waste, as defined in Section 250.13(a) of Subpart A,

(iii) Reactive waste, as defined in Section 250.13(c) of Subpart A, or

(iv) Volatile waste.

Note: (Relative to ii, iii, and iv) see Note associated with Section 250.45(c).

<u>Rationale</u>: The pollution potential of a surface impoundment depends, among other things, on the specific characteristics of the wastes to be contained. The possible reactions between the materials being used as barriers to movement, and contained hazardous wastes can detrimentally affect the ability of surface impoundment to islolate wastes and prevent

their escape to the environment.

The impermeable barriers (liners, in-place soil, dikes) consist either of clay and fine-grained soils, or artifical materials (concrete, plastics, etc.). However, some materials are not compatible with some hazardous wastes. For example, some natural impermeable soils may fail when exposed to strong acids; synthetic membranes and asphalts are vulnerable to attack by certain hydrocarbon solvents. Table 1 summarizes some of the advantages and disadvantages of several liner types.

The reactions between the contained wastes and liner or dike construction materials can increase permeability or cause dissolution of these materials and can result in the escape of the hazardous substances to the environment, with the subsequent adverse effects on human health and the environment. It is, therefore, imperative that the hazardous wastes to be contained are compatible with construction materials, and that such determination is made before wastes

TABLE 1[12]

ADVANTAGES AND DISADVANTAGES OF SEVERAL LINERS

Alternatives	Advantages	Disadvantages
Natural Clayey Soil	Self-sealing elements provide adequate ground-water protection	Not available in all geographic regions. Exposure to certain acids and chemicals may cause failure
Bentonite Clay	Very low permeability provides ground-water protection	Failure may occur when exposed to acids and certain chemicals
Low-cost synthetic membranes	Most membranes have good tensile strength, low temperature flexibility and resistance to a number of chemical wastes	Not recommemded for retention of hydrocarbons and solvents. Data on long-term integrity is lacking. High-cost may cause use to be economically infeasible
Paved asphalt with a tar cover	Provides firm structural support	Vulnerable to attack by certain hydrocarbon solvents
Paved asphalt with a synthetic membrane	Provides structural integrity and resisitance to chemical attack	Vulnerable to attack by certain hydrocarbon solvents. Use of certain synthetic membranes could elevate cost
1.2 m (4 ft) layer of common clay	Low permeability specifications provide ground-water protection	Exposure to certain acids may cause failure. Not available in all geographic areas
Clay barrier with synthetic membrane	Structural integrity and self-sealing properties of clay provide a very high degree of ground-water protection	Expose to certain acids over a long-term period may cause failure. Clay is not available in all geographic regions. Use of certain synthetic membrane could elevate cost

are deposited, so that such incidents are avoided.

The containment of hazardous wastes that are highly reactive, ignitable, or volatile, in surface impoundments, may generate hazardous emissions endangering workers or neighbors of a facility, and potentially disrupt the environmental soundness of the operation. The explosions could disrupt the structural integrity of the impoundment and cause subsequent leaks of hazardous wastes into the area groundwater and surface water. The impermeability of some artificial liners (e.g., synthetic liners) could be adversely affected by the fire and result in hazardous leaks into the groundwater and surface water. The containment of highly volatile hazardous wastes in surface impoundments could result in unregulated discharges into the air. The fires could also cause unregulated discharges into the environment. For example, burning of hazardous organic wastes containing halogens or heavy metals will result in formation of toxic gaseous components and their transmission into the air. The potential fires and explosions, with subsequent environmental problems, could be also a result of containment of hazardous wastes that are highly reactive with air and water. It is, therefore, imperative that such practices are avoided.

The rationale for selection of vapor pressure greater than 78 mm Hg at 25°C (under (iv)), is given in a separate background document - (3) Air Human Health and Environmental Standard.

Standard: (2) Hazardous waste which is incompatible (see Appendix I) shall not be emplaced together in a surface impoundment.

Rationale: Mixing of hazardous wastes that are not compatible with each other in hazardous waste surface impoundments can result in many environmental problems, such as: violent reactions, excessive heat or pressure generation and potential fires and explosions, and subsequent dispersion of hazardous components into the air, or formation of hazardous gaseous fumes and their transmission into the air. For example, mixing of cyanide and sulfide containing alkaline wastes with acidic wastes will release toxic HCN and H_2S vapors into the environment; uncontrolled mixing of concentrated acidic and akaline wastes could result in violent reactions and excessive heat generation and subsequent environmental problems. Mixing of hazardous wastes containing highly reactive components (e.g., oxidation-reduction agents and organics, etc.) could result in explosions and fires. The major objective of the above regulation is to ensure that such disruptions do not occur.

Standard: (3) All hazardous waste shall be tested, prior to placement in a surface impoundment, for compatibility with the intended liner materials to determine whether it will have any detrimental effect (e.g., cause cracks, dissolution, decrease mechanical strength, or increase permeability) on the soils or lining materials used to prevent leakage from the surface impoundments.

Rationale: The conceptual objectives and rationale for this regulation are described in a rationale given for regulation (b)(1)(i) of this section; i.e., to assure that the hazardous wastes to be contained are compatible with soils and lining materials used for construction of hazardous waste surface impoundment.

The possible reactions between the soils and/or lining materials can detrimentally effect the ability of the impoundment to isolate wastes and prevent their escape into the environment. It is, therefore, evident that the compatibility of wastes with potential lining materials should be the first consideration in design and construction of the surface impoundment. No waste having a significant detrimental effect on the materials used as barriers to movement of the wastes from the impoundment (e.g., causing dissolution, increasing permeability), and consequently resulting in seepage of such hazardous wastes into the environment, should be deposited in such facilities.

The liner materials have been characterized to some extent in the literature, particularly in information that is available from various manufacturers, fabricators, suppliers, installers and trade associations. Manufacturers and fabricators do make available information concerning the physical, chemical and mechanical properties of specific materials that they either manufacture or formulate. However, the literature is fairly sparse as far as meaningful information regarding engineering and performance data, on which to base engineering analysis for a specific liner/waste situation.

Liner studies presently being undertaken by Matrecon, Inc, under a contract to EPA have shown that certain liner materials, are incompatible with certain waste types.[13] For example, clays can only hold strongly acidic and caustic wastes for a short time period; aromatic hydrocarbons wastes will dissolve, or cause most membrane liners and asphaltic materials to swell. However, the above study does not test all liner/waste situations, nor does it test the durability of all liner adhesive and seaming techniques, nor the durability of liners under various climatic conditions.

The fact that the individual waste characterisitcs vary necessitates testing of different lining materials with the hazardous wastes of interest, to determine maximum performance characteristics. Factors to be considered should include liner's deterioration upon contact and after prolonged contact with hazardous wastes of interest, and alterations of the liner material's permeability with time. For the ultimate success of surface impoundments for the containment of hazardous wastes, and to assure environmentally sound performance, it is, therefore, necessary to require testing for compatibility of hazardous wastes with the intended liner materials, either during the design stage, or prior to disposition of hazardous wastes into an existing impoundment, if the waste is different from that of previously deposited in such impoundment.

(c) Design and Construction

Standard:(1) A surface impoundment shall be designed and constructed so as to be capable of preventing discharges or releases to the groundwater or navigable water.

Rationale: The objective of the above regulation is to assure that the surface impoundments are designed and constructed in a manner that will assure their environmenatlly sound operation during the expected life of the facility.

Surface impoundments, in general are the most common industrial and/or hazardous waste management facilities. These versatile installations could serve many basic purposes, including:

* settling and removal of suspended solids,
* holding and impoundment of wastewater,
* holding and impoundment of settled solids,
* equalization,
* aeration,
* neutralization,
* biological treatment,
* disposal through evaporation.

Their relative simplicity and low operating cost makes them a preferred technology for handling of various industrial wastes, including hazardous wastes. Treatment, storage and disposal of hazardous wastes in properly located, designed and constructed surface impoundments can be an acceptable, environmentally sound hazardous waste management practice.

By their nature, surface impoundments, with the exception of disposal ponds/lagoons, are temporary structures with variable lengths of service life. However, regardless of the expected service life, the environmental soundness of each impoundment depends directly on the materials used for construction, i.e., compatibility with the hazardous wastes to be contained; durability upon prolonged contact with the hazardous wastes of interest; and alteration of permeability over time. Since the above characteristics may vary with each construction material and each material/ waste situations, all construction materials should be selected such that their durability and permeability is not adversely affected by prolonged contact with the hazardous wastes of interest and remains unchanged during the expected service life of the facility.

The potential consequences of improper design and construction of surface impoundments are the failure of hazardous waste containment and subsequent leaks of hazardous components into the environment or shortening of the expected service life of the facility.

Standard: (2) Where natural geologic conditions allow, a surface impoundment shall have a natural in-place soil barrier on the entire bottom and sides of the impoundment. This barrier shall be at least 3 meters (10 feet) in thickness and composed of natural in-place soil which meets the specifications of paragraph (c)(4).

Note: An owner/operator of a surface impoundment may use a natural in-place soil barrier of different thickness and different specifications if the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that equivalent or greater waste containment can be achieved. However, under no circumstances shall the thickness of the natural in-place soil barrier be less than 1.5 m (5 feet), or its permeability be greater than 10^{-7} cm/sec.

Rationale: The hydraulic conductivity and the thickness of the soil liner are factors addressed by the States that have existing regulations or guidelines for hazardous waste surface impoundments. Oklahoma requires 10 feet in-place soil thickness of $\leq 1X10^{-7}$ cm/sec. of clay-rich soil for "ponds and lagoons;" Texas specifies 4 feet of $\leq 1X10^{-7}$ cm/sec. in-place underlying soils for "ponds and lagoons." In Pennsylvania, the natural deposits underlying the potential "pond/lagoon" sites must have at least 2 feet of $\leq 1X10^{-7}$ cm/sec. clay-rich soil.

The criteria chosen for the EPA regulation followed the precedent in Oklahoma's requirements, which provide the greatest groundwater protection of the above state regulations/guidelines. The rationale is given below:

Movement of contaminants through the underlying strata is governed by hydraulic factors, including the relative permeability of the underlying material, the depth to the zone of satruation (water table), and the location and areal extent of recharge (positive head). Physical, chemical, and biological properties of the geologic materials may effect a reduction of contaminant levels (natural attenuation).

Any contaminant deposited on the ground surface is in a position where it can easily enter the geologic environment of soils, and unconsolidated or solid rocks, as long as they contain pore spaces or other openings. Liquid contaminants and solid contaminants that undergo leaching by water from precipitation can infiltrate whenever the soils are sufficiently permeable, and percolate downward through the unsaturated material to the water table.

The factors that relate to the release characteristics of the site include soil thickness, soil permeability, depth of water table, and other soil characteristics specified under (c)(4). The release time will vary with changes in the thickness of clay, depth to water table, and hydraulic conductivity of the material above the water table.

The regulatory philosophy prevailing in the United States today favors maximum containment instead of slow release into the environment.

Containment is of course directly affected by the liquid content of the waste materials. Increasing the liquid fraction will generally decrease the potential of containment. Since the wastes contained by surface impoundments are primarily liquids or sludges with high water content, the potential for containment is much lower, when compared to landfills, which could regulate the liquid content in wastes or the amount of percolation. Therefore, the use of the most stringent requirements for surface impoundments are fully justified.

Objections, however, can be raised as to the availability of natural sites that will satisfy the above requirements. In that respect, the "note" under (c)(2), of this section, provides needed flexibility by allowing other combinations of soil thickness and permeabilities that will achieve equivalent containment, and by providing an alternative design specified under (c)(3) of this section.

Surface impoundments designed in accordance to (c)(2), are subject to leachate monitoring, as specified in 250.43-8. The primary objectives of leachate monitoring under the natural in-place soil, is to prevent contamination of usable aquifers through early detection of any failure of natural containment, and to allow initiation of necessary corrective procedures before the contaminants reach the groundwater. The rationale for leachate monitoring requirement is given in a separate background document - (12) "Groundwater and Leachate Monitoring".

Standard: (3) Where geologic conditions do not allow use of the design in paragraph (c)(2), a surface impoundment shall have a liner system covering the entire bottom and sides of the impoundment. This liner system shall consist of top liner, a bottom liner and leachate detection system which meet the following specifications:

(i) The top liner shall consist of emplaced soil at least 30 centimeters (12 inches) in thickness which meets the criteria in paragraph (c)(4), or an artificial liner which meets the criteria in paragraph (c)(5).

(ii) The bottom liner shall consist of natural in-place soil or emplaced soil which meets the criteria in paragraph (c)(4) and is at least 1.5 meters (5 feet) in thickness, or an artificial liner which meets the criteria in (c)(5).

(iii) The leachate detection system shall be a gravity flow drainage system installed between the top and bottom liners and shall be capable of detecting any leachate that passes through the top liner. Provisions shall be made for pumping out any leachate that passes through the top liner and for removal of noxious gases that occur in the system.

Note: An owner/operator may use a different design if he can demonstrate that an equivalent or greater degree of waste containment is achieved. The Regional Administrator shall take into account the length of time the surface impoundment has been in existence, projected facility life, and artificial liner, natural in-place soil, or emplaced soil permeability and thickness when arriving at a decision regarding whether an equivalent degree of containment exists. In the case of existing facilities, the facility owner/operator may conduct leachate (zone of aeration) monitoring to determine whether any significant increase in the background levels of chemical species has occurred. If no significant increase is observed, the design shall be considered to provide the same or greater degree of performance.

Rationale: The objective of the above regulation is to provide maximum protection for human health and the environment at the sites where natural soil conditions do not allow use of the design in (c)(2), (i.e., are not suitable for "natural containment"), and to provide maximum flexibility in design and construction.

In accordance with the above regulation, the top (facility) liner could be constructed of natural or specific reconstituted or rework soils which meet the criteria under (c)(4), or of the artificial materials which meet the criteria under (c)(5) of this section.

The primary function of the top liner is to serve as a barrier between the hazardous wastes and the environment. Because the top liner will be in direct contact with contained wastes, compatibility is the primary criterion for its selection (see (b)(1)(i) of this section). Both soil and artificial liners are permitted as a top (facility) liner. This allows for needed flexibility to match liner with hazardous wastes to achieve maximum compatibility and environmental protection.

The use of artificial liners for hazardous waste surface impoundments is considered to be a good engineering practice. Texas, Oklahoma, Pennsylvania and other states permit the usage of artificial liners as long as they are compatible with subject wastes. Although clay liners are preferable for landfills, the specific nature of impoundments makes artificial liners acceptable. The surface impoundments are normally temporary containing devices for hazardous wastes. In the event a liner failure is detected, the wastes can be removed, and the liners replaced or repaired before a usuable aquifer is adversely affected. On the other hand, however, the long-term effect of wastes on permeability and integrity of membrane liners is generally not known.

Accordingly, artificial liners are allowed only in situations where they are used for temporary containment of wastes (i.e., in ponds where the wastes are removed upon closure).

The bottom liners, based on the intended purpose of the surface impoundment, and on the local conditions, could consist of natural in-place soils, reconstituted or reworked clays or artificial materials.

The primary function of the bottom liner is to serve as a barrier between hazardous wastes, in the case of their migration/seepage through the top (facility) liner, and the zone of aeration. Since the EPA regulations do not specify permeability of the underlying strata under the facility liner system (zone of aeration), the soils could be highly permeable. In this situation, if a bottom liner did not exist and a leak in the top liner occurred, hazardous wastes would probably infiltrate into the ground water very rapidly.

The incorporation of the impermeable bottom liner into the design/construction criteria serves as an additional protection of usable aquifers. Because of the above fact and the closer proximity to the groundwater, the impermeability and mechanical integrity of the bottom liner is more critical than that of the top liner.

The selection of the bottom liner should be based primarily on the compatibility with expected wastes and intended use of the surface impoundment (i.e., temporary or permanent containment of wastes). The clay liners would be preferable as bottom liners. An advantage of clay liners over synthetic liners is that clay remains a semi-fluid material when wet and is, therefore, self-sealing should the barrier be penetrated. Furthermore, the long-term effect of the majority of hazardous wastes on artificial membranes is not known at the present. This information is critical, especially if the wastes are to remain in the impoundment after its closure. Therefore, if the artificial liner is used as a bottom liner, wastes and the liner must be removed from the surface impoundment prior to its closure (see (e)(1)) of this section. If the wastes are to remain in the surface impoundment permanently, the facility essentially becomes a secure landfill and must have liners which comply with the landfill regulations under 250.45-2 of this section.

The requirement of a minimum thickness of 1.5 m (5 feet) for all soil bottom liners is consistent with regulations under (c)(2) of this section.

The above regulation requires installation of a leachate detection system installed between top and bottom liners. Since the purpose of the leachate detection system is to detect any failure of the top liner, the monitoring of the aeration zone, specified under Section 250.43-8, is not required.

Noxious gases may accumulate under the top liner as a result of biological activities or chemical reactions. Air is also frequently trapped under the membrane liner during construction in loose porous soils and depressions are formed under the membrane. As the membrane begins to conform to its bearing surface, air begins to accumulate and to appear as bubbles under the liner. Once the problem is corrected, the air bubbles will not normally reappear. However, in some situations decaying organics or chemical reactions will release gas under the liner on a continuing basis. If the situation is encountered, permanent vents should be provided to constantly vent the generated gas, to prevent operating problems or permanent damage of the liner.

Standard: (4) Soils used for surface impoundments liners or natural in-place soil barriers shall:

(i) Be classified under the Unified Soil Classification Systems as CL, CH, SC, or OH, (ASTM Standard D2487-69);

(ii) Allow more than 30 percent passage through a No. 200 sieve (ASTM Test D1140);

(iii) Have a liquid limit equal to or greater than 30, (ASTM Test D423);

(iv) Have a plasticity index equal to or greater than 15, (ASTM Test D424);

(v) Have a pH of 7.0 or higher, (See Appendix IV);

(vi) Have a permeability equal to or less than $1X10^{-7}$ cm/sec. (ASTM Test 2434); and

(Vii) Have a permeability not adversely affected by the waste to be placed in the impoundment/

Note: Soil not meeting the above criteria may be used provided that the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that such soil will provide equivalent or greater structural stability and waste containment properties and will not be adversely affected by the waste to be placed in the impoundment.

Rationale: The above regulation is applicable to both natural in-place soil barrier, specified under (c)(2) of this section and to the soil liners specified under (c)(3).

The specifications concerning soil properties used by State regulatory agencies reflect a preference for tight clay soils with no sand or gravel seams and a hydraulic conductivity of less than $1X10^{-7}$ cm/sec. Overall, the California Department of Health "Draft of Minimum Standards for Hazardous Waste Management" incorporates the principal soils criteria used in varying detail by other States surveyed. The California regulations and the proposed EPA regulations for PCB disposal stipulate: (1) hydraulic conductivity of $1X10^{-8}$ cm/sec. or less; (2) CL, CH or OH soils as per the Unified Soil Classification System; (3) passage of not less than 30 percent by weight through a standard U.S. No. 200 sieve; (4) a liquid limit of not less than 30 units using ASTM Test D423; (5) plasticity index of not less than 15 units based upon ASTM Test D424; and (6) a soil permeability that must not be adversely affected by chemical or physical reaction with anticipated wastes.

The rationale for requirement under (i); i.e., a passage of not less than 30 percent of soil (by weight) through

200-mesh sieve, is related to the suitability of the soils to serve as liners or barriers to the passage of hazardous wastes or leachates.

Where possible, it is advantageous to locate surface impoundments in thick, relatively impermeable formations such as massive clay beds. Where this is not possible, then the soils with a high clay and silt content (i.e., fine-grained soils) should be sought. According to the Unified Soil Classification System, the boundary between coarse-grained and fine-grained soils is taken to be the 200-mesh sieve (0.074 mm), or percentage of the soil (by weight) passing through such sieve. Thus, the percentage of the soil passing through 200-mesh sieve is one of the indicators of the presence or absence of the clay or silt, to be used to determine the suitability of the soil to serve as a barrier to hazardous waste movement into the environment.

The draft hazardous waste surface impoundment regulations have followed the precedent established by the EPA PCB regulations and the California and Texas regulations; the passage of not less than 30 percent by weight through a standard U.S. No. 200-sieve.

The rationale for the requirements under (ii), i.e., liquid limit not less than 30 and (iii) i.e., plasticity index not less than 15, are related to the consistency, workability and firmness (i.e., compressibility, dry strength, shearing resistance, etc.) of the soils intended as liners or barriers to the passage of hazardous wastes of leachates from surface impoundments.

The "liquid limit", "plasticity limit" and "plasticity index" are the most useful indicators of the engineering behavior of clay soils. The above limits, also termed as Atterberg limits, are defined by the water contents required to produce specific degrees of consistency that are measured in the laboratory.

The "liquid limit" (upper plastic limit) is the point at which soil becomes semifluid. In operational terms, the liquid limit is defined as water content at which a trapezoid groove of specific shape, cut in moist soil held in a special cup is closed after 25 taps on a hard rubber plate (ASTM Test D423).

The "plastic limit" (lower plastic limit) is defined as the water content at which soil begins to crumble on being rolled into a thread 1/8 inch (3 mm) in diameter (ASTM Test D424). It represents the lowest water content at which soil can be deformed readily without cracking.

The "plastic index", a difference between the liquid and plastic limits, is the range of water content of the soil at which plastic behavior occurs. It is also an indicator of the plasticity of "clayeyness" of the soil.

It has been observed (A.Casagrande) that many properties of clay and silts, such as their dry strength, their compressibility, their reaction to the shaking test, and their consistency near the plastic limit, can be correlated with the Atterberg limits by means of the so-called plasticity chart. (In this chart, the ordinates represent the plasticity index and the abscissas the corresponding liquid limit). According to the above chart, clays with liquid limits less than 30 are considered to be of "low" plasticity. Those with liquid limits between 30 and 50 exhibit "medium" plasticity and those above 50 exhibit "high" plasticity. The plasticity index is useful in estimating the dry strength and compressibility of the soil. The soils with plastic index less than 10 have low compressibility. Those with plastic index between 10 and 20 exhibit medium compressibility, and those above 20 high compressibility.

Since the consistency of the soil, its workability, compressibility and dry strength are critical for construction and environmentally sound operation of hazardous waste surface impoundments, both "liquid limit" and "plastic index" are important factors in determination of the soil suitability for such construction.

The draft hazardous waste surface impoundments regulation followed the precedent established by the EPA PCB regulation, and California and Texas regulations, in respect to both "liquid limit" and "plasticity index."

The draft hazardous waste surface impoundment regulations have followed the precedent established by the EPA PCB regulations and the California regulations on soil criteria in all areas except permeability and pH.

The requirement under (iv) that soil liners have a pH of 7.0 or higher was added because of the higher attenuation ability of soils at higher pH values, and the ability of high pH soils to inhibit the reaction of wastes with low pH with the soils.

The impoundment regualtions under (v) specify 10^{-7} cm/sec. rather than 10^{-8} cm/sec. because more state regulations use 10^{-7} cm/sec.; almost all reviewers outside the Agency support

10^{-7} cm/sec.; and because there is no definite evidence that 10^{-8} cm/sec. is necessary for human health and environmental protection.

The Texas and Oklahoma parameters for soil liners in hazardous waste "ponds and lagoons" (in-place natural soils and recompacted or reworked soil liners) are similiar to the California specification, with the exception of the soil permeability. Both Texas and Oklahoma require soil permeability for hazardous waste "ponds/lagoon" liners to be less than an equal to $1X10^{-7}$ cm/sec. In Pennsylvania, the natural deposits underlying the potential "pond or lagoon" site also must have permeability of less than or equal to $1X10^{-7}$ cm/sec.

The permeability criteria chosen for the EPA regulations follow the precedents established by Texas, Oklahoma and Pennsylvania. California's requirement for 10-8 cm/sec. appears more protective. However, in conjunction with the design and construction criteria under (c)(2) and (c)(3), and the other regulations in this section, this number

(10^{-7} cm/sec.) should be adequate to provide satisfactory groundwater and surface water protection.

In addition to the criteria listed under (i) to (v) of this regulation, it is required under (vi) that the permeability of soil liners should not be adversely affected by the anticipated wastes.

The rationale for the above regulation is the fact that clay liners, although suitable for the majority of hazardous wastes, are not compatible with certain wastes. For example, natural impermeable soils may fail when exposed to strong acids; and strong alkaline waste may cause clay liners to swell. Therefore, the wastes which are not compatible with soil liners should not be deposited into such surface impoundments. The rationale concerning waste compatibility with the liner is given in (b)(1) of this section.

Standard: (5) Artificial liners for surface impoundments (e.g., concrete, plastic) shall:

(i) Be of sufficient strength to insure mechanical integrity;

(ii) Have a minimum thickness of 30 mils;

Rationale: Liners should be of adequate strength and thickness to insure mechanical integrity of the liner. The failure to provide liners of adequate mechanical stength and thickness could result in liner failure (e.g., rupture, puncture, laceration, development of cracks, etc.) with subsequent seepage of hazardous wastes into the environment.

Thickness of artificial liners, especially membrane liners, and their mechanical strength are closely related (i.e. the thicker the liner, the higher mechanical strength could be anticipated). The criteria chosen for EPA regulation followed the precedent in Texas requiremnts established for hazardous waste "ponds and lagoons".

Standard: (iii) Be compatible with the waste to be placed in the impoundment;

Rationale: Among the first consideration in selecting a liner for hazardous waste surface impoundment is the compatibility with the hazardous wastes to be contained. The possible reactions between the liner and wastes can detrimentally affect the ability of the impoundment to contain such wastes and prevent their seepage to the environment.

The compatibility criteria for artificial liners and rationale are same as specified under (b)(1)(i) of this section.

Standard: (iv) Have a permeability less than or equal to $1X10^{-7}$ cm/sec.

Rationale: The permeability criteria for artificial liners and rationale are same as specified under (c)(4) of this section for clay liners.

Standard: (v) Have an expected service life at least 25 percent longer than the expected time of facility usage;

Rationale: Estimates of the predicted life-time of liner materials are usually available from the literature, various manufacturers, fabricators, suppliers, installers and trade unions. However, accurate information concerning the long-term effect of subject wastes on specific liners is generally not known. The hazardous wastes after prolonged contact could have a detrimental effect on liner durability and permeability. Continuous use of artificial membranes after their predicted life time would considerably increase the potential for liner failure and subsequent groundwater contamination. Lacking the actual field test data, the projected life of the liner for the specific liner/waste situation can only be assumed. To compensate for the lack of specific data, the EPA regulation has incorporated a safety factor, allowing use of the specific liner for no more than 3/4 of its projected life.

Standard: (vi) Be placed on a stable base;

Rationale: The installation of a manufactured liner requires prior preparation of the base. The base should be stable so that settling or other movement after liner installation does not tear or weaken the liner through stretching. The improper installation of even the best material will defeat the purpose of the lining.

Standard: (vii) Satisfactorily resist attack from ozone, ultraviolet rays, soil bacteria, and fungus;

Rationale: The exposure to ozone, ultraviolent rays, soil bacteria and fungus could adversely affect the durability and impermeability of membrane liners.

Standard: (viii) Have ample weather resistance to withstand the stress of freezing and thawing;

Rationale: Liners should have ample weather resistance to withstand the stresses associated with wetting and drying, freezing and thawing as dictated by the geographic location of the impoundment site.

Standard:(ix) Have adequate tensile strength to elongate sufficiently and withstand the stress of installation and/or the use of machinery or equipment;

Rationale: The liner materials without adequate tensile strength may rupture during installation or be affected by continuous use of machinery and equipment required for the operation of the pond or lagoon.

Standard: (x) Resist laceration, abrasion and puncture from any matter that may be contained in the fluids it will hold;

Rationale: The sharp objects and abrasive materials present in contained waste could lacerate, puncture or decrease durability of the liner.

Standard: (xi) Be of uniform thickness, free of thin spots, cracks, tears, blisters, and foreign particles;

Rationale: Thin spots, cracks, tears, blisters, foreign particles present in the liner materials, and variable thickness of the liner could adversely affect durability and permeability of the liners.

Standard: (xii) Be easily repaired.

Rationale: The liner material should be capable of being repaired easily so that if a puncture does occur, it can be remedied.

Standard: (6) To prevent their rupture, all artificial liners in a surface impoundment where mechanical equipment is used for operation (e.g., sludge dredging and collecting) shall have a protective cover of selected clean earth material, not less than 45 centimeters (18 inches) thick, placed directly on top of the liner.

Rationale: All artificial liners are prone to rupture or damage caused by mechanical equipment, such as sludge dredging and collecting equipment, if such machinery/equipment is used for operation. To prevent such problems, it is recommended that all surface impoundments lined with artificial liners, and using mechanical equipment, should have a protective cover of selected clean earth material, not less than 45 cm (18 inches) thick, placed directely upon the liner.

The usage of protective covers for artificial liners, if needed because of operating conditions, is generally considered to be a good engineering practice, although the recommended thickness may vary (i.e., with type of liner, manufacturer specification, usage, etc.). The thickness recommended in the above regulation is based on liner manufacturer recommendations, discussions with experts, and what has generally been found effective in actual practice.

Standard: (7) A surface impoundment shall have a groundwater monitoring system and a leachate monitoring system that meet the specifications in Section 250.43-8.

Rationale The one cause of groundwater contamination in the United States is leakage of wastes from unlined holding surface impoundments. In nearly all cases, unlined impoundments or impoundments constructed in permeable soils leak. The pollution problems such as these can be alleviated if surface impoundments are constructed in impermeable clay soil or lined with clay and/or artificial liners. (See (c)(2) and (c)(3)). However, all liners are prone to failure, due to incompatibility with contained wastes, mechanical failure, prolonged usage exceeding projected life (artificial liners), or effective life of clay liners; improper installation, etc., resulting in hazardous waste seepage into the environment.

The objective of the above regulation is to detect and correct any liner failure or groundwater contamination before more serious problems can develop.

Monitoring requirements for hazardous waste surface impoundments over usable aquifers, under 250.43-8 specify monitoring in zone of saturation, applicable to all facilities constructed after the effective date of this regulation.

The objectives and rationale for requiring monitoring in the zone of saturation are the same as specified under 250.43-8 of 3004.

Standard: (8) All surface impoundment dikes shall be designed and constructed in a manner that will prevent discharge or release of waste from the facility, both horizontally and vertically.

Rationale: The primary function of any surface impoundment dike is the containment of a definite volume of waste within the impoundment area, and to serve as a barrier between the contained wastes and the environment. To serve its intended purpose, the surface impoundment dikes should be designed and constructed so as to prevent hazardous waste seepage into the environment.

The method of constructing surface impoundment usually consists of building the dike around the selected area, either without excavation - for "above-ground" construction, or around the excavated area - for "below-ground" impoundments.

The waste level in surface impoundment, depending on design and construction, could be at ground level, below, or above the ground level, the latter being the case with all "above-ground" structures. If the waste level remains at all times at ground level or below, the risk of wastes flowing out of the surface impoundment, in the event the dike is breached at the ground level, is greatly reduced. However, if the waste level would normally be maintained some distance above the ground level, and the dike is breached, hazardous wastes will flow freely out of the impoundment and into the area drainage system. Therefore, the design and construction criteria should be more stringent in this case.

To serve its intended purpose, the earthen dikes should be constructed from impermeable soils (see requirements under (c)(9)), to prevent migration or seepage from the impoundment, and be structurally stable to serve its intended purpose during the anticipated service life without cracking or breaking. In addition, all dikes should have an adequate seal between the dike bottom and underlying soils.

The dike height and width is usually determined by the intended use of the surface impoundment (e.g., volume to be retained, method of delivery, etc.). The dike height should be adequate to contain anticipated/projected volume of the wastes and allow sufficient freeboard above the impoundment peak operating water level. (See freeboard requirements under (d)(2) of this section.)

The dike slope depends chiefly on the size of the impoundment and on materials available for their construction. Surface impoundment dikes are usually designed and constructed with slopes between (6) horizontal to (1) vertical, and (2) horizontal to (1) vertical. Normally, good pond soil would support slopes of (3) horizontal to (1) vertical. The wind and water erosion effect, and the protection to be provided, are another important design and construction criteria for dikes. All soils, regardless of the slope, need protection in zones subject to turbulence and agitation (e.g., created by wind induced wave action, inlet and outlet increased hydraulic activity, aerator agitation, etc.). Generally, the larger ponds and lagoons in windy areas are more susceptible to erosion (and require more protection). The steeper the side slope, the less area there is for protective covering.

The consequences of failure to provide adequate design and construction for hazardous waste surface impoundments are listed below:

The hazardous wastes could seep through permeable dikes both horizontally and vertically, enter the area groundwater and surface waters and cause contamination, or the hazardous wastes could migrate/seep laterally through the base of dike and enter the environment.

The surface water pollution problems are usually the result of breaks in the dikes or overtopping, with subsequent spill over of hazardous wastes to the surface waters, resulting in contamination, fish kills, and degradation of the stream. The seepage of hazardous wastes through the impoundment dike into the groundwater can also cause public health and environmental problems. As indicated elsewhere, the groundwater has little assimilation capacity compared to the surface water. It is therefore imperative to assure that all surface impoundment dikes are designed and constructed in a manner that will preclude seepage of wastes from the facility into the groundwater.

The guidelines for "pond and lagoon" construction in Texas and Oklahoma recommend construction of secondary or back-up dikes (if necessary due to poorly engineered or unstable/inadequate primary dikes), capable of retaining 1.25 times the volume retained above the ground level within the primary dike, for all "pond/lagoons" retaining wastes above the ground level; or methods other than back-up dikes may be utilized to prevent waste escape into the area water. The proposed EPA regulations do not specifically require construction of secondary or back-up dikes for new surface impoundments, under the presumption that the properly designed and constructed primary dikes alone would be capable to prevent waste escape from the facility. However, for existing facilities, the construction of impermeable secondary (back-up) dikes could be a good alternative for solving a pollution problem resulting from poorly engineered, unstable, or inadequate primary dikes.

Standard: (9) All earthen dikes at the facility shall be constructed of clay-rich soil with a permeability less than or equal to $1X10^{-7}$ cm/sec.

Rationale: The conceptual objectives and rationale for this regulation are similar to those given for regulation (c)(8) of this section; i.e., to prevent seepage of hazardous wastes through impoundment dike and enter the environment. If the impoundment dikes are constructed from permeable soils, contained hazardous fluids would penerate through them and enter into the area groundwater or surface water.

To achieve the above objective, it is recommended that all earthen dikes are constructed of a clay-rich soil with permeability less than or equal $1X10^{-7}$ cm/sec. The permeability criterial for dike construction are similar to those specified under (c)(2) and (c)(4).

It is believed that the above permeability will provide adequate protection against the hazardous waste seepage through dikes, both horizontally and vertically. The precedent set by the State of Texas established the fact that this procedure is a recognized good practice. A portion of Texas' construction criteria for ponds and lagoons requires earthen dikes to be constructed of a clay-rich soil with permeability less than or equal to $1X10^{-7}$ cm/sec, where compacted to 95% standard proctor at optimum moisture content.

Standard:(10) All earthen dikes shall have an outside protective cover (e.g., grass, shale, rock) to minimize erosion by wind and water.

Rationale: The structural stability of the dike must be maintained for an environmentally sound operation of the surface impoundment. In order to minimize the erosion of earthen dikes by wind and water and subsequent deterioration of their structural stability, it is recommended that all earthen dikes should be stabilized by a protective cover.

The potential consequences of failure to provide adequate protection against erosion by wind and water is deterioration of structural stability, causing breaching of the dike and subsequent release of hazardous wastes to the environment.

Surface impoundment dikes are usually constructed with side slopes between six horizontal to one vertical and two horizontal to one vertical. The final slope selected will depend on the dike material and water-erosion protection to be provided. All soils, regardless of slope, will require some type of protection in zones subject to turbulence and agitation. Such zones can be created by wind-induced wave action, inlet and outlet increased hydraulic activity and aerator agitation. Examples of turbulent zones are areas around the discharge areas at recirculation pumping station and areas around the influent and effluent connections.

If the wind is always in one direction, wave-action erosion protection usually can be limited to those areas that receive full force of the wind-driven waves. Protection should always extend from at least one foot below the minimum surface to at least one foot above the maximum water surface. Protection against hydraulic turbulence should extend several feet beyond the area subject to such turbulence.

Erosion protection can be provided by cobble stones, broken or cast-in-place concrete, wooden bulkheads, asphalt strips, etc. Whatever is used should recognize the need to control shoreline and aquatic growth. The steeper the side slope, the less area there is for such protective coverings and aquatic or shoreline growth. Large ponds in windy areas require heavier erosion protection.

Exterior slopes of the dike are also subject to erosion by wind and rain and require stabilization by a protective cover (e.g., grass, rocks, etc.).

The precendents set by the State of Texas, and indicated elsewhere[14,15], establish the fact that requirement of protective cover for soil dikes is a recognized good practice, as quoted: "Stabilization and Maintenance -- In order to minimize the erosion of earthen dikes by wind and water, it is suggested that where practical all earthen dikes be stabilized by establishing a protective cover such as, but not limited to, grass, shell, rock, etc., over the top and sides of the exposed portions of the dikes."

Standard: (11) Those surface impoundments which are intended to be closed without removing the hazardous waste shall meet the landfill requirements under Section 250.45-2.

Rationale: In accordance with applicable closure standards under (e) of this section, there are two acceptable approaches to a close-out of surface impoundments.

The first approach requires removal of hazardous wastes and/or hazardous waste residuals and liners from the surface impoundment, with subsequent disposal, as requried in Subparts B, C, and D.

The second approach is to close surface impoundment without removal of hazardous wastes, and/or hazardous residuals, and/or liners from the impoundment.

In the later case, the surface impoundment becomes a hazardous waste landfill, and, therefore, a subject to the landfill regulations, under 250.45-2.

The objective of the above regulation, is to assure, that those surface impoundments which are intended to be closed without removal of hazardous wastes, and/or hazardous residuals, are located, designed and constructed in a manner which will satisfy both, the surface impoundment regulations and landfill regulations under 250.42-2.

(d) Operation and Maintenance

Standard: (1) A surface impoundment shall be operated and maintained so that discharges or releases to groundwater and navigable water do not occur.

Rationale: The primary objective and rationale for the above regulation is to assure that all hazardous waste surface impoundments are operated and maintained in such a manner as to preclude any human health and environmental problems.

Regardless of the type of surface impoundment constructed, it must be operated in such a manner as to serve its intended purpose without posing any water pollution or air pollution threat. Maintaining proper freeboard, accepting only those wastes which are compatible with and not detrimental to the impoundment lining, taking care not to rupture liner, keeping records of the contents of each impoundment at all times to prevent unregulated mixing of incompatible wastes, are just a few things that the operator must be constantly concerned with to assure an environmentally sound operation at all times.

Routine maintenance of all facilities at the surface impoundment site, such as roads, ditches, fences, freeboard markers, etc. and especially dikes, is essential to maintain a clean, orderly, safe and environmentally acceptable operation. All needed maintenance or corrective action necessary to restore the dike or liners to their original condition should be accomplished expeditiously due to the possibility of more serious consequences.

The failure to operate and maintain hazardous waste surface impoundments properly can result in various environmental problems. For example, failure to provide sufficient freeboard could result in waste overflowing from the impoundment with subsequent movement into the surface waters, or infiltration into the groundwater if surrounding soil is permeable. Wastes that are incompatible with liner materials could cause their deterioration, dissolution or otherwise increase their permeability, and can result in unregulated discharges into the groundwater. The rupture of the liner could cause hazardous waste migration/seepage into the groundwater. The failure to maintain dikes can cause their deterioration and result in breaching with subsequent movement of hazardous wastes into the environment.

Standard: (2) The freeboard maintained in a surface impoundment shall be capable of containing rainfall from a 24-hour, 25-year storm but shall be not less than 60 centimeters (2 feet).

Rationale: The objective of the above regulation is to prevent spillover of hazardous waste from the impoundment with the subsequent possibility of ground or surface water contamination.

The failure to provide sufficient freeboard could cause hazardous wastes to overflow or be washed over the dike by wave-action or hydraulic turbulence, and consequently migrate into the area waters. The overflows are one of the primary sources of surface water pollution problems relative to hazardous waste impoundments. If surrounding soils are premeable, hazardous wastes washed over the dike could also infiltrate into the groundwater.

Because of the higher degree of mobility, liquid wastes present a somewhat greater environmental hazard than do solids or viscous high solid content sludges. Greater care, therefore, must be exercised when handling the liquid wastes, since the possibility of wave action being generated by strong winds and/or hydraulic turbulence is more probable in such facilities, and hazardous spills involving liquids would more rapidly enter the environment.

The States of Texas and Pennsylvania require a minimum of two feet of freeboard for all hazardous waste "ponds and lagoons;" Oklahoma specifies three feet of freeboard. The 3-foot requirement could provide additional safety, but in addition to increasing cost of construction, it could also adversely affect mechanical stability of the dike.

The most critical factor in establishing freeboard requirements is the amount of the rainfall in the subject area. The freeboard requirements in arrid areas may be less strict because the possibility of impoundment overflowing as a result of the rain storm or prolonged rainfall is negligible.

The proposed regulation requires freeboard to be adequate either to contain rainfall from a 24-hour 25-year storm or to be at least two feet (60 cm), the former figure being in correspondence with 250,43(c) of Section 3004 of the RCRA, applicable to all hazardous waste facilities. Although the more conservative value (2 feet) was chosen for minimum freeboard requirement, when used with the above rainstorm protection figure, and other requirements in this section (i.e., erosion control, dike inspection and maintenance etc.), it should provide adequate protection against associated environmental problems.

Standard: (3) Records shall be kept of the contents and location of each surface impoundment. These records shall be maintained as specified in Section 250.43-5(b).

Rationale: The objective of the above regulation is to prevent unregulated mixing of noncompatible wastes and to prevent all subsequent health hazard and environmental problems. The maintenance of such records should preclude accidental mixing of noncompatible wastes in hazardous waste ponds and lagoons. Additionally, in the event ground water or surface water contamination is detected, such records will assist in identifying the source of contamination.

Mixing of hazardous wastes that are not compatible with each other in hazardous waste surface impoundments, if performed under uncontrolled conditions, can create human health and environmental hazards resulting from violent reactions, excessive heat or pressure generation, potential fires and explosions and subsequent dispersion of hazardous components into the air, or formation of hazardous gaseous fumes and their transmission into the air. In addition, such reactions, or products of such reactions could adversely affect the impermeability of the liner or dike and result in unregulated discharges into the groundwater or surface waters.

The precedents set by the State of Texas and Oklahoma established the fact that this procedure is a recognized good practice. Both the Texas and Oklahoma specifications for hazardous waste "ponds and lagoons" require maintenance of records on the quantity and quality of the waste treated or disposed of in the pond/lagoon.

Standard: (4) The integrity of the natural in-place soil barrier or the liner system installed in a surface impoundment shall be maintained until closure of the impoundment. The liner system or natural in-place soil barrier shall be repaired immediately upon detection of any failure (e.g., liner puncture).

Rationale: The purpose of liners or natural in-place soil barriers in hazardous waste surface impoundments is to assure containment of hazardous wastes and prevent their seepage into the area groundwaters. The potential consequence of not maintaining the integrity of liners is the failure to contain hazardous wastes, and subsequent seepage into the groundwaters. The objective of the above regulation is that such disruption does not occur.

The integrity of the installed liners could be endangered by the following:

* hazardous waste/liner incompatibility,
* improper installation,
* any matter in hazardous waste (sharp objects, etc.) with potential to rupture, puncture or lacerate liners,

* use of machinery or equipment,
* adverse weather conditions (subsequent freezing and thawing),
* attack from ozone, ultraviolet rays, soil bacteria and fungus.

Any detected failure of the natural in-place soil barrier, or liner failure should be corrected immediately, to prevent contamination of usable aquifers by hazardous waste. If a specific chemical, element, or compound known to be present in the surface impoundment is detected by a monitoring system, the impoundment should cease the operation immediately, and the problem should be either immediately corrected, or the facility closed following the requirements under (e) of this section. If the failure of a liner system remains undetected, or is not corrected promptly, hazardous waste could migrate from the surface impoundment and contaminate the underlying aquifer.

Standard: (5) Surface impoundment dikes shall be visually inspected daily, as specified under Section 250.43-6, for the purpose of detecting and correcting any deterioration. Any maintenance or corrective action necessary to restore the dike to its original condition shall be accomplished expeditiously.

Rationale: The primary objective of the above regulation is to minimize the possibility of the impoundment dike failure through routine visual inspection, proper maintenance of dikes, and prompt corrective measures upon detection of any dike failure.

The primary function of any surface impoundment dike is the containment of a finite volume of pumpable liquids and sludges within the impoundment area and to serve as a barrier between the contained wastes and the environment. To serve its intended purpose, the dike should be impermeable and structurally stable to prevent hazardous waste seepage or relaease into the environment.

The structural integrity and impermeability of dikes can be adversely affected by improper operation or erosion. As a result, a portion of the dike could be washed away, develop cracks, or break, thus allowing hazardous waste to be released into the environment. The breaching of dikes is known to be one of the primary sources of surface water pollution problems, relative to hazardous waste surface impoundments. Furthermore, if the surrounding soils are highly permeable, hazardous wastes released from the impoundment could also infiltrate into the area groundwater.

Therefore any maintenance or corrective action necessary to restore the dike to its original condition should be accomplished expeditiously to avoid more serious consequences (i.e., groundwater and surface water contamination).

Standard: (6) Any system provided for detecting the failure of a liner system or natural in-place soil barrier shall be visually inspected daily, as specified in Section 250.43-6, to insure that it is operating properly for the purpose intended.

Rationale: The objective of the above regulation is to minimize the possibility of failure of the leachate detection system through routine inspection.

All liners are prone to failure due to their incompatibility with contained wastes, mechanical rupture, prolonged usage exceeding projected life of the liner, etc. The reactions between the liner and hazardous wastes could result in dissolution of the liner or increase its permeability. If the liner failure is not detected, hazardous wastes can escape from the surface impoundment and migrate/seep into the groundwater, or eventually, to the surface water.

The primary function of leachate detection system is to detect any such failures. The proper operation of such a system is, therefore, essential for environmentally sound operation of the impoundment. Because any leachate detection system is prone to mechanical failure after prolonged use, the requirement for routine inspection is fully warranted.

(e) Closure and Post-Closure

Standard: (1) Upon final close-out, all hazardous waste and hazardous waste residuals shall be removed from the surface impoundment, if the impoundment does not meet the landfill requirements under Section 250.45-2, and disposed of as hazardous waste pursuant to the requirements of this Part.

Rationale: The proper close-out of surface impoundments is essential for protection of human health and the environment. The hazardous wastes and/or hazardous residuals remaining in the impoundment after facility closure may become a source of environmental problems due to failure of hazardous waste containment, and subsequent leaks of hazardous components into the environment in those facilities which were not designed to contain wastes for an extended period of time.

By their nature, surface impoundments, with exception of disposal ponds/lagoons, are temporary structions, designed for variable lengths of the service life; the environmental soundness of each impoundment depending directly on the materials used for construction, i.e., compatibility with the hazardous wastes to be contained; durability upon prolonged contact with the hazardous waste of interest; and alteration of permeability with time. Since the above characteristics may vary with each construction and each material/waste situation, EPA regulations for surface impoundments require construction materials to be compatible with wastes of interest, and that the durability and permeability of such materials remains unchanged during the expected service life of the facility.

However, the long-term effect of the majority of hazardous wastes on artificial membranes, is not known at the present. This information is critical, especially if the wastes are to remain in the impoundment after its closure for the unspecified length of the time. The hazardous wastes after prolonged contact could have a detrimental effect on liner durability and permeability. Therefore, the continuous contact of hazardous waste with liners after their predicted life time, as may be the case after the facility closure, would considerably increase the potential for liner failure and subsequent groundwater contamination.

Based on the above facts, the EPA regulation requires removal of all hazardous wastes and hazardous waste residuals from those surface impoundments which do not meet the criteria for landfills under 250.42-2, e.i. those, which are not designed and constructed to contain hazardous wastes for an extended-unspecified period of the time.

Therefore, the continuous contact of hazardous waste with liners after their predicted life time, as may be the case after the facility closure, would considerably increase the potential for liner failure and subsequent groundwater contamination.

Based on the above facts, the EPA regulation requires removal of all hazardous wastes and hazardous waste residuals from those surface impoundments which do not meet the criteria for landfills under 250.42-2, e.i. those, which are not designed and constructed to contain hazardous wastes for an extended-unspecified period of the time.

Standard: (2) Upon final close-out of a surface impoundment which meets the criteria for landfills under Section 250.42-2, all hazardous waste and hazardous waste residuals shall be:

(i) Removed and disposed as hazardous waste pursuant to the requirements of this Part, or

(ii) Treated in the impoundment pursuant to the note following Section 250.45-2(b) (6)(iv), and then the impoundment shall be closed according to the closure requirements for landfills under Section 250.45-2(c).

Rationale: The proper closure of surface impoundments is essential for protection of public health and the environment. The hazardous waste and/or hazardous waste residuals remaining in the impoundment after the closure may become a source of environmental problems, if facility fails to contain remaining hazardous wastes. Therefore, those surface impoundments, which were not designed to contain wastes for an extended period of time, (e.i. after facility closure), may become source of groundwater and surface water contamination.

The objective of the above regulation is to prevent environmental problems resulting from the improper closing procedures, by allowing retention of hazardous wastes and hazardous waste residuals only in those impoundments which were designed and constructed to contain hazardous components permanently - e.i. those which in addition to the surface impoundments criteria meet also the criteria for landfills under 250.42-2.

For those impoundments which meet the criteria for landfill, EPA regulatory approach permits two basic closing procedures:

(i) Removal of hazardous wastes/hazardous residuals and disposal in accordance with all applicable requirements of this Part, or

(ii) Treatment of hazardous waste/hazardous residuals remaining in the impoundment in accordance with the landfill criteria under 250.45-2(b)(6)(iv), and closure of the impoundment in accordance with landfill closure requirements under 250.45-2(c). After the closure, facility becomes also subject to all post-closure requirement specified for landfills under 250.45-2(d).

The primary rationale for this approach is to provide maximum protection for human health and the environment and in the same time provide needed flexibility in respect to the closing procedures.

The rationale for closure and post-closure requirements for surface impoundments closed in accordance to (ii) of this standard are given in a separate background document - No. 17 - Landfills.

Standard: (3) Emptied surface impoundments shall be filled with an inert fill material and seeded with a suitable grass or ground cover crop, or converted to some other acceptable use that meets the requirement under Section 250.43-7.

Rationale: The objective of the above regulation is to assure, that the surface impoundments, after the removal of hazardous wastes/hazardous residuals are closed in environmentally acceptable manner, and in the same time converted to some acceptable use. The regulation is preventing the abandonment of the emptied site or sloppy closure. By specifying inert fill materials, the regulation is preventing conversion of the site to an open dump or unsecured land disposal facility.

The primary rationale for this approach is to provide maximum protection for public health and the environment and in the same time provide needed flexibility in respect to the closing procedure.

Standard: (4) Those surface impoundments which were closed as landfills shall meet all post-closure requirements for landfills under Section 250.45-2(d).

Rationale: The objective of the above regulation is to assure, that those surface impoundments which were closed as landfills, e.i. without removal of hazardous wastes and hazardous waste residuals, meet all post-closure requirements specified for landfills under Section 250.45-2(d).

The rationale for post-closure requirements for landfills is given under separate background document (see No. 18 - Landfills).

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RD-28

BD-28

Resource Conservation and Recovery Act

Subtitle C - Hazardous Waste Management

Section 3004 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

DRAFT

BACKGROUND DOCUMENT

Section 250.45-4 Standards for Basins

U.S. Environmental Protection Agency

Office of Solid Waste

December 15, 1978

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being issued as a draft to support the proposed regulation. As new information is obtained, changes may be made in the regulations as well as in this background material.

This document was first drafted many months ago and has been revised to reflect information recieved and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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I. Introduction

A. RCRA Mandate and/or Authority for the Regulation

Section 3004 of the Resource Conservation and Recovery Act of 1976 (RCRA) mandates that the EPA Administrator promulgate~~s~~ regulations establishing standards applicable to owners and operators of facilities for the treatment, storage, and disposal of hazardous waste~~s~~, as may be necessary to protect human health and the environment. Among other things, these standards are to include requirements respecting:

1. the treatment, storage or disposal of all such waste received by the facility pursuant to such operating methods, techniques, and practices as may be satisfactory to the Administrator, and

2. the location, design, construction, operation and maintenance of such hazardous waste treatment, storage, or disposal facilities.

B. Definition of the Area Being Regulated and Other Key Words Used in Background Document

For the purpose of this regulation "basin" means any uncovered device constructed of artificial materials, used to retain waste as part of a treatment process, usually with a capacity of less than 100,000 gallons. Examples of basins include open mixing tanks, clarifiers, and open settling tanks.

The other pertinent definitions -- key words used in background document are as follows:

(1) "Administrator" - See Sec. 1004(1)

(2) "Aquifer" means a geologic formation, group of formations, or part of a formation that is capable of yielding useable quantities of groundwater to wells or springs.

(3) "Close Out" means the point in time at which facility owners/operators discontinue operation by ceasing to accept hazardous waste for treatment, storage, or disposal.

(4) "Closed Portion" means that portion of a facility which has been closed in accordance with the facility closure plan and all applicable closure requirements in this Subpart.

(5) "Closure" means the act of securing a facility pursuant to the requirements of Section 250.43-7.

(6) "Closure Procedures" means the measures which must be taken to effect closure in accordance with the requirements of Section 250.43-7 by a facility owner/operator who no longer accepts hazardous waste for treatment, storage, or disposal.

(7) "Contamination" means the degradation of natrally occurring water, air, or soil quality either directly or indirectly as a result of man's activities.

(8) "Disposal Facility" means any facility which disposes of hazardous waste.

(9) "Endangerment" means the introduction of a substance into groundwater so as to:

(i) cause the maximum allowable contaminant levels established in the National Primary Drinking Water standards in effect as of the date of promulgation of this Subpart to be exceeded in the groundwater; or

(ii) require additional treatment of the groundwater in order not to exceed the maximum contaminant levels established in any promulgated National Primary Drinking Water regulations at the point such water is used for human consumption; or

(iii) Reserved (Note: Upon promulgation of revisions to the Primary Drinking Water Standards and National Secondary Drinking Water Standards under the Safe Drinking Water Act and/or standards for other specific pollutants as may be appropriate).

(10) "EPA" means the U.S. Environmental Protection Agency.

(11) "EPA Region" means the States and other jurisdictions in the ten EPA Regions as follows:

Region I - Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island.

Region II - New York, New Jersey, Commonwealth of Puerto Rico, and the U.S. Virgin Islands.

Region III - Pennsylvania, Delaware, Maryland, West Virginia, Virginia, and the District of Columbia.

Region IV - Kentucky, Tennessee, North Carolina, Mississippi, Alabama, Georgia, South Carolina, and Florida.

Region V - Minnesota, Wisconsin, Illinois, Michigan, Indiana, and Ohio.

Region VI - New Mexico, Oklahoma, Arkansas, Louisiana, and Texas.

Region VII - Nebraska, Kansas, Missouri, and Iowa.

Region VIII - Montana, Wyoming, North Dakota, South Dakota, Utah, and Colorado.

Region IX - California, Nevada, Arizona, Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Region X - Washington, Oregon, Idaho, and Alaska.

(12) "Facility" means any land and appurtenances, thereon and thereto, used for the treatment, storage, and/or disposal of hazardous waste.

(13) "Freeboard" means the vertical distance between the average maximum level of the surface of waste in a surface impoundment, basin, open tank, or other containment and the top of the dike or sides of an impoundment, basin, open tank, or other containment.

(14) "Fugitive Emissions" means air contaminant emissions which are not planned and emanate from sources other than stacks, ducts, or vents or from non-point emission sources.

(15) "Groundwater" means water in the saturated zone beneath the land surface.

(16) "Hazardous Waste" has the meaning given in Section 1004(5) of the Act as further defined and identified in Subpart A.

(17) "Hazardous Waste Facility Personnel" means all persons who work at a hazardous waste treatment, storage, or disposal facility, and whose actions or failure to act may result in damage to human health or the environment.

(18) "Incompatible Waste" means a waste unsuitable for commingling with another waste or material, because the commingling might result in:

(i) Generation of extreme heat or pressure,

(ii) Fire,

(iii) Explosion or violent reaction,

(iv) Formation of substances which are shock sensitive friction-sensitive, or otherwise have the potential of reacting violently,

(v) Formation of toxic (as defined in Subpart A) dusts, mists, fumes, gases, or other chemicals, and

(vi) Volatilization of ignitable or toxic chemicals due to heat generation, in such a manner that the likelihood of contamination of groundwater, or escape of the substances into the environment, is increased, or

(vii) Any other reactions which might result in not meeting the Air Human Health and Environmental Standard. (See Appendix I for more details.)

(19) "Leachate" means the liquid that has percolated through or drained from hazardous waste or other man emplaced materials and contains soluble, partially soluble, or miscible components removed from such waste.

(20) "Leachate Monitoring System" means a system beneath a facility used to monitor water quality in the unsaturated zone (zone of aeration) as necessary to detect leaks from landfills and surface impoundments. (For example, a pressure-vacuum lysimeter may be used to monitor water quality in the zone of aeration.)

(21) "Liner" means a layer of emplaced material beneath a surface impoundment or landfill which serves to restrict the escape of waste or its constituents from the impoundment or landfill.

(22) "Monitoring" means all procedures used to systematically inspect and collect data on operational parameters of the facility or on the quality of the air, groundwater, surface water, or soils.

(23) "Monitoring Well" means a well used to obtain water samples for water quality analysis or to measure groundwater levels.

(24) "Navigable Waters" means "waters of the United States, including the territorial seas." This term includes, but is not limited to:

(i) All waters which are presently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide, intermittent and adjacent wetlands. "Wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, prarie potholes, wet meadows, prarie river overflows, mudflats, and natural ponds.

(ii) Tributaries of navigable waters of the United States, including adjacent wetlands;

(iii) Interstate waters, including wetlands; and

(iv) All other waters of the United States, such as intrastate lakes, rivers, streams, mudflats, sandflats, and wetlands, the use, degradation or destruction of which would affect or could affect interstate commerce, including, but not limited to:

(A) Intrastate lakes, rivers, streams and wetlands which are or could be used by interstate travelers for recreational or other purposes:

(B) Intrastate lakes, rivers, streams, and wetlands from which fish or shellfish are or could be taken and sold in interstate commerce; and

(C) Intrastate lakes, rivers, streams, and wetlands which are used or could be used for industrial purposes by industries in interstate commerce.

(v) All impoundments of waters of the United States otherwise defined as navigable waters under this paragraph.

(25) "Non-Point Source" means a source from which pollutants emanate in an unconfined and unchannelled manner, including, but not limited to the following:

(i) For non-point sources of water effluent, this includes those sources which are not controllable through permits issued pursuant to Sections 301 and 402 of the Clean Water Act. Non-point source water pollutants are not tracable to a discrete identifiable origin, but result from natural processes, such as nonchannelled run-off, precipitation, drainage, or seepage.

(ii) For non-point sources of air contaminant emissions, this normally includes any landfills, landfarms, surface impoundments, and basins.

(26) "Owner/Operator" means the person who owns the land on which a facility is located and/or the person who is responsible for the overall operation of the facility

(27) "Partial Closure Procedures" means the measures which must be taken by facility owners/operators who no longer accept hazardous waste for treatment, storage, or disposal on a specific portion of the site.

(28) "Permitted hazardous waste management facility (or permitted facility)" means a hazardous waste treatment, storage, or disposal facility that has received an EPA permit in accordance with the requirements of subpart E or a permit from a State authorized in accordance with Subpart F.

(29) "Reactive Hazardous Waste" means hazardous waste defined by Section 250.13(c)(1) of Subpart A.

(30) "Regional Administrator" means the Regional Administrator for the Environmental Protection Agency Region in which the facility concerned is located, or his designee.

(31) "Run-off" means that portion of precipitation that drains over land as surface flow.

(32) "Saturated Zone (Zone of Saturation)" means that part of the earth's crust in which all voids are filled with water.

(33) "Spill" means any unplanned discharge or release of hazardous waste onto or into the land, air or water.

(34) "Soil Barrier" means a layer of soil of a minimum of 1.5 meters (5 feet) in thickness with a permeability of 1 x 10^{-7} cm/sec or less which is used in construction of a landfill or a surface impoundment.

(35) "Sole Source Aquifers" means those aquifers designated pursuant to Section 1424(e) of the Safe Drinking Water Act of 1974 (P.L. 93-523) which solely or principally supply drinking water to a large percentage of a populated area.

(36) "Storage Facility" means any facility which stores hazardous waste, except for generators who store their own waste on-site for less than 90 days for subsequent transport off-site, in accordance with regulations in Subpart B.

(37) "Surface Impoundment" means a natural topographic depression, artificial excavation, or dike arrangement with the following characteristics: (i) it is used primarily for holding, treatment, or disposal of waste; (ii) it may be constructed above, below, or partially in the ground or in navigable waters (e.g., wetlands); and (iii) it may or may not have a premeable bottom and/or sides. Examples include holding ponds and aeration ponds.

(38) "Treatment Facility" means any facility which treats hazardous waste.

(39) "True Vapor Pressure" means the pressure exerted when a solid and/or liquid is in equilibrium with its own vapor. The vapor pressure is a function of the substance and of the temperature.

(40) "24-hour, 25-~~hour~~ year Storm" means a storm of 24-hour duration with a probable recurrence interval of once in twenty-five years as defined by the National Weather Service in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States", May 1961, and subsequent amendments, or equivalent regional or State rainfall probability information developed therefrom.

(41) "Unsaturated Zone (Zone of Aeration)" means the zone between the land surface and the nearest saturated zone, in which the interstices are occupied partially by air.

(42) "United States" means the 50 States, District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Marinana Islands.

(43) "Underground Drinking Water Source" (UDWS) means:

(i) an aquifer supplying drinking water for human consumption, or

(ii) an aquifer in which the groundwater contains less than 10,000 mg/l total dissolved solids; or

(iii) an aquifer designated as such by the Administrator or a State.

(44) "Underground Non-Drinking Water Source" means an underground aquifer which is not a UDWS.

(45) "Volatile Waste" means waste with a true vapor pressure of greater than 78 mm Hg at 25°C.

(46) "Water Table" means the upper surface of the zone of saturation in groundwaters in which the hydrostatic pressure is equal to atmospheric pressure.

II. Rationale for the Regulation

A. Actual Damage Incidents

There are no known damage incidents associated with ~~the~~ basins in EPA files. However, there are several damage cases involving surface impoundments which are closely related to basins.

B. Potential Damage Resulting from the Absence of Regulation

The environmental media potentially endangered by the hazardous waste basins are: ~~the~~ surface water, groundwater, and the air.

Surface Water

Surface water pollution problems relative to basins are the potential for overflow, spills, or cracking, breaking, or other damage of the basin walls with subsequent movement of hazardous waste to surface water, resulting in gross contamination, fish kills, and degradation of the receiving water. Because surface water is an important source of drinking water, and an agricultural and industrial water supply, contamination of the surface water will have a direct impact on the public health and the environment.

Groundwater

The migration/seepage of hazardous waste from a basin to the groundwater due to overflow, spills, or cracking, breaking or other damage to the basin structure, could cause severe human health and environmental problems. Because ~~the~~ groundwater will have a direct impact on the public health, and the environment.

Groundwater normally has little assimilation capacity compared to surface waters. The rate of movement of groundwater is extremely slow, relative to surface waters. Unlike streams, which can recover from polluted conditions in a few years, groundwater does not experience the flushing action of stream flow, nor does it experience purifying effects of air, light, or aerobic biological activity. Instead, it flows very slowly, receives ~~less~~ dilution, has essentially no oxygen to degrade pollutants under aerobic conditions, and flows through a medium wher surface tension tends to hold pollutants in a "plume" instead of dispersing them. Since the potential for ~~the~~ groundwater to recover from polluted conditions is very low, a high degree of groundwater protection should be provided in these regulations.

Air

Treatment of hazardous waste that is highly reactive, ignitable, incompatible, or volatile in basins may generate hazardous emissions into the air and endanger public health and the environment. Wastes may react violently with water and air, or may react with each other, causing fires, explosions, and/or formation of toxic gaseous components and their release into the air.

III. Identification of Regulatory Options

A. Specific Standards Mandated by RCRA

Subpart D establishes performance standards applicable to operators and owners of facilities that treat, store, or dispose of hazardous waste identified or listed under Subpart A and/or designated as hazardous waste by the generator of the waste pursuant to Subpart B.

In accordance with EPA regulatory strategy, Subpart D includes two types of performance standards: Health and Environmental Standards (under Section 250.42), and design and operating standards (Sections 250.43 through 250.45). The design and operation standards, which cover general facilities standards, storage standards, and treatment and disposal standards, are designed to protect public health and the environment and, therefore, to achieve compliance with the Health and Environmental Standards under most situations. The Health and Environmental Standards supercede the design and operating standards in certain circumstances.

Under this regulatory structure, it is intended that the design and operating standards will be the principal regulatory criteria used to manage the treatment, storage and disposal of hazardous wastes. Where there is a reason to believe that the design and operating standards will not achieve compliance with the Health and Environmental Standards, it is intended that the latter will be used as the basis for regulatory action.

Following the foregoing rationale, the design and operating standards are designed to provide protection of public health and the environment for most situations.

In achieving this purpose, however, these standards may, in some instances, unnecessarily overregulate some situations. Additionally, being based on the current state-of-the-art of treatment, storage, and disposal practices, the standards may preclude technological innovation and advancement of the state-of-the-art. In recognition of this feature, some of the design and operating standards include <u>Notes</u>, which prescribe the criteria for deviation from such standards. In all cases, the basis for deviation is achievement of equivalent containment or destruction of the hazardous waste. It is believed that the above approach will prevent overregulation without sacrificing public health and environmental protection, and will allow application of new technology which would not otherwise be permitted by the specificity of the design and operating standards.

In accordance with the definition, "basin" means any uncovered device constructed of artificial materials, used to retain waste as part of a treatment process, usually with a capacity of less than 100,000 gallons.

Based on the definition, basins are always only hazardous waste structures temporarily used for treatment and/or containment of hazardous wastes, and are never used for permanent disposal or long term storage.

Basins are usually engineered structures, with sides and bottom constructed from artificial materials (e.g., concrete, steel, synthetic materials, etc.) serving as primary barriers to movement of waste from such structures. Basins can be either lined or unlined. However, liners serve only as a protection against corrosion of construction materials or waste incompatibility with such materials.

Because of the small size and method of construction, most corrosion problems, cracks, or other damage that can cause hazardous waste migration/seepage from the basin could be detected through visual inspection.

Based on the above, hazardous waste basins should be subject to all Human Health and Environmental Standards and General Facility Standards, and to the standards applicable to treatment facilities, but should not be subject to the standards applicable to storage and disposal facilities.

B. Existing Federal, State or Local Regulations That Could Be Adopted

Review of existing Federal, State, or local regulations revealed an absence of existing regulations that can be used as a precedent for regulation of hazardous waste basins. However, because of their similarity with surface impoundments, in respect to the environmental impact on groundwater, surface water, and air, some aspects of the "surface impoundments" standards are applicable to "basins".

IV. Analysis of Regulatory Options

The environmental media most endangered by basins are: groundwater, surface water, and the air. Regulatory options for protecting each of these media from pollutants from basins are discussed below.

Section 3004 requires that EPA develop facility performance standards as necessary to protect human health and the environment .however, it does not specify the nature of those standards. Therefore, EPA was faced with a dilemma inherent in the standard-setting process. On the one hand, standards may be drafted calling for a certain level of environmental quality which is known to be protective. This type of standard (e.g., ambient air quality, water quality, etc.) is difficult for government to enforce and difficult to determine which actions cause a particular level of degradation in environmental quality. Additionally, it is difficult to prescribe "safe levels" of thousands of toxic substances that might be found in hazardous waste.

On the other hand, performance (technology-based) standards may be drafted to prescribe limits on waste management activities aimed at preventing human health and environmental damage. The problem with such perscriptive restrictions on waste management action is that such standards tend to freeze the development of technology at the level of the standard. There is little incentive to develop new and better techniques to achieve a particular environmental goal if the use of particular techniques are required by EPA regulations.

A third method of standard setting to achieve environmental protection is to directly regulate the amount of pollutant which is allowed to be released into the environment from a given source (e.g., effluent limitations, new source performance standards). This has the advantage of encouraging the development of new technology to meet those standards, while providing environmental protection that is more enforceable than standards based on environmental quality. Unfortunately, this regulatory approach is far more applicable to discrete sources of pollution (smokestack or outfall pipe) than it is to the overall land and groundwater degradation relative to improper hazardous waste management, with respect to basins.

In view of the drawbacks to each of these types of standards, EPA proposed an innovative combination of these types of standards. This approach is intended to accomplish the high degree of protection of public health and the environment provided for by the Act, provide sufficient guidance necessary for industry compliance and government enforcement, and encourage technological innovation.

In accordance with the EPA regulatory approach, the human health and environmental protection strategy used in the regulation of basins should require compliance with control technology standards, with respect to:

1. Design and construction
2. Hazardous waste characteristics.
3. Operation and maintenance.
4. Closing procedures.

All these factors, with respect to the human health and environmental protection provided, and analysis of whether each option meets the RCRA mandate are discussed below.

1. Design and Construction

The primary objective of design and construction standards for basins should be to assure that the basins are designed/constructed in a manner that will prevent discharge of hazardous waste into the environment during the life of the facility. The environmental media to be protected are navigable waters and the groundwater. (Because basins are always uncovered structures, the design and construction standards have no impact on discharge into the air.)

In dealing with hazardous wastes, appropriate material of construction is a critical factor for environmentally safe operation of basins. Sufficient strength and thickness to assure mechanical integrity and to prevent seepage, and compatibility with hazardous waste and treatment chemicals to be contained under expected treatment conditions (i.e., temperature, etc.), are the critical factors to be considered. The potential consequence of improper selection of construction materials is of containment, and subsequent leaks of hazardous waste into the groundwater or surface waters in the area.

One method of standard setting to achieve groundwater and surface water protection would be to prescribe materials to be used for basin construction. The problem with this regulatory options is that it would require the listing of all permitted construction materials for each hazardous waste/ treatment situation. Considering the number of possible combinations, it is very difficult to provide such a comprehensive list. In addition, such a regulation would freeze the development of technology at the level of the standard.

Another regulatory approach would be to prescribe a certain level, which is known to be protective, for ground water and surface water quality directly affected by a specific basin. This type of standard would be, however, difficult for government to enforce. Also, it would be difficult to determine which actions cause a particular level of degradation in groundwater and surface water quality. Additionally, it would be difficult to prescribe "safe levels" of contaminants that may be found in hazardous waste contained in basins.

A third method of standard setting would be, to directly regulate the amount of pollutant allowed to be released into the groundwater and surface water from a given basin. This type of standard would be, however, difficult for government to enforce, since the majority of hazardous waste discharges from basins are the result of uncontrolled conditions or accidents (e.g., seepage due to cracking, corrosion, or dissolution, increased permeability, spillage, etc.).

In view of the drawback of each regulatory approach, the combination of all three approaches seems to be most reasonable. This method of standard setting would require basins to be constructed of impermeable materials of sufficient strength and thickness to insure mechanical integrity and to prevent the discharge of wastes to surface waters or groundwater. It should also be required that the materials used for construction of basins are compatible with the hazardous waste and treatment chemicals used under expected operating conditions (i.e., temperature, etc.), or are protected by a liner compatible with such waste or treatment chemicals and/or treatment conditions.

In addition, it should be required that all hazardous wastes are tested prior to disposition in a basin to determine whether they will have any detrimental effect (e.g., cause dissolution, corrosion, increase permeability, decrease mechanical strength) on materials used for construction of such basins.

This approach would accomplish the high degree of protection of public health and the environment provided for by the Act, provide sufficient guidance for industry compliance and government enforcement, and at the same time, encourage technological innovation.

2. Hazardous Waste Characteristics

The primary objective of regulation with respect to the hazardous waste characteristics is to prevent public health and environmental problems related to the retention of hazardous wastes in basins. The environmental media to be protected are: the surface water, groundwater, and the air.

The incompatibility of hazardous wastes and treatment chemicals or reagents with materials used for construction could potentially disrupt the structural integrity of a facility, allowing the escape of hazardous components into the groundwater and surface waters. The main objective of the regulation should be that such disruption does not occur.

Treatment of hazardous wastes that are highly reactive, ignitable, volatile, or incompatible with each other in basins may generate hazardous waste emissions into the air and endanger public health and the environment. The main objective of the regulation should be to prevent such environmental problems.

One method of standard setting, to achieve groundwater, surface water and air protection would be, to provide a list of hazardous wastes and/or hazardous waste combinations which can be retained in basins, based on waste characteristics and compatibility with intended construction materials. The major drawback of this regulatory approach is that EPA presently lacks a supportive data base to prepare such a comprehensive list. Furthermore, such a list would prevent placement of hazardous wastes that are not listed into the basins without changes in the regulations.

Another approach would be to prescribe certain levels, which are know to be protective for groundwater, surface water and air quality directly affected by a specific basin. A third method of standard setting would be to directly regulate the amount of pollutants allowed to be released into the groundwater, surface water, and into the air from a given basin. While both regulatory approaches provide needed public health and environmental protection, they would be difficult for government to enforce.

In view of the drawback of each regulatory approach, the combination of all three approaches seems to be most reasonable. This method of standard setting should require that the basins are not to be used to contain waste, which is:

(a) detrimental to the basins' construction materials;

(b) reactive, as defined in Subpart A;

(c) ignitable, i.e., as defined in Subpart A;

(d) volatile; i.e., those having a vapor pressure greater than 78 mm Hg at 25°C.

The regulation should also require that hazardous wastes which contain incompatible chemical groups shall not be mixed together in basins.

This approach would accomplish the high degree of protection of public health and the environment mandated by the Act, provide sufficient guidance for industry compliance and enforcement, and at the same time encourage technological innovation.

3. Operation and Maintenance

The primary objective of operation and maintenance standards for basins should be to assure that the basins are operated and maintained in a manner that will prevent public health and environmental problems. The envrionmental media to be protected are surface waters and the groundwater. Because basins are always uncovered structures, the operation and maintenance of basins has no impact on the discharges into the air. (The air pollution potential associated with waste characteristics and treatment chemicals, and the regulatory options are discussed under Part 2 of this section.)

The primary purpose of basins (in addition to the intended treatment objectives) is to provide containment of hazardous wastes during the treatment and prevent discharges of hazard ous wastes into the surface or groundwater in the area.

Waste incompability with construction materials and improper operating conditions and maintenance are among the primary contributing factors effecting structural integrity and ipermeability of basins. For example, wastes with corrosive properties would attack construction materials, thus causing corrosion problems. Mechanical abrasion from any matter contained in wastes could cause erosion problems. Certain wastes could cause gradual dissolution of certain construction materials. Improper operation and adverse weather conditions not anticipated in design/construction (frequent freezing and thawing, etc.) could deteriorate structural integrity of construction materials, cause cracking and other damage, which could allow migration or seepage of hazardous wastes from the basin and subsequent environmental problems.

Most of the corrosion and erosion problems, the material cracking and other damages could be detected early through visual inspection, before more serious environmental problems could develop. Since the majority of basins have capacity usually less than 100,000 gal. (380 m^3), their visual inspection would be technically feasible. Groundwater degradation can be detected through groundwater monitoring.

The uncorrected corrosion and erosion problems, cracking or other structural damage of basin construction materials could result in hazardous wastes release or seepage from the basin and subsequent movement to the environment. It is therefore imperative that any damage detected is repaired immediately.

One method of standard setting to achieve groundwater and surface water protection would be to require only visual inspection, regardless of the size of the basin, or the potential of the basin for discharge to the underground drinking water source. While visual inspection may be effective in some instances, it would require emptying basins periodically. Such a practice may be costly, or may interfere with existing continuous treatment processes, if basins are of such an operation.

Another approach would be to require only groundwater monitoring systems. While groundwater monitoring would detect groundwater contamination, it would not provide early detection of problems and/or a ~~varing~~ warning to initiate any measures to correct such problems. Furthermore, groundwater monitoring will not prevent surface water contamination, and may be too costly for small basins.

In view of the drawbacks of each regulatory approach, the combination of both apporaches seems to be most effective means of regulation. This method of standard setting should require that:

- basins are monitored or visually inspected for leaks, corrosion, cracks or other damages, and that any damage detected is repaired immediately.

It should also be required that:

- All basins which have the potential for discharge to underground drinking water sources have groundwater monitoring systems.

- o Basins do not have to have groundwater monitoring systems if the facility owner/operator can demostrate that a leak could be detected by visual inspection or other means.

This approach will accomplish a high degree of public health and environmental protection provided for by the Act. It will also provide sufficient guidance for industry compliance and government enforcement, and at the same time encourage technological innovation.

4. Closing Procedures

The primary objective of "closing" standards for basins should be to assure that basins are closed in a manner that will preclude public health and environmental problems after facility closure. The environmental media to be protected are surface waters and the groundwater.

Any hazardous waste remaining in the basins after facility closure may become a source of groundwater and surface water contamination due to failure of containment and subsequent leaks.

The hazardous waste, after prolonged contact, may have a detrimental effect on the construction material, its durability and impermeability. The continuous contact of hazardous waste with such materials, after their predicted life time, as may be the case after the facility closure, would considerably increase potential for groundwater and surface water contamination.

Therefore, a regulation requiring removal of all hazardous wastes from basins after facility closure is essential for protection of public health and the environment.

The improper handling of hazardous waste, after their removal from basins, can also become a source of environmental problems and should be regulated.

Based on the above, the standard respecting the closure of basins should require that, upon final closure, all hazardous waste and hazardous waste residues are removed from basins and disposed of as required in Subparts B, C, and D.

This approach will accomplish the high degree of protection of public health and the environment mandated by the Act.

V. <u>Identification of Chosen Regulation and Associated Rationale</u>

(a) A basin shall be constructed of impermeable materials of sufficient strength and thickness to ensure mechanical integrity and to prevent the discharge of waste to navigable waters or groundwater.

The primary objective of the above regulation is to assure that all basins containing hazardous waste are constructed in a manner that will assure containment of hazardous waste during treatment operations throughout the projected life of the facility, without posing any threats to human health and the environment. To satisfy the above objectives, all basins containing hazardous wastes should be constructed of materials that have an adequate strength and thickness to withstand the stress to the operation, and in the same time are capable to prevent the seepage of hazardous wastes into the environment.

In dealing with hazardous wastes, appropriate materials of construction are required to provide reasonable service life for equipment and environmentally safe operation. Coated and lined basins may frequently be used to meet material requirements, e.g., carbon steel lined with lead, rubber, glass, plastic, or other corrosion resistant materials. Nature of the hazardous wastes and treatment chemicals, expected length of service, temperature of operation, desired physical strength, liquid flow rate and mechanical abrasion are among the factors to be considered in material selection. Because of the complexity of the problem, only general guidance can be provided.

The potential consequence of improper selection of construction materials is the failure of hazardous waste containment, and subsequent leaks of hazardous components into the groundwater or surface waters, or shortening of the expected service life of the facility.

(b) A basin shall not be used to contain hazardous waste which is:

(1) Detrimental to the basin's construction materials;

(2) Ignitable waste, as defined in Section 250.13(a)

of Subpart A;

(3) Reactive waste, as defined in Section 250.13(c) of Subpart A; or

(4) Volatile waste.

Note: With respect to (b) (2, 3 and 4), see Note associated with Section 250.45(c).

The incompatibility of hazardous wastes and treatment chemicals or reagents with materials used for construction under operating conditions could cause corrosion of facility, allowing the escape of hazardous components into the environment. The main objective of the above regulation is to assure that such disruption does not occur.

Treatment of hazardous wastes that are highly reactive, ignitable, or volatile, in basins may generati hazardous emissions endangering workers or neighbors of a facility, and potentially disrupt the environmental soundness of the operation. Explosions could disrupt the structural integrity of the basin and cause subsequent leaks of hazardous wastes into ~~the area~~ nearby groundwater and surface water. The impermeability of some construction materials or liners could be adversely affected by chemical reactions or fire and result in hazardous leaks into the groundwater and surface water. Reactions and fires could also cause discharges into the air. For example, burning of hazardous organic wastes conaining halogens or heavy metals will result in formation of toxic gaseous components and their transmission into the air. The potential fires and explosions, with subsequent environmental problems, could be also a result of containment of hazardous wastes that is highly reactive with air and water. It is, therefore, imperative that such practices are avoided.

The rationale for selection of vapor pressure greater than 78 mm at 25°C (under (iv)), is given in a separate background document - (3) Air Human Health and Environmental Standard.

(c) Hazardous waste which is incompatible (See Appendix I) shall not be placed together in a basin.

Mixing of hazardous wastes that are not compatible with each other in basins can result in many environmental problems, such as: violent reactions, excessive heat or pressure generation and potential fires and explosions and subsequent dispersion of hazardous components into the air, or formation of hazardous gaseous fumes and their transmission into the air. For example, mixing of cyanide and sulfide containing alkaline wastes with acidic wastes will release toxic HCN and H_2S vapors into the environment; uncontrolled mixing of concentrated acidic and alkaline wastes could result in violent reactions, excessive heat generation, and subsequent environmental problems. Mixing of hazardous wastes containing highly reactive components (e.g., oxidation-reduction agents and organics, etc.) could result in explosions and fires. The major objective of the above regulation is to ensure that such disruptions do not occur.

(d) A hazardous waste shall be tested prior to placement in a basin to determine whether it will have any detrimental effect (e.g., cause dissolution or corrosion, increase permeability, decrease mechanical strength) or materials used for construction of the basin.

The conceptual objective and rational for this regulation is to assure that the hazardous wastes to be contained are compatible with materials used for construction of basins.

The possible reactions between the wastes and construction materials can detrimentally effect the ability of basins to isolate wastes and prevent their escape into the environment. It is, therefore, evident that the compatibiltiy of wastes with construction materials should be the first consideration in design and construction of basins. No waste having a significant detrimental effect on the materials used as barriers to movement of the wastes form the basin (e.g., causing dissolution, increasing permeability), and consequently resultin in seepage of such hazardous wastes into the environment, should be deposited in such facilities.

The fact that the individual waste characteristics vary, necessitates testing of different construction materials with the hazardous waste of interest, to determine maximum performance characteristics. Factors to be considered should include deterioration upon the contact and prolonged contact with hazardous wastes of interest, and alterations of the material's permeability with time. For the ultimate success of basins for the containment of hazardous wastes, and to assure environmentally sound performance, it is, therefore, necessary to require testing of hazardous wastes with the intended construction materials for compatibility, either during the design stage, or prior to disposition of hazardous wastes into an existing basin, if a waste is different from that of previously deposited in such facility.

(e) The materials used for construction of basins shall be compatible with the hazardous waste and treatment chemicals to be used under expected operating conditions (i.e., temperature, pressure) or shall be protected by a liner compatible with the hazardous waste and treatment chemicals to be used under expected operating conditions.

In dealing with hazardous wastes, appropriate materials, of construction are required to provide reasonable service life for equipment and the environmentally safe operation. Material of construction must be chosen very carefully, to protect personnel, the environment and economic equipment life. Coated and lined basins may frequently be used to meet material requirements, e.g., carbon, steel lined with lead, rubber, glass, plastic, or other corrosion resistent materials. Nature of the hazardous wastes and treatment chemicals, expected length of service, temperature of operation, desired physical strength, liquid flow rate, and mechanical abrasion are among the factors to be considered in material selection. Because of the complexity of the problem, only general guidance can be provided.

The incompatibility of hazardous waste and treatment chemicals or reagents with materials used for constuction under operating conditions could cause corrosion problems or potentially disrupt the structural integrity of a facility, allowing the escape of hazardous components into the environment. The main objective of the above regulation is to assure that such disruption does not occur.

The potential consequences of improper selection of construction materials are listed below:

1. Corrosion

Besides the influent waste stream itself, the chemical reagents often possess corrosion properties (for example, the lime used to precipitate metals from an acidic waste streams or to neutralize acidic wastes). In dealing with acids and alkalines, appropriate materials of construciton are required to provide reasonable service-life for equipment. For example, lead is attacked by hydrochloric acid, but can be used with concentrated sulfuric acid (75-95%). Chromic acid (oxidizing agent) generally corrodes all metals, but will not deteriorate glass, polyethylene, or PVC. In many cases the specific concentration of the reagent is important. The presence of moisture in wastes could be another critical factor. Elevated temperatures generally increase corrosivity, also.

The above discussion addresses only some of the problems concerning corrosion. In general, corrosion may cause rapid deterioration of construction materials, resulting in equipment failure or subsequent hazardous waste leaks into the environment.

2. Salting and Scaling

Salting and scaling is the formation of an insulating layer at the heat transfer sufaces, causing a considerable loss of heat transfer efficiency. It is commonly encountered in evaporation basins and can potentially lead to their failure and subsequent environmental problems. Scaling and salting may be reduced or prevented by preliminary treatment of liquid streams, careful choice of materials of construciton, and by operational control.

3. Pressure

Unanticipated high pressure can disrupt the structural intergrity of the facility and cause the escape of hazardous materials into the environment.

4. Liquid flow rate and mechanical abrasion

The mechanical abrasion from any matter that may be contained in the waste, and flow rates higher than anticipated in problems. If not detected and/or controlled, erosion may cause design and construction, can cause erosion ~~may~~ rapid deterioration and reduce service life of unsuitable construction materials, and ultimately result in failures and subsequent hazardous waste leaks into the environment.

(f) A basin shall be monitored or visually inspected daily in accordance with the requirements under Section 250.43-6 for leaks, corrosion, cracks, or other damages. Any damage detected shall be repaired immediately.

The primary purpose of basins (in addition to the intended treatment objectives) is to assure containment of hazardous wastes during treatment operations throughout the expected life of the facility and prevent unregulated discharges of hazardous wastes into the environment. Therefore, their structural integrity and impermeability must be maintained at all times.

The primary objective of the above regulation is to prevent such environmental problems through frequent ~~periodical~~ visual inspection. The rationale for this approach is that most of the corrosion and erosion problems, the material cracking, and other damages ~~could~~ may be detected early through visual inspection, and before more serious environmental problems ~~could~~ develop. At the same time, visual inspection could replace leachate monitoring. Since the majority of basins have capacities usually ~~capacity usually~~ less than 100,000 gal. (380 m^3), their visual inspection would be technically feasible. Furthermore, since basins are only temporary structures, and wastes are never expected to remain in basins after facility closure, the requirement of leachate monitoring instead of visual inspection, would place and unnecessary burden on industry.

Furthermore, the objective of this regulation is to assure that any damage detected through visual inspection is repaired immediately before more serious problems could develop.

The uncorrected corrosion and erosion problems, cracking or other structural damage of basins construction materials could result in hazardous wastes release or seepage from the basins and subsequent movement to the environment. It is therefore imperative, that all basins, after any problem is detected, are emptied and repaired if this is technically feasible. The structure should not be used until all repairs, or renovation work is completed. If the basin cannot be repaired such that it would assure environmentally sound operation, it must be replaced by other structures.

(g) A basin shall have a groundwater monitoring system meeting the specifications of Section 250.43-8.

Note: A basin does not need a groundwater monitoring system if the facility owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that any leaking can be detected by visual inspection or other means.

The objective of the above regulation is to detect and correct any failure, or groundwater contamination, before more serious problems can develop.

Monitoring requirements for basins, which have the potential for discharge to UDWS, specify monitoring in zone of saturation, applicable to all facilities constructed after the effective date of this regulation.

The objectives and rational for requiring monitoring in the zone of saturation are the same as specified under section 250.43-8 ~~Section~~ of the regulations 3004.

(h) At final closure, all hazardous waste and hazardous waste residues shall have been removed from a basin and disposed of as hazardous waste pursuant to the requirements of Subparts B, C, and D.

The proper close-out of basins is essential for protection of human health and the environment. The hazardous wastes and/or hazardous residuals remaining in the basins after facility closure may become a source of environmental problems due to failure of hazardous waste containment, and subsequent leaks of hazardous components into the environment in those facilities which were not designed to contain wastes for an extended period of time.

By their nature, basins are temporary hazardous waste containment structures designed for variable lengths of service life.

The environmental soundness of each basin depends directly upon the materials used for construction, i.e. compatibility with the hazardous wastes to be contained, durability upon prolonged contact with the hazardous wastes of interest, and alteration of permeability with the time.

The hazardous wastes, after prolonged contact, could have a detrimental effect on durability and permeability of construction materials. Therefore, the continuous contact of hazardous wastes with such materials after their predicted life time, as may be the case after facility closure, would considerably increase the potential for failure, and subsequent groundwater and/or surface water contamination.

Based on the above facts, the regulation requires removal of all hazardous wastes and hazardous waste residuals from basins, upon their final closure, and disposal of removed hazardous waste/hazardous residuals in accordance with the requirements in Subpart B, C, and D.

BD-29

Resource Conservation and Recovery Act

Subtitle C - Hazardous Waste Management

Section 3004 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

BD-29

DRAFT

BACKGROUND DOCUMENT

Section 250.45-5 Standards for Landfarms

U. S. Environmental Protection Agency

Office of Solid Waste

December 15, 1978

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft for comment. As new information is obtained, changes may be made in the regulations, as well as in the background material.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Timothy Fields, Jr.
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Office of Solid Waste
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Washington, D.C. 20460

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I. Introduction

A. RCRA Mandate for the Regulation:

The Congress of the United States, via Section 3004 of Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976 (P.L. 94-580), mandated that the Administrator of the Environmental Protection Agency promulgate regulations establishing performance standards applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities as may be necessary to protect human health and the environment. These standards are to include, but not be limited to, requirements respecting (1) location, design, and construction, and (2) operating methods, techniques, and practices of these facilities.

Compliance with this mandate necessitates the development and promulgation of regulations that will protect human health and the environment from the adverse effects of air, land, and water pollution that may result from hazardous waste disposal.

"Disposal," in the sense that it is defined in Section 1004(3) of the Act, includes the landfarming of hazardous wastes. Though standards for landfarming are not specifically required by the Act, it is believed that improper landfarming disposal methods may pose a threat to human health and the environment and therefore such practices should be regulated. Landfarming is an environmentally acceptable method for disposing of some hazardous waste, provided certain operating and design parameters are adhered to. This document discusses the rationale used in developing the proposed standards for landfarms (40 CFR Part 250.45-5 Subpart D).

B. Key Definitions:

The following are key definitions pertinent to the standards applicable to landfarms. Except for the term "disposal", which is defined in Section 1004(3) of the Act, all definitions were developed from other sources.

"Attenuation" means any decrease in the maximum concentration or total quantity of an applied chemical or biological constituent in a fixed time or distance traveled resulting from a physical, chemical, and/or biological reaction or transformation occurring in the zone of aeration or zone of saturation.

"Contamination" means the degradation of naturally occuring water, air, or soil quality either directly or indirectly as a result of man's activities.

"Direct Contact" means the physical intersection between the lowest part of a facility (e.g., the bottom of a landfill, a surface impoundment liner system or a natural in-place soil barrier, including leachate collection/removal systems) and a water table, a saturated zone, or an underground drinking water source, or between the active portion of a facility and any navigable water.

"Disposal", means the discharge, deposit, injection, dumping, spilling, leaking or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters.

"Facility" means any land and appurtenances, thereon and thereto, used for the treatment, storage, and/or disposal of hazardous waste.

"Fertilizer" means any substance containing one or more recognized plant nutrient(s) which is used for its plant nutrient content, and which is designed for use or claimed to have value in promoting plant growth.

"Flash Point" means the minimum temperature at which a liquid or solid gives off sufficient vapor to form an ignitable vapor-air mixture near the surface of the liquid or solid. An ignitable mixture is one that, when ignited, is capable of the initiation and propagation of flame away from the source of ignition. Propagation of flame means the spread of the flame from layer to layer independent of the source of ignition.

"Food Chain Crops" means tobacco; crops grown for human consumption; or crops grown for pasture, forage or feed grain for animals whose products are consumed by humans.

"Groundwater" means water in the saturated zone beneath the land surface.

"Hazardous Waste" has the meaning given in Section 1004(5) of the Act as further defined and identified in Subpart A.

"Incompatible Waste" means a waste unsuitable for commingling with another waste or material, because the commingling might result in:

(i) Generation of extreme heat or pressure,

(ii) Fire,

(iii) Explosion or violent reaction,

(iv) Formation of substances which are shock-sensitive, friction-sensitive, or otherwise have the potential of reacting violently,

(v) Formation of toxic (as defined in Subpart A) dusts, mists, fumes, gases or other chemicals, and

(vi) Volatilization of ignitable or toxic chemicals due to heat generation, in such a manner that the likelihood of contamination of groundwater, or escape of the substances into the environment, is increased, or

(vii) Any other reactions which might result in not meeting the air human health and environmental standard. (See appendix 3 for more details.)

"Landfarming of a Waste" means application of waste onto land and/or incorporation into the surface soil, including the use of such waste as a fertilizer or soil conditioner. Synonyms include land application, land cultivation, land irrigation, land spreading, soilfarming, and soil incorporation.

"Navigable Waters" means "waters of the United States, including the territorial seas". This term includes, but is not limited to:

(i) All waters which are presently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide, intermittent streams, and adjacent wetlands. "Wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

(ii) Tributaries of navigable waters of the United States, including adjacent wetlands;

(iii) Interstate waters, including wetlands; and

(iv) All other waters of the United States, such as intrastate lakes, rivers, streams, mudflats, sandflats, and wetlands, the use, degradation or destruction of which would affect or could affect interstate commerce, including, but not limited to:

(a) Intrastate lakes, rivers, streams, and wetlands which are or could be used by interstate travelers for recreational or other purposes; and

(b) Intrastate lakes, rivers, streams and wetlands from which fish or shellfish are or could be taken and sold in interstate commerce; and

(c) Intrastate lakes, rivers, streams, and wetlands which are used or could be used for industrial purposes by industries in interstate commerce.

(v) All impoundments of waters of the United States otherwise defined as navigable waters under this paragraph.

"Owner/Operator" means the person who owns the land on which a facility is located and/or the person who is responsible for the overall operation of the facility.

"Publicly Owned Treatment Works" or "POTW" means a treatment works as defined in Section 212 of the Clean Water Act (CWA), which is owned by a State or muncipality (as defined by Section 502(4) of the CWA). This definition includes any sewers that convey wastewater to such a treatment works, but does not include pipes, sewers or other conveyances not connected to a facility providing treatment. This term also means the municipality as defined in Section 502(4) of the CWA, which has jurisdiction over the indirect discharges to, and the discharges from, such a treatment works.

"Reactive Hazardous Waste" means hazardous waste defined by Section 250.13(c)(1) of Subpart A.

"Run-off" means that portion of precipitation that drains over land as surface flow.

"Soil Conditioner" means any substance added to the soil for the purpose of improving the soil's physical properties by increasing water content, increasing water retention, enhancing aggregation, increasing soil aeration, improving permeability, increasing infiltration, or reducing surface crusting.

"Treated Area of a Landfarm" means that portion of a landfarm that has had hazardous waste applied to it, to include the zone of incorporation.

"True Vapor Pressure" means the pressure exerted when a solid and/or liquid is in equilibrium with its own vapor.

The vapor pressure is a function of the substance and of the temperature.

"Zone of Incorporation" means the depth to which the soil on a landfarm is plowed or tilled to receive waste.

II. Rationale for Regulation

Landfarming is an environmentally acceptable method for treating and disposing of certain types of hazardous waste, provided certain operating and design parameters are adhered to. In the absence of regulatory control, landfarming has the potential to adversely impact all environmental media. Unlike landfills, there are usually no liner or leachate collection systems associated with a landfarm. Maintaining environmental integrity depends entirely on the biological, chemical, and physical attenuation properties of the soil and the management techniques used to optimize those properties. Unfortunately, such management techniques are not employed at some existing operations. Site visits to two landfarms (1,2) bore witness to the fact that some systems are severly abused as a result of waste over application, and operation during periods of extended rainfall.

A successful landfarm is a delicate system with biological and chemical cycles in dynamic equilibrium with the soil-waste medium. Such a system requires perpetual monitoring and maintenance if environmental integrity is to be maintained.

In terms of a threat to public health and the environment, there is a dearth of documented damage cases involving hazardous waste landfarms, even though the potential for contamination exists. This could be a result of current landfarm monitoring practices which may be absent, inadequate, or inappropriate. State landfarm regulations frequently stress groundwater monitoring and rarely require soil monitoring. Groundwater contamination may take years to manifest itself, thus, even if a site is currently leaching contaminants, it could take years to detect the problem.

The absence of air emission monitoring at hazardous waste landfarms may be another reason for the dearth of damage cases. According to a recent study (3), there is no specific mention of protection of air resources in any State regulation. The study concludes that there is a strong need for national regulations which recognize the potential for air pollution from landfarming. A major objective of the landfarming regulations is, therefore, to close the gap existing in the State's current regulatory approach for controlling air emissions from hazardous waste landfarms.

Finally, compared to other methods of disposal, such as landfilling or incineration, landfarming represents only a small percentage, hence the potential for damage may be correspondingly small. If this assumption is true, then as the quantity of waste destined for disposal at landfarms increases, which it is expected to do, so too will the potential for human health and environmental impacts.

The following is a discussion of the actual and potential avenues of contamination and damage incidents associated with hazardous waste landfarms.

Surface Water Contamination

Surface water situated near a landfarm site is subject to pollution from contaminated run-off resulting from erosion of the soil-waste medium of the treated areas. Because the process of landfarming concentrates wastes in the soil surface, run-off water may be contaminated to the extent that it will impact certain trophic levels in the aquatic ecosystem (4).

One of the few incidents reported in the literature (5) involved the removal of contaminated soil from a landfarm as a result of a rainstorm occcurring soon after an oily sludge was applied. Erosion of the soil-waste medium by run-off carried contaminants to a lake (on-site), resulting in a fish kill.

Air Emissions

A recent EPA study (3) that evaluated emission control criteria for hazardous waste management facilities describes one air-related damage incident resulting from landfarming of oil refinery waste. In this case, neighbors complained of odors and there were some reports of damage to paint on nearby houses.

Although there are few documented cases of air pollution from landfarming, the potential for release of significant quantities of pollutants to the atmosphere exist. The disposal of oily type wastes provides an excellent example of air pollution potential. Gases and odors generated increase initially during spreading operations and subside as microbial decomposition occurs. However, in the weathering (spreading) method of disposing of leaded-gasoline storage tank wastes, the vapors can be inhaled or absorbed through the skin. At the levels of organically bound lead (20 to 200 ppm) encountered in the storage tank sludge, potential lead-in-air hazard could occur during the weathering process (6).

Since many of the oily wastes have a high water content, they are commonly applied to the land by spraying. This would allow for aerosol formation and release of waste constituents. In addition, air pollution can occur through direct volatilization of constituents contained in the waste after it has been spread on the land. Again, because of the high water content of many oily type wastes, initial disposal often involves allowing the water to evaporate from the waste prior to mixing with the soil. During this period of time, all constituents of equal or higher volatility than water will be released to the atmosphere and other waste constituents will also evolve due to co-solvent processes (3).

A third mechanism for air pollution is by entrainment of particulates through wind erosion. This latter mechanism becomes increasingly important throughout the life of an active landfarming site. Since most oily wastes contain trace elements, these tend to accumulate in the soil with each additional application of waste material. The initial particles released to the atmosphere through wind erosion for a new site will contain low concentrations of trace elements; however, several years after a site has been in operation the concentration of trace elements in soil particles will be much higher(3).

In addition to the potential for creating ambient air concentrations of pollutants, in the vicinity of landfarming areas, which are potentially hazardous to health, there is a real potential for a significant contribution to the reduction of ambient air quality through photochemical reactions of constituents evolving from the waste disposal site. This may be of particular concern in areas where ambient concentrations of photochemical oxidants are already high, such as in parts of California (3).

Groundwater Contamination

The landfarming of nonhazardous waste has resulted in contamination of groundwater by nitrates and phosphates which were present in the waste or added as fertilizer (7). Hazardous waste landfarms are subject to the same consequences, though EPA is not aware of any documented groundwater contamination incidents resulting from the practice. This lack of documentation should not, however, be interpreted to mean that hazardous waste landfarms pose no threat to the groundwater. The potential for contamination is, in fact, greater for hazardous than nonhazardous wastewater and sludge, because the waste is in a liquid/semi-liquid form and the contaminants are present at greater concentration (4).

The paucity of data available on landfarm-related groundwater damage cases may be a result of inappropriate monitoring methods and the time required for problems to manifest themselves (as discussed previously).

In light of the potential pollution problems, landfarming can cause (and the expected increase in utilization of this disposal method), regulation of this practice is deemed warranted by the Agency. A landfarm, as mentioned previously, is a very delicate disposal system requiring perpetual monitoring and maintenance. Without proper regulatory control, landfarms can become "open dumps," which threaten surrounding environmental media and have little potential for reclamation, save excavation of the contaminated soil-waste medium.

III. Existing Federal or State Regulations/Guidelines

Initial development of the Section 250.45-5, Landfarming regulations, involved an analysis of existing Federal and State regulations and guidelines. No Federal standards for landfarming existed except for draft guidelines to control the landspreading of sewage sludge to land used for the production of food-chain crops (43 FR 4942 Section 257.3-5). These guidelines are primarily concerned with plant up-take of cadmium and were considered inadequate to control industrial hazardous waste.

The existence of State regulations or guidelines was determined by contacting State agencies responsible for regulating solid waste disposal. A survey of 32 States was conducted by a contractor (4) performing a state-of-the-art study on the landfarming of industrial and municipal wastes. This study was published in August 1978 and a summary of the contractor's survey is in Appendix I.

The survey revealed that only four States had guidelines and that Texas (Texas Department of Water Resources) and Oklahoma (Oklahoma State Department of Health) were the only two States that utilized comprehensive guidelines to evaluate landfarming disposal permits. Minnesota

(Minnesota Pollution Control Agency) developed hazardous waste landfarming guidelines but never gave them the force of law because the prevailing political climate did not favor it (8).

Maine and South Carolina have guidelines that pertain to land cultivation of cellulosic waste materials from the paper and allied products industry. Land cultivation of other types of waste is evaluated on a case-by-case basis.

Although 28 of the States surveyed did not have specific land cultivation regulations or guidelines, indications are that several States plan to develop regulations in the future. Mississippi is currently in the process of developing specific regulations for land cultivation of different types of wastes, such as agricultural and food processing wastes, and oily materials. Kentucky, in contrast, has no plans to write regulations and feels that specific regulations are inappropriate for a variety of reasons. In particular, the belief was expressed that it is important to have flexibility to match wastes to appropriate disposal sites, especially in a State with such widely varying terrain and soil conditions.

Even though specific regulations may not currently affect land cultivation in most States, State policies may have an impact on the type of wastes that can be landfarmed. In New York and Vermont, State policy is to discourage and minimize land cultivation of wastes other than those from agriculture or food processing.

The 28 States not having regulations or guidelines evaluate landfarming on a case-by-case basis. Evaluation procedures vary from State to State, but normally include consideration of the following factors: site topography, depth to groundwater and adjacent water courses, soil type, site operating proceudres and deactivation plans, and monitoring requirements. In general, a case-by-case review can be anticipated to yield requirements that are site and waste specific. Ideally, this is the most effective method of regulation in terms of protecting the environment. The economics and manpower requirements, however, are excessive, making this approach inpractical on the Federal level.

Additionally, if States are to assume primacy, specific Federal regulations will provide EPA with an objective means of evaluating the equivalency of State programs.

Developing standards of this nature is feasible as is evidenced by the accomplishments of the Texas Department of

Water Resources (TDWR). The TDWR has specific land cultivation guidelines that are generally applicable to all types of industrial wastewaters/sludges. The guidelines address a number of factors that must be evaluated when considering a site for landfarming, including: soils, topography, climate, surrounding land use, and groundwater conditions. Similarly, waste composition and cation exchange capacity of the soils at the disposal site are factors that must be addressed in detail to facilitate determining the appropriate waste application rate.

Oklahoma's guidelines are similar to those of Texas, both of which are summarized in Appendix II. In Oklahoma, land cultivation guidelines are aimed at oily waste. The suitability of other types of industrial wastewaters/sludges for disposal by landfarming is determined on a case-by-case basis. Oklahoma has specifically excluded water soluble inorganic waste, judging that such waste is not suitable for land cultivation. A list of wastes deemed to be amenable to landfarming is also given. The list includes: API separator sludge, oil storage tank bottoms, biological waste treatment sludge, process filter clays, petroleum coke waste, process catalyst, water treatment sludge, and process water treatment sludge.

The guidelines from both of these States were used in the development of Section 250.45-5, landfarm regulations. Modifications, if any, were made to make State guidelines more suitable for application on a national scale. Other sources of input to the regulations were the guidelines developed by the Minnesota Pollution Control Agency. Meetings and conversations with industry, academia, the Food and Drug Administration, the U. S. Department of Agriculture, and consultants to industry provided valuable information and lended much technical support to the regulations.

The derivation of each regulation, and its associated rationale, are addressed in Section V.

IV. Analysis of Landfarming Regulatory Strategies

There are essentially two regulatory strategies currently used to control the treatment, storage, and disposal of hazardous waste. The strategies can be divided into three approaches, as follows:

I. No standards; regulate on a case-by-case basis.

II. Process and performance standards. Process standards include material restrictions, and operating and design standards. Performance standards specify a desired result without specifying the method to achieve it.

III. Process and performance standards with a provision for varying from the prescribed standards.

The application of these three approaches is discussed in terms of their suitability as a Federal regulatory framework to control the landfarming of hazardous waste. The advantages and disadvantages of each approach are discussed as are the rationale for choosing or not choosing a particular approach.

Approach I

Evaluation of landfarming practices on a case-by-case basis (Approach I) is the ideal regulatory approach in terms of insuring that the permit is tailored to the site and takes into account site and waste specific parameters. This approach advantageously requires that the permitting official carefully scrutinize and assess each permit application, on its own merits, in an effort to determine the appropriate permit requirements.

The major drawback of Approach I is the excessive economic, manpower, and time requirements needed for implementation. Another problem is that if EPA does not promulgate specific standards, there will be no means by which to assess or compare the equivalency of State hazardous waste programs to the Federal program. It may be difficult for a State to even develop a comparable hazardous waste program without Federal standards to use as guidance.

A recent survey (4) of the landfarming regulatory practices of 32 States revealed that 28 use Approach I, two use a variation of Approach I, and two discourage the practice. Evaluation procedures vary from State to State, but normally include consideration of one or more of the following factors: site topography, depth to groundwater and adjacent surface water courses, soil type, site operating procedures and closure plans, and monitoring requirements.

Guidelines for controlling the land spreading of nonhazardous waste are used by some States as guidance to aid in evaluating permit applications for the landfarming of hazardous waste. Nonhazardous land spreading guidelines are often grossly inappropriate and inadequate for this purpose.

Only two States, Oklahoma and Texas, use guidelines developed specifically for controlling the landfarming of hazardous waste. The guidelines specify minimum requirements, of either a process or performance type, and are incorporated into the permit. These guidelines, although lacking the force of law, are included in all permits, except when certain site or waste-specific parameters dictate that a modification to the guideline(s) be made. Depending on the parameter in question, the guideline(s) may be made more stringent, less stringent, or deleted. If made less stringent or deleted, the owner or operator of the facility may be required to demonstrate that the objective of the original guideline(s) will still be achieved.

Professional judgement must frequently be exercised when modifying a guideline. This requires a considerable amount of expertise on the part of the permitting official. Finding and hiring individuals of the appropriate caliber may be a major limiting factor (of this approach) at both Federal and State levels.

The apparent popularity of Approach I with the States surveyed does not necessarily mean it was selected because it was the best approach. It is possible that selection of Approach I may have been based on it being the only available choice, rather than the best choice. State regulatory agencies frequently issue permits on a case-by-case basis, especially for practices that are uncommon (relative to the State agency's experience). The reason Oklahoma and Texas were the only two States that chose to develop specific landfarming guidelines, rather than rely on the "no guidelines, case-by-case basis" approach, lends credence to this assumption. Discussions with representatives of the Oklahoma State Department of Health (11) and the Texas Department of Water Resources (12) revealed that there is a prevalence of landfarming as a waste disposal method in both States because of the significant number of petroleum refineries and petrochemical plants that utilize the practice. Landfarming in these two States, unlike the majority of the States surveyed, is a common waste disposal practice. There was a need for a uniform method of evaluating permit applications, which both States responded to in the form of specific guidelines.

Approach I, in spite of its apparent popularity, was not selected by EPA as a framework for regulating land-farming. Excessive resource requirements and the lack of a means for assessing and comparing State programs to the Federal program make this approach impractical on a national scale.

Approach II

Approach II involves the use of specific process and performance standards applicable to all landfarms. These standards specify the minimum requirements a facility owner/operator must meet in order to obtain a permit. Process standards include material restrictions, and location, design and operating requirements. Standards of this type essentially tell a facility owner/operator: (1) what materials (hazardous waste) are or are not acceptable for certain treatment, storage, and disposal practices, and (2) where to locate and how to design and operate a facility. Process standards find favor with facility owners/operators that are seeking regulatory guidance on material restrictions and site location, design and operation.

Performance standards specify a desired result without specifying how to achieve it. Standards of this type are favored by facility owners/operators that have the necessary treatment, storage, and disposal expertise and want only to know what end result is desired by the regulatory agency.

As a result of its "cookbook" nature, Approach II would be easier to implement on a national scale and would utilize less resources than Approach I. This approach also provides a basis for assessing the equivalency of State programs.

A major disadvantage of Approach II is its inflexibility. Even when an alternative method can be demonstrated to meet or exceed the objective of a set standard, there are no provisions for deviating from that standard. Because of this inflexibility, Approach II discourages the development of new and innovative technologies by industry.

None of the States surveyed used this approach to regulate the landfarming of hazardous waste. Its unpopularity is thought to result primarily from its inflexibility and, to a lesser extent, from the decision of some States not to develop specific regulations for a practice that is still being proven. The inflexibility associated with Approach II arises from the fact that standards developed for such an approach are usually derived from existing guidelines, which, as the name implies, were meant to guide, not lead the way step-by-step. This type of standards development is not an uncommon practice, especially when the guideline has been tried and tested, and has found wide application and acceptance. Even with these attributes, it is sometimes unsafe to transform a guideline into a rigid standard. The solution to this problem is to incorporate flexibility into an otherwise rigid standard; expecially a standard that might not be suitable for all existing or future technologies. Because Approach II as presented has no provision for flexibility, it was rejected for use as a regulatory framework. In lieu, a hybrid approach, Approach III, was developed, and selected for use as a regulatory framework.

Approach III

In developing Approach III, emphasis was placed on maximizing the beneficial attributes of Approaches I and II, and minimizing their inherent disadvantages.

The Section 250.45-5 landfarming regulations were derived primarily from the guidelines of the Texas Department of Water Resources and the Oklahoma State

Department of Health, and to a lesser extent from other sources discussed in Section II of this document. In an effort to eliminate the inherent inflexibility associated with developing standards from guidelines, many of the standards, where appropriate, are accompanied by notes. The notes, which are performance oriented, provide for deviation from the standard provided the owner or operator can demonstrate to the EPA Regional Administrator, prior to receiving a permit, that the proposed alternative method(s) meets the objective(s) of the standard. The Regional Administrator, therefore, has the discretion to permit the use of alternate, but equivalent or better, technologies on a case-by-case basis. This approach affords maximum flexibility, where possible, by allowing industry to either follow the standard or demonstrate the efficacy of an equivalent method.

Not all of the standards are accompanied by notes, hence some lack flexibility. Several of the process standards do not have notes because the Agency made a decision, based on the best data available, that it was not possible to deviate from the standard and still meet the objective (of the standard). The landfarming performance standards are not accompanied by notes for two reasons: (1) they specify a desired result, e.g., preventing the zone of incorporation from becoming anaerobic, which is essential to operating a successful landfarm and, therefore, cannot be deviated from, and (2) the performance standards are not restrictive in the sense that the method to achieve the desired result is not specified, thus, a note is not needed to provide for deviation from a particular method . The latter reason is important in that it differentiates a performance standard from a process standard, and it justifies why performance standards are not restrictive (or inflexible) even in the absence of a note.

Implementation of Approach III, on a national scale will impact upon economic and manpower resources to a much lesser extent than Approach I. This is because Approach III is "cookbook" in nature and, when deviation from a standard is proposed, the burden of proof is upon the facility owner or operator. This attribute will keep judgmental decisions to a minimum, thereby lessening the need for a workforce of the caliber required in Approach I.

Approach III was selected for use as a framework to regulate the landfarming of hazardous waste because it: (1) lends flexibility in the form of notes to what would otherwise be rigid standards, (2) provides a means by which permit applications can be more easily evaluated, and (3) provides an objective basis for comparing the Federal program to State programs.

V. Identification of Chosen Regulatory Option and Associated Rationale

(a) Hazardous Waste not amenable to landfarming

The following hazardous waste shall not be landfarmed:

(1) Ignitable waste, as defined in Section 250.13(a) of Subpart A;

(2) Reactive waste, as defined in Section 250.13(c) of Subpart A;

(3) Volatile waste;

(4) Waste which is incompatible when mixed (see Appendix I).

Note: A landfarm facility may be used to treat or dispose of ignitable, reactive, volatile, or incompatible waste provided that the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that such treatment or disposal will not:

(1) contribute any airborne contaminant to the atmosphere such that concentrations above the source have the potential: (i) to exceed permissible exposure levels for that airborne contaminant promulgated in 29 CFR 1910.1000 (see Appendix III) pursuant to the Occupational Safety and Health Act of 1970, or (ii) to contribute two or more listed airborne contaminants in a manner which causes the sum of the following expression to exceed unity:

$$E_m = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \ldots \frac{C_n}{L_n}$$

Where:

E_m is the equivalent exposure of a mixture of airborne contaminants, C is the concentration of a particular contaminant, L is the exposure limit for that contaminant (29 CFR 1910.1000, Table Z-1, Z-2, Z-3), and (2) affect the attenuation capacity of a landfarm, through heat generation, fires, or explosive reactions.

The objective of this regulation is to reduce the potential for air emissions resulting from the landfarming of ignitable, reactive, volatile, or incompatible waste. Discouraging the landfarming of waste within these four categories reduces the potential occurrence of accidental fires, explosions, reactions, and related adverse effects; all of which can lead to hazardous air emissions.

Cognizant of the possibility that certain waste types within the four categories could be landfarmed in an environmentally acceptable manner, deviation from this standard is permitted provided certain requirements (specified in the note) are adhered to. A detailed discussion of the options considered by the Agency for controlling air emissions from hazardous waste facilities and the rationale supporting the approach taken are presented in the background document on Air Human Health and Environmental Standard, Section 250.42-3.

The rationale presented in this document are specifically concerned with whether or not landfarming is a viable disposal method for a waste that falls into one or more of the four categories.

Ignitable Waste

The landfarming of waste with a flash point of less than 60°C (140°F), i.e., waste characterized as ignitable in 250.13(a)(1) and listed in 250.14(a) of Subpart A, is considered an unsafe practice due to the potential for fires, explosions, air emissions, and related adverse effects.

A recent study (4) has shown that during landfarming operations, fires and explosions can occur. Even after soil incorporation, some of the waste materials that are partially exposed can cause fire hazards resulting from spontaneous combustion of flammable materials.

Potential waste ignition sources exist both during and after landfarming disposal operations. Actual examples of potential ignition sources, cited below, provide rationale for prohibiting the landfarming of ignitable wastes.

Potential Ignition Sources

1) Heat energy from dark objects absorbing sunlight. Temperatures can approach 49°C (120°F) in parts of the United States.

2)* Heat energy generated during waste biodegradation (in landfills). Temperatures can reach 60°C (140°F).

* see footnote next page

3)* Heat energy generated during composting of wastes. Temperatures can reach 70°C (158°F).

4) Electrical energy generated from ignition sources.

Reactive Waste

Reactive waste , characterized in 250.13(a)(3) and listed in 250.14(a) of Subpart A, is not amenable to landfarming because of the actual and potential problems associated with its disposal. Examples of the types of waste affected by this regulation are those that are:

1) Normally unstable and readily undergo violent chemical change;

2) Capable of detonation or explosive detonation by a strong initiating source, including waste which reacts explosively with water;

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*It is acknowledged that soil/waste temperatures during normal landfarming operations are not expected to approach those encountered in (2) and (3), however, over-application of waste and subsequent soil/waste anaerobiosis can create similar conditions.

3) Readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures;

4) Forbidden explosives (49 CFR 173.51), Class A explosives (49 CFR 173.53), or Class B explosives (49 CFR 173.58), which include pyrophoric substances, explosives, autopolymerizable material and oxidizing agents.

An example of problems associated with the landfarming of reactive wastes, specifically waste explosives, is provided from the results of field studies conducted by the military (9). Efforts at landfarming by the Army Materiel Development and Readiness Command, at Natick, Massachusetts, and at Edgewood Arsenal, have produced less than satisfactory results. Whereas some celluosic materials appeared to biodegrade, others tended to biotransform to a recalcitrant residue. The military has expressed obvious concerns about the control of leachate from a farmed area. Additional research by the military suggests that the best results, for the complete destruction of waste explosives via "soft" or non-energy intensive disposal methods, appear to be derived from composting. Indeed, the destruction mechanism in composting may be thermal rather than biological.

The conclusion reached as a result of the studies by the military is that, aside from safety problems, existing methods for the landfarming of waste explosives are environmentally inadequate. Generally, according to the military, "the most environmentally sound method of disposal, controlled incineration, is potentially the most dangerous from a personnel safety viewpoint."

One EPA study (13) assessing alternatives for hazardous waste management in the explosive industry recommended against land disposal of waste explosives because of obvious safety considerations. Alternative disposal methods such as: 1) wet grinding, wet oxidation, sewage treatment, 2) wet grinding, reduction, filtration/evaporation, calcination, and 3) incineration are proposed in lieu of landfarming.

The need for further research in this area is essential and requisite if reactive wastes are to be considered acceptable for disposal via landfarming.

Volatile Waste

Volatile waste is defined as waste with a vapor pressure exceeding 78mm Hg at 25°C. The rationale for selecting this vapor pressure are presented in the background document on Air Human Health and Environmental Standard, Section 250.42-3.

The landfarming of volatile waste is considered to be an unsafe practice because it has the potential to release significant quantities of pollutants to the atmosphere (3). The hazards associated with the release of air contaminants from a landfarm, presented in Section II of this document, support the need for this regulation and the Agency's view that volatilization of hazardous waste should not be considered an acceptable avenue of disposal at hazardous waste landfarms.

Incompatible Waste

Rationale for prohibiting the landfarming of incompatible waste are derived from a draft report by the California Department of Health (CDOH) (14). The report cites the fact that there is an exceedingly high risk of contact of potentially incompatible substances at hazardous waste disposal facilities as a result of a lack of accurate information and indiscriminate handling of wastes. Such contact can result in chemical reactions (and in reaction consequences) which are often more reactive that the reactants themselves, e.g., intense heat generation, pressure generation, fire, explosion, violent reaction, formation of latent reactive substances, dispersal of toxic substances, formation of toxic fumes, gases, and other toxic chemicals, volatilization of flammable or toxic chemicals and solubilization of toxic substances. These consequences can lead to secondary consequences such as injury, intoxication, or death of workers, members of the public, domestic animals and wildlife. Many of these incidents are documented in Appendix I of the CDOH report. The severity of these adverse consequences and the swiftness with which they can occur emphasize the necessity for adequate precautionary measures regarding management of potentially incompatible hazardous waste . These measures must be designed to prevent contact of incompatible substances in all aspects of handling, storage, and disposal. It is only through such measures that future damage incidents can be prevented.

(b) General Requirements

(1) A landfarm shall be located, designed, constructed, and operated to prevent direct contact between the treated area and navigable water.

Hazardous waste deposited in a landfarm should not be allowed to interact with navigable water because it increases the liklihood that wastes will escape to the environment (4). Additionally, the processes of attenuation, upon which the environmental integrity of a landfarm depends, cannot function properly under saturated conditions.

A portion of the State of New Jersey's hydrologic criteria for site location includes a recommendation to prohibit the establishment of facilities in places where disposal would bring waste in contact with surface water (navigable water). This precedent establishes the fact that a requirement to prevent direct contact is recognized as good practice.

The potential consequences of not having this regulation are listed below and serve as support rationale.

(A) Direct contact would hasten the movement of hazardous wastes to navigable water. Interaction of the soil/waste mixture and navigable water has the potential to carry dissolved and undissolved hazardous constituents away from the site.

(B) Direct contact will preclude the existence of an unsaturated zone. This will destroy the integrity and purpose of a landfarm by interfering with attenuation, both in the zone of incorporation and in the underlying soil profile (which serves as a buffer zone). Additionally, the time to detect and rectify a problem before environmental damage can occur is reduced if not eliminated.

(2) A landfarm shall be located, designed, constructed, and operated to minimize erosion, landslides, and slumping in the treated area.

Erosion, landslides, and slumping are three geophysical forces that can potentially disrupt the environmental integrity of a landfarm. The main objective of the above regulation is to ensure that such disruption does not occur.

Being cognizant of the fact that few existing or potential landfarm sites will be free of such forces, the regulation was written to allow flexibility, i.e., engineering against such geophysical forces is acceptable for both existing and potential sites. It is germane to point out that locating a landfarm in an area known to be subject to extensive erosion, landslides, or slumping, will require that site improvements be made and/or special operational techniques be employed.

The potential consequences of not locating or designing against erosion, landslides, and slumping are listed below:

A) Erosion

Because the zone of incorporation of a landfarm occupies the uppermost soil layer, it is constantly exposed to the erosive forces of wind and water. Wind erosion can effect removal of soil-waste particles from the landfarm site and create air pollution problems as well as contamination of surrounding land and water.

The erosive forces of water are capable of physically deteriorating the zone of incorporation. Water erosion can effect removal of the soil/waste medium via suspension or solution. The ultimate result is polluted run-off which, if not collected, can contaminate adjacent land and water.

B) Landslides

Landslides, along with floods and erosion, are common phenomena due to weather, the nature of soils, and gravity. Landslides can effect physical changes in a site, thereby directly affecting the rate at which contaminants reach the environment. All environmental media could be adversely affected in the event a landslide disrupted the treated area of a landfarm.

Areas subject to or having had landslides are undesirable locations for siting a landfarm because the loose, unconsolidated rock material that characterizes such an area would be structurally unsound. Additionally, the soils present would not be suitable for a landfarming operation.

c) Slumping

The slumping or subsidence of land beneath a landfarm can:

i) Bring the zone of incorporation and groundwater into closer proximity, if not direct contact;

ii) Create depressions in the surface of the landfarm in which ponding of waste and/or water can occur.

The consequences of decreasing the space between the zone of incorporation and groundwater are included in the discussion on paragraph (b)(3).

The ponding of waste and/or water in the treated area can create a hydraulic head which facilitates the movement of contaminants to the subsurface and possibly to groundwater. Additionally, if the water or waste stands for extended periods of time, anaerobic conditions may arise. The adverse effects of anaerobiosis are presented in the discussion on paragraph (d) (1).

(3) A landfarm shall be located, designed, constructed and operated so that the treated area is at least 1.5 meters (5 feet) above the historical high water table.

Note: The treated area may be located less than 1.5 meters (5 feet) above the historical high water table if the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that no direct contact will occur between the treated area and the water table.

The objective of this regulation is to ensure that sufficient distance exists between the treated area and the historical high water table. Rationale in support of this regulation are similar to rationale (A) and (B) of paragraph (b) (1). Additionally, groundwater monitoring at hazardous waste landfarms will not be required, therefore, it is imperative that the treated area and the water table be separated to allow for soil monitoring. The entire concept of landfarming as a disposal method is based on the premise that waste will be attenuated by the soil. This process cannot operate properly in the absence of an unsaturated soil zone. Requiring separation of the soil/waste medium and the water table is necessary if a zone of natural attenuation is to be relied upon. Additionally, the separation is needed to provide a zone to compensate for fluctuations in the height of the water table during its yearly hydrological cycle.

According to one study (15), chemical contamination of groundwater as a result of landfarming can, to a great extent, be controlled by proper siting of the facility. The study suggests that a reasonable distance to groundwater be one of the location criteria.

A distance of 1.5m to the historical high water table is considered reasonable and is used by several States for landfill siting requirements. The rationale supporting the use of 1.5m and the term historical high groundwater table are presented in the Landfill Background Document (paragraph a,2).

Based on groundwater damage cases alone, the 1.5m distance requirement for landfills is easily supported. Application of this number to landfarms cannot be justified on the basis of groundwater damage cases, since none to date have been documented. However, landfarms, unlike landfills, do not rely on a natural or artificual liner for waste retention, and in any land application practice, there is always a risk of contaminating subsurface waters (16). This is especially true at sites with poor management practices (15).

Based on the fact that groundwater monitoring and liners are not required at landfarms and being cognizant of the inherent risk of groundwater pollution at such sites, the 1.5m distance is justifiable.

Recognizing the fact that some sites may be engineered such that depth to the water table can be less than 1.5m, e.g., use of an impermeable liner, a note providing for variance accompanies this paragraph.

(4) The treated area of a landfarm shall be at least 150 meters (500 feet) from any functioning public or private water supply or livestock water supply.

Note: The treated area of a landfarm may be less than 150 meters (500 feet) from any functioning public or private water supply or livestock water supply, provided the facility owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that:

(i) No direct contact will occur between between the treated area of the landfarm and any functioning public or private water supply or livestock water supply;

(ii) No migration of hazardous constituents from the soil in the treated area of the landfarm to any public or private water supply or livestock will occur; and

(iii) A soil monitoring system as specified in Section 250.45-5(e) has been installed and is being adequately maintained.

The objective of this regulation is to provide a buffer zone between the waste disposal site and nearby water supplies. A distance of 150m is relied upon in terms of providing a margin of safety and is not expected to serve as the main barrier for preventing pollution of a water supply well. Rationale for this regulation are derived, in part, from existing State landfill regulations. The case for applying landfill regulations to landfarms is presented in the discussion in paragraph (b)(3) of this document.

A review of several States' regulations reveals a dichotomy in the approach used to develop buffer zone regulations. Most States prefer regulating on a site-specific basis, the premise being that the distance needed between a land disposal site and water supply well is dependent upon site specific variables, such as soil permeability, groundwater flow and direction, groundwater quality and use, etc.

At least two States, Texas (State Department of Health Resources) and Wisconsin (Department of Natural Resources), prefer to specify a distance, 500 feet (150m) and 1250 feet (375m) respectively. The States' rationale behind specifying a number is that it provides a tangible point of reference and simplifies enforcement. Being cognizant that a specified distance may not be applicable in some situations, both States maintain a flexible attitude and allow for concessions to be made. Wisconsin requires special construction techniques be used for constructing wells within 1250 feet (375m) of a landfill. Texas allows wells within 500 feet (150m) of a disposal site if certain site parameters can provide the equivalent of 500 feet (150m) of protection.

The regulatory approach taken by EPA, like that of Texas and Wisconsin, incorporates the advantages of having a tangible reference point with the versatility of allowing for concessions to be made under special circumstances (via the note).

Although the conservative value of 150m was chosen, when it is used in conjunction with other requirements in Section 250.45-5(b), it provides adequate time for detecting and responding to a problem when one is detected.

(4) A landfarm shall be located on an area that has fine grained soils (i.e., more than half the soil particles are less than 73 microns in size which are of one of the following types, as defined by the Unified Soil Classification

system (ASTM Standard D 2487-69(: OH - organic clays of medium to high plasticity; CH - inor-organic clays of medium to high plasticity; CH - inorganic clays of high plasticity, fat clays; MH - inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts; CL - inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays; OL - organic silts and organic silt-clays of low plasticity.

Note: A landfarm may be located on an area with soil types other than those specified above provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that the alternative soil types will prevent hazardous constituents from verticlly migrating a distance that exceeds three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

The objective of requiring landfarms to be located in areas with the soil types specified above is to provide for maximum attenuation (retention) of hazardous waste constituents. The soils specified were selected for their physical and chemical properties, which directly effect the capacity of the soil to attenuate wastes. Essentially, the soil types selected are:

- fine-grained - more than half of the soil particles are less than 73 microns in diameter;
- silts, clays, or silt-clays with organic or inorganic components.

Fine-grained soils (silts, clays, and colloids) are characterized by an extremely large specific surface, i.e., area per unit weight. Clays, especially swelling clays, like montmorillonite and vermiculite, have both internal as well as external surfaces. Their specific surface can reach 800 square meters per gram (17). The larger the specific surface, the greater is the available area for attenuation reactions, therefore, finer soil materials have greater attenuating characteristics than coarser materials (18, 19). Consequently, the finer the soil mixture, the less is the migration of waste constituents. Specific surface is an extremely important waste-attenuation parameter, however, it is highly variable as a result of differences in soil texture, types of clay minerals, and amount of organic matter. Optimizing this parameter, via specifying desirable physical and chemical soil properties, is necessary if landfarming is to be an efficient and environmentally acceptable method of waste disposal.

Similar soil types, to those discussed, are recommended by the Oklahoma State Department of Health and Texas Department of Water Resources in their landfarming guidelines. Both of these States have had extensive experience with landfarming because of the significant number of petroleum refineries and petrochemical plants (in both States) that utilize the practice. The soil types recommended are based on experience and serve as precedent for this paragraph.

(b) Site Preparation

(1) Surface slopes of a landfarm shall be less than 5 percent, to minimize erosion in the treated area by waste or surface run-off, but greater than zero percent to prevent the waste or water from ponding or standing for periods that will cause the treated area to become anaerobic.

Note: Surface slopes of the landfarm may be greater than 5 percent provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that such slopes will not result in erosion caused by waste or surface run-off in the treated area.

The objective of this regulation is to prevent erosion and ponding of water and waste in the treated area.

The consequences of erosion have been discussed previously in the rationale for paragraph (b)(2). According to one landfarming study (4), prospective sites should be on relatively level ground with an average grade of 0 to 5 percent. Grades greater than 5 percent will significantly increase run-off and water velocities with a subsequent increase in erosion (4).

The opposite end of the spectrum is the ponding of water and waste as a result of insufficient slope. According to the Oklahoma State Department of Health Guidelines on landfarming, a perfectly flat or 0 percent slope will cause water and waste to accumulate or pond in the treated area. Anaerobic conditions will subsequently arise with resultant odor production. Additionally, ponding can create a hydraulic head, or driving force, which will push waste constituents to the subsurface and possibly to groundwater. Further consequences of anaerobiosis in the treated area are addressed in the discussion on paragraph (d)(1). A grade greater than 0 percent, preferably around 1 percent, should be sufficient, in most cases, to prevent ponding and to ensure a noneroding surface (4).

Additional precedent for requiring a slope of 0 to 5 percent are the guidelines for land cultivation developed by the Oklahoma State Department of Health, the Minnesota Pollution Control Agency, and the Texas Department of Water Resources (formerly Texas Water Quality Board). All three States recommend slopes of 0 to 5 percent. The American Petroleum Institute has recommended the same slope for the landfarming of oily wastes.

Cognizant of the fact that a landfarm may have a slope that exceeds 5 percent, yet be engineered to prevent erosion in the treated area, a variance is provided. Slopes are permitted to be greater than 5 percent provided no erosion in the treated area will occur. An actual example of how this can be achieved is the overland flow method. Landfarms of this type rely on a heavy vegatative ground cover to prevent erosion in the treated area.

(2) Caves, wells (other than active monitoring wells) and other direct connections to the

subsurface environment within the treated area of a landfarm, or within 30 meters (100 feet) thereof, shall be sealed.

The objective of this regulation is to prevent the direct entry of wastes to the subsurface environment. Direct access to the subsurface environment facilitates pollution, especially groundwater pollution. The fate of waste that accidentally enters the subsurface environment, in a more or less direct manner, i.e., without undergoing attenuation, is difficult to predict and control. Remedial measures are usually ineffective and are extremely costly.

The reason for applying this requirement to the area that extends 30m (100 feet) beyond the border of the treated area is to provide an additional margin of safety. This 30m buffer zone will be expecially important during periods of severe storms, when the potential for contaminated surface water to escape the site increases. The buffer zone will also be important in the event of an accidental spill outside the confines of the treated area.

(3) Soil pH in the zone of incorporation shall be equal to or greater than 6.5.

Note: Soil pH in the zone of incorporation may be less than 6.5 provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that hazardous constituents, especially heavy metals, will not migrate vertically a distance that exceeds three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

The objective of requiring the pH in the zone of incorporation to be 6.5 or above is to maximize the biological and chemical attenuation properties of the soil. Controlling soil pH can enhance bacterial growth, hence waste biodegradation. Stewart and Webber (20) found that the optimum pH for bacterial growth is near 7. More importantly, maintaining a pH of 6.5 or above immobilizes, with few exceptions, heavy metal cations in the soil. Current research concerning the pH effect on heavy metal fixation and mobility arises from the concern over the uptake of such metals by food-chain crops grown on sludge amended soils. There have been many studies showing that liming to raise pH decreases the solubility of many heavy metals and their availability to plants. As a result of these studies and current acceptable practices, EPA has published proposed criteria (43 FR 4942) specifying a minimum pH of 6.5 for agricultural lands amended with heavy metal-bearing sewage sludge.

Immobilization of heavy metals via pH control is the crux of landfarming hazardous wastes. What has been learned about pH in agriculture is directly applicable to hazardous waste management practices. In the mining industry, pH control is a well established practice for treatment of trace metal-bearing waste waters (19).

Much of the waste landfarmed today contains heavy metals with concentrations in the thousands of parts per million range. Heavy metals are not biodegradable and, therefore, accumulate in the soil. Their availability for leaching is what makes them potentially hazardous. As long as the metals remain immobilized in the soil, they will pose no threat to groundwater or surface water. With most agricultural soils, the pH can be maintained at or above a level of 6.5 through the application of lime.

Utilizing a minimum pH of 6.5 or 7.0 is a recommended practice at many operating landfarms, especially those disposing of oil refinery waste (4). Both the Oklahoma State Department of Health and the Texas Department of Water Resources recommend a pH of 6.5 or greater in their landfarming guidelines for hazardous waste.

Although most heavy metals become less soluble in neutral to alkaline soils, there are some notable exceptions. Studies have shown that the degree of attenuation for anionic species, such as boron, selenium, hexavalent chromium, molybdenum, and some valency states of arsenic, decreases under neutral to alkaline soil conditions. Migration of these anions to groundwater is a potential problem if waste containing these species is applied to soil with a pH of 6.5 or greater.

Banning the landfarming of waste containing mobile anionic species was considered. Unfortunately, a ban would categorically prevent the landfarming of waste with even a trace amount of mobile anionic species. This is not practical because certain concentrations of such metals could, in all probability, be landfarmed safely. The fact that selenuim, chromium, and molybdenum are essential trace elements further complicates the issue. In lieu of a ban, extensive soil monitoring is required in the regulations. The intent of soil monitoring is to detect problems such as migration before groundwater contamination can occur.

The note that accompanies this regulation provides for the situation in which the owner/operator can demonstrate to the Regional Administrator that employing a pH of less than 6.5 will prevent the waste from migrating. The note allows for design flexibility and encourages the development of new landfarming technologies.

An alternative landfarm design might involve the use of a low permeability, e.g., 10-7 cm/sec or less, natural or artificial liner to prevent migration of mobile waste constituents. Another design might utilize soil with a pH (less than 6.5) that is the optimum for immobilization of the waste being applied. This would be a waste-specific landfarm and would necessarily be limited to accepting a particular type of waste.

(b) Waste Application and Incorporation

(1) Waste application and incorporation practices shall prevent the zone of incorporation from becoming anaerobic.

The objective of this regulation is to prevent the zone of incorporation from becoming anaerobic once waste has been applied. The assimilatory capacity of the soil system for a wide variety of chemical and biological transformations is dependent upon the presence of an aerobic zone at the soil surface.

Conditions favoring the growth of most higher plants generally favor the chemical and biological reactions that enhance waste degradation in the soil. Management of a landfarm can, therefore, be patterned after a successful crop production enterprise, which is in fact the case at a number of landfarms. Farm equipment is routinely used to plow, disc, or otherwise till the treated area. This practice serves to bring the waste into intimate contact with the soil and, most importantly, aerates the soil. Mixing and aeration, expecially the latter, facilitate and enhance biological and chemical attenuation of the waste.

Aerobic decomposition of organic waste is one of the main factors that differentiate a landfarm from a landfill. Soil conditions at a landfill are predominantly anaerobic and are responsible for many of the problems associated with landfills, such as gas and odor generation and, to a certain extent, leachate migration and leachate quality.

Soil conditions at a landfarm are (or should be) predominantly aerobic, and the environmental integrity of the operation depends upon that fact, as the following discussion on the consequences of anaerobic systems demonstrates:

Consequences of anaerobic systems are (19):

(1) Gas production

The potential for human health and environmental damage is significantly increased due to gas production resulting form anaerobiosis of organic compounds.

Normally gas production and associated odors are minimal at a landfarm if the waste is incorporated into the soil and undergoes aerobic decomposition (4). Under anaerobic conditions, however, degradation of organic products can produce carbon dioxide, methane, and hydrogen sulfide in significant quantities. Lesser quantities of alcohols, ammonia, organic amines, mercaptans, and organic acids can also be produced (21). Evolution of volatile compounds containing mercury or arsenic is also possible under anaerobic conditions.

The carbon dioxide that is produced under anaerobic conditions can unite with water to form carbonic acid. Carbonic acid production reduces pH and can effect accelereted migration of certain trace contaminants.

(2) Reducing conditions (redox effect)

Reducing (anoxic) conditions favor accelerated migration of heavy metals as compared with oxidative (oxic) conditions. Trace contaminants such as arsenic, beryllium, chromium, copper, iron, nickel, selenium, vanadium, and zinc are much more mobile under anaerobic than aerobic soil conditions, all other factors the same.

(3) Organic Acid Production (pH effect)

Organic acids will be produced when organic materials decompose in a limited oxygen environment. Organic acids are weak acids which can, via lowering pH, enhance the mobility of most trace contaminants through the soil. Organic acids, produced under anaerobic conditions, form chelates with many heavy and trace metals. These metals are then protected (from immobilization reactions) and are available for accelerated movement through soils.

(4) Retardation of Biodegradation

Anaerobic degradation of organic matter proceeds more slowly than aerobic degradation.

In addition, anaerobic degradation often stops at some intermediate stage of oxidation leaving an accumulation of organic intermediates (which may be more toxic than the original compound) in the soil.

In summary, anaerobic decomposition can evolve a variety of gases (and associated odors) and can accelerate the movement of trace and heavy metals through the soil. Cognizant of these effects, preventing anaerobic conditions must be given major consideration when siting, designing, constructing, and operating a landfarm. For this reason, a major emphasis on preventing anaerobic conditions is reflected in the regulations. Three other paragraphs, (b)(1)(2)(3), (c)(1), and (d)(2), are indirectly related to preventing or minimizing the frequency and duration of anaerobic conditions. All three regulations concern preventing saturation of the zone of incorporation, which is the most common cause of anaerobiosis at a landfarm.

This paragraph specifies an end result, i.e., prevent anaerobic conditions, rather than a specific practice to achieve the desired end result. A specific operating requirement, such as frequency of tilling or waste application rate, was considered but, because landfarming methods are site specific (as a result of the variables associated with site location, waste type, waste quantity, etc.), this was considered impractical.

(2) Waste shall not be applied to the soil when it is saturated with water.

Note: Waste may be applied to the soil when it is saturated with water provided the facility owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that the soil-waste mixture will remain aerobic and that hazardous constituents, especially heavy metals, will not migrate vertically a distance that exceeds three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

The objective of this regulation is to prevent the application of waste to soil that is saturated with water. The source of the water can be from precipitation or other exogenous sources, or from the waste itself. The main reason for this requirement is that saturated soil favors accelerated migration of waste constituents via dissolution or physical removal, or as a result of anaerobic conditions (19).

Dissolution of waste constituents will be a severe problem if the waste contains significant amounts of water soluble substances such as the anions of carbonic, sulfuric, hydrochloric, and nitric acids, and certain pesticides such as carbaryl (19). Migration of undissolved constituents is not anticipated to be a major problem on fine textured soils with small pore spaces, such as the soil types cited in paragraph (b)(5).

Migration of waste constituents as a result of anaerobic conditions is, and will be, a major problem at hazardous waste landfarms. The presence and availability of oxygen in saturated soil is low compared to unsaturated soil and, as a result, saturated soil is highly susceptible to becoming anaerobic. This situation is further aggravated when the BOD and/or COD of a waste exerts its effect on the soil system. The major consequences of anaerobic conditions, previously discussed in paragraph (d)(1), are enhancement of factors that favor waste migration and maladorous emissions. Site visits to landfarms in Texas and California (1, 2) revealed that saturated soil conditions created odor and waste application problems. There was no attempt made, at either site, to determine if vertical waste migration was occurring.

Attempts at manipulating saturated soil, or even wet soil, usually aggravate problems because plowing with heavy machinery obliterates soil pore space~~s~~. Loss of soil pore space~~s~~ enhances anaerobic conditions because pore spaces ~~they~~ are the channels through which oxygen diffuses into the soil. The California Regional Water Quality Control Board (San Francisco Bay Region) feels that landfarming on saturated soils is not good operating practice. The Board stipulates, as a permit requirement, that the landfarming of waste alum sludge from a water treatment plant not be applied during rainy weather or when soils are saturated (4).

Because the Agency recognizes that some landfarming operations may dispose of waste safely, even when the soil is saturated with water, the note that accompanies this regulation provides for operational flexibility. For example, some waste will contain an amount of water that will saturate the soil for a short period of time, i.e., a period not long enough for anaerobic conditions to manifest themselves. Under such conditions, if the owner/operator can demonstrate that aerobic conditions will prevail during the period the soil is saturated and that their is no migration of hazardous constituents, a permit will be issued.

(3) Waste shall not be applied to the soil when the soil temperature is less than or equal to $0^{\circ}C$.

The objective of this regulation is to prevent the accumulation of hazardous waste in the treated area of a landfarm as a result of decreased microbial activity, hence waste biodegradation, during periods of freezing temperatures.

The metabolism of an organism is very closely tied to temperature. Within the narrow range of temperatures to which the active organism is tolerant, the metabolic rate increases with increasing temperature and decreases with decreasing temperature in a very regular fashion. This well known biological phenomenon has a significant effect on the rate of waste biodegradation by soil bacteria. Essentially the rate of waste biodegradation is dependent upon the metabolic rate of the bacteria which is dependent on temperature. According to Harris (22), microbial activity slows during the cool seasons and ceases when the soils are frozen. Empirically, application of waste to soil during low or freezing temperatures has yielded undesirable results. Francke and Clark (23) reported that low temperatures and above average precipitation has an adverse effect on microbial activity at an experimental waste oil/machine coolant landfarm site in Tennessee. Decreased microbial activity, as a result of low temperatures, were also reported for an oil refinery landfarm in Texas (24).

Besides decreased microbial activity, frozen soils are difficult at manipulate and, as a result, bringing the waste into intimate contact with the soil cannot be effectively accomplished. This results in less of an exposure of waste surface area to biological and chemical attenuation mechanisms. Lewis (24) reported that at an oil refinery landfarm in Texas, operation is discontinued during the winter months because the soil is either frozen or too wet.

Physical characteristics of the waste, such as viscosity, may change significantly with temperature. Kincannon (25) found that at low temperatures (approximately 4.5°C), congealing and solidification of oily waste sludges was a severe problem. He found that mixing of the viscous oily matter into the soil was not successful until ambient temperatures approached 27°C.

Highly contaminated run-off is another potential problem. As a result of poor mixing and negligible degradation at low temperatures, waste applied during the winter can effect contamination of run-off during the spring thaw. In addition, the accumulated waste can overload the soil and destroy the bacterial population. The consequences are the same as a waste spill or an over application of waste. Natural recovery of the soil system is slow and remedial measures are required.

Because of the severity of the consequences associated with applying waste to the soil during freezing temperatures, no deviation from this regulation is permitted.

(4) The pH of the soil-waste mixture in the zone of incorporation shall be equal to or greater than 6.5 and maintained until the time of facility closure.

Note: The pH of the soil-waste mixture in the zone of incorporation may be less than 6.5 provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that hazardous constituents, especially heavy metals, will not vertically migrate a distance that exceeds three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

The rationale for this regulation and the accompanying note are presented in the discussion on paragraph (c)(3). The two regulations differ in that this paragraph requires the pH of the soil-waste mixture to be above 6.5 and maintained until closure. Paragraph (c)(3) requires that the soil of the zone of incorporation have a pH of 6.5 or greater prior to waste application. The objective is to ensure that pH is controlled both prior to and after waste application.

Maintenance of a pH of 6.5 until closure is necessary because the pH - dependent attenuation mechanisms are all reversible. If the soil pH of a site containing heavy metals is allowed to decrease, previously immobilized metals might begin to migrate. Monitoring and maintenance of pH is necessary because it will gradually decrease over time, either as a result of decomposition by-products or, in certain parts of the country, acid precipitation (26). In the latter case, laboratory and field studies have shown that acid precipitation can increase the leaching of certion ions from the soil and decrease soil respiration.

(5) Supplemental nitrogen and phosphorous added to the soil of the treated area, for the purpose of increasing the rate of waste biodegradation, shall not exceed the rates of application recommended for agricultural purposes by the United States Department of Agriculture or Agricultural Extension Service.

The objective of this regulation is to allow the addition of fertilizers to landfarms for the purpose of enhancing waste biodegradation at rates that will not adversely impact the soil microbes or create groundwater or surface water pollution problems.

The benefit of supplemental nutrients in enhancing waste decomposition is well known. Increased rates of waste biodegradation in soils as a result of fertilizer addition have been demonstrated both in laboratory and field experiments. Kincannon (25) reported that supplemental nutrients can increase decomposition by 80 to 100 percent. Highly carbonaceous waste, particularly oily waste, benefit from the addition of nitrogen. Without additional nitrogen, a carbonaceous waste added to the soil creates a carbon-nitrogen imbalance, i.e., a high carbon to nitrogen or C:N ratio. The C:N ratio is perhaps the most important determinant of decomposition rate (20). A large C:N ratio may result in excess nitrate. According to Stewart and Webber (20), a C:N ratio of from 15 to 1 to 30 to 1 is desirable as a general guideline.

The positive attributes of fertilizers are quickly negated when the fertilizer is applied in quantities that exceed the demands of the system. Excess nitrates in the soil can, and do, contribute to contamination of groundwater as a result of their mobility through the soil (4). Overapplication of phosphorous is also a problem. It has been reported that accumulation of phosphorous in surface soil can occur if supply exceeds bacterial or plan demands (20). The excess phosphorous is then available for removal via erosion by surface run-off. Percolation of phosphorous to groundwater is also possible under reducing conditions.

In addition to posing surface water and groundwater pollution problems, excess nutrients can adversely impact, instead of enhance, waste degradation by soil bacteria. Both nitrogen and phosphorous can contribute to excessive total soluble salts which may cause unfavorable osmotic conditions for bacterial growth, and excess nitrogen fertilizer elements can hinder (poison), instead of enhance, bacterial action (25).

Determining the appropriate amount of supplemental nutrients to add to a soil disposal system is difficult because of site and waste specific parameters, and the dearth of information on the subject. Both of these factors make specifying fertilizer application rates based on bacterial needs infeasible at this time. Instead, the selection of fertilizer quantities is based upon agricultural-oriented experience. This is a common practice at many land-farms and has been endorsed as an appropriate environmental and regulatory mechanism (27, 28).

(e) Soil Monitoring

(1) Background soil conditions shall be determined by taking one soil core per acre in

the area to be treated. The depth of the soil core shall be three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater. The bottom one-third of the soil core shall be quantitatively analyzed for those constituents known or expected to be in the waste which make it hazardous. At new facilities, soil cores shall be taken and analyzed prior to beginning operation. At existing facilities, background soil cores shall be taken and analyzed within six months after the effective date of these regulations.

(2) Soil conditions in the treated area of a landfarm shall be determined by taking one soil core per acre, semi-annually. The depth of the soil core shall be three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater. The bottom one-third of the soil core shall be quantitatively analyzed for those constituents in the waste which make it hazardous.

Note: Soil monitoring may be conducted by taking less than one soil core per acre and/or by monitoring less frequently than semi-annually, provided the owner/operator can demonstrate to the Regional Administrator, at the time a permit is issued pursuant to Subpart E, that hazardous constituents, especially heavy metals, will be detected before vertically migrating a distance that exceeds three times the depth of the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

(3) If soil monitoring shows that the concentration of a hazardous constituent in the bottom one-third of the soil core has significantly exceeded the background levels established in accordance with paragraph (e)(1), the owner/operator shall:

(i) Notify the Regional Administrator within seven days;

(ii) Determine, by soil monitoring, the areal extent of vertical contaminant migration in the soil; and

(iii) Discontinue all landfarming in the contaminated area, as determined in (ii), until corrective measures can be taken.

Due to the interrelationship of the three soil monitoring requirements, complete comprehension is best achieved by initially discussing them as a whole and then delving into the purpose and rationale for each regulation.

The overall objective of soil monitoring is to identify physical and chemical changes in the soil conditions of a landfarm that indicate a pending pollution problem. This is accomplished by:

1) establishing background soil conditions;

2) periodically determining the soil condition of the treated area; and

3) taking apprpriate measures when contamination has been detected.

The use of soil monitoring at landfarms has been recognized as the most efficient mechanism by which the efficiency of disposal can be quantitatively assessed.

Recent studies show that chemical analysis of core samples from waste disposal sites permits positive identification of any chemical constituent within the soil profile (29) This is true regardless of whether the chemicals are present in precipitated form in the zone of soil incorporation, are retained in soil particles in the semi-saturated fringe, or are dissolved in groundwater within the zone of saturation. Chemical analyses of soil core samples are usually faster, easier, and more economical than analyses of groundwater samples collected from observation wells (4).

By determining the distribution of a chemical constituent or contaminant in the soil (concentration vs. soil depth), it is possible to discover whether the pollutant is retained in the surface soil or is moving slowly to lower soil depths (30). This information can be used as an early warning of pending groundwater contamination, and as a result, makes groundwater monitoring unnecessary at landfarms. Additionally, EPA is not aware of any documented cases of groundwater pollution as a result of hazardous waste landfarming practices.

A discussion of the rationale/purpose for each paragraph in soil monitoring is presented. The requirements for the number of soil cores per acre, the frequency of sampling, and the analyses of the core samples are, for the most part, identical in paragraphs (e)(1) and (2), therefore, these requirements are discussed together, following the general rationale for paragraphs (e)(1) and (2).

Paragraph (e)(1)

The purpose for establishing background conditions is to provide a point of reference or measure to which another point or measure, obtained during site operation, can be compared (4). Based on this comparison, it will be possible to quantitatively determine whether or not a landfarm is accomplishing its intended function in an environmentally acceptable manner.

Paragraph (e)(2)

The rationale for monitoring the soil of the treated area of a landfarm are covered in the opening discussion on the overall objective of soil monitoring at landfarms.

Soil Core Sampling Requirements

A) One soil core per acre

Requiring one soil core per acre was arrived at as a result of discussions within EPA (31, 32) and members of academia with expertise in the area of landfarming (33, 34). The number is based on the procedures used for sampling the soil conditions of agricultural lands. Normally this involves taking five to seven cores per ten acres. Because of the role soil monitoring plays in the landfarming of hazardous waste, requiring one core per acre was not considered to be an excessive requirement. Taking less than one soil core per acre is permitted provided certain conditions (specified in the note) can be met.

B) Semi-annual soil monitoring of the treated area

Monitoring the treated area of a landfarm at a minimum of two times per year is suggested as being adequate to detect vertical migration of hazardous waste before groundwater is threatened (4). The success of soil monitoring to detect problems is contingent upon adherence by the the facility owner/operator to the other landfarming regulations. When landfarmed properly, waste contaminants in the treated area rarely move beyond the zone of incorporation (4, 18, 25, 35, 36). The Agency acknowledges that some sites may not require semi-annual monitoring because of a certain site parameter or operating practice. This is provided for by the note which requires the owner/operator to demonstrate that waste migration will be detected prior to exceeding three times the depth of the zone of incorporation.

C) Core sample depth of three times the zone of incorporation or 30 centimeters (12 inches), whichever is greater.

In lieu of requiring a fixed core sample depth for all sites, one was selected that is dependent on the depth to which the waste is incorporated into the soil. This means if the waste is to be plowed or tilled into the soil to a depth of six inches, the depth of a core sample would be 18 inches. In situations where the waste is not incorporated into the soil or is incorporated to a depth of less than four inches, the depth of a core sample will be a minimum of 12 inches. In this manner, variability in incorporation methods between sites is taken into account. Additionally, there is a direct relationship between the depth to which a waste is found in the soil profile and the depth to which it is incorporated into the soil (4, 18, 25, 35, 36).

This requirement was developed within EPA and has ~~met with~~ been accepted by State regulatory agencies, industry, and academia.

D) Quantitatively analyze the bottom one-third of the core sample for those constituents known or expected to be in the waste which make it hazardous.

The core sample is composed of three sections, each of which represents a distinct zone. The upper section (top one-third of core) represents the zone of incorporation. This is the zone or layer into which the waste is incorporated or mixed. Data from the literature show that at properly managed landfarms, no migration of waste contaminants occurs beyond the zone of incorporation (4, 18, 25, 35, 36).

The middle section (middle one-third of core) is the buffer zone. Even though data indicate that the extent of migration of waste contaminants is limited to the zone of incorporation, a buffer zone is provided to allow for the effects of within site variability, e.g., the depth of the zone of incorporation may vary from six to eight inches.

The lower section (bottom one-third of core) represents the indicator zone. The presence or absence of waste contaminants in this zone indicates whether or not a landfarm is functioning properly. Contamination of this zone, in view of data from the literature, is considered unacceptable, and appropriate remedial measures must be taken. It is for this reason that only the bottom one-third of the soil core need be analyzed.

Although no precedent for the EPA soil monitoring approach could be found in State regulations or guidelines, a similar approach was arrived at independently by an EPA contractor that recently performed a state-of-the-art study on landfarming practices (4). The contractor, in the "operational recommendations" section, stated that "a landfarm site must be properly monitored to ensure that waste constituents are retained in the layer of incorporation. This can be accomplished by collecting soil samples at three depths (0 to 30, 30 to 60, and 60 to 90 cm) prior to site activation and at 3-to 6-mo intervals thereafter. Soil samples collected should be analyzed for those constituents present in the waste which may result in water pollution problems." The only major difference between this and the EPA approach is the contractors' recommendation of a fixed core sample depth which, as mentioned previously, is considered inappropriate due to variations in incorporation methods. On the whole, the contractor's approach lends complete support to the EPA approach.

Paragraph (e)(3)(i, ii, iii)

This paragraph prescribes the plan of action that must be taken when contamination is detected in the bottom one-third of the soil core. Part (i) of this paragraph requires that the EPA Regional Administrator be notified. The purpose of this is to apprise EPA of the problem and receive technical assistance on remedial measures. Parts (ii) and (iii) of this paragraph require determining the areal extent of contamination and the cessation of waste application in that area. The latter requirement is necessary because application to the contaminated area will only aggravate the problem and lessen the chances of reversing the damage to the soil system. Notably this approach allows site operation to continue, except in the contaminated area, thus preventing a backlog of wastes.

(f) Growth of Food-Chain Crops

Food-chain crops shall not be grown on the treated area of a landfarm.

Growth of food-chain crops upon hazardous waste landfarms is prohibited. The purpose of this prohibition is to protect against human consumption of toxic materials that may adhere to or be taken up by such crops. It is recognized, however, that there may be certain hazardous waste that could be safely applied to land on which food-chain crops are grown if certain management practices are employed. For example, for waste similar to sewage sludge from publicly owned treatment works, it may be possible to develop management controls similar to those that EPA is currently developing for such sludges under Section 4004 of this Act and Section 405 of the Clean Water Act (e.g., control of application rates, soil/waste pH, etc.). However, EPA has considerable data on the effect that

POTW sewage sludge has on food-chain crops. This data made it possible to develop rules for land-farming management controls in lieu of a rule prohibiting the growth of food-chain crops. In contrast, there is a dearth of information on the effects that other types of sludges have on food-chain crops.

Given the potential for high levels of toxic constituents in the hazardous waste that could be landfarmed under these regulations, and the lack of information on crop uptake of contaminants from these wastes, a general prohibition on the growing of food crops is deemed warranted.

(g) Closure

(1) A landfarm shall be designed and operated so that, by the time of closure, the soil of the treated area(s):

(i) is returned to its pre-existing condition, as established in paragraph (e)(1) if the facility began operation after promulgation of this requirement (i.e., a new facility).

(ii) is returned to equivalent pre-existing condition, as determined by soil analysis of similar local soils that have not had hazardous waste applied to them, if the facility began operation prior to the promulgation of this requirement (i.e., an existing facility). Soil analysis of similar local soils shall not be required at existing facilities if background soil data are available and those data establish background conditions for the treated area(s).

(2) Soil of the treated area(s) of a new or existing facility that does not comply with paragraph (g)(1)(i) or (ii), respectively, shall be analyzed to determine if it meets the characteristics of a hazardous waste as defined in Subpart A. In the event the soil is determined to be a hazardous waste, it shall be removed and managed as a hazardous waste in accordance with all applicable requirements of this Part.

Note: The soil at a landfarm, if determined to be a hazardous waste, need not be removed provided the owner/operator can demonstrate to the Regional Administrator that, because of its special design and/or because of its location, the landfarm provides long term integrity and environmental protection equivalent to a landfill as specified in Section 250.45-2. In the event of such a showing, the owner/operator shall comply with the applicable closure and post-closure provisions of Sections 250.43-7 and 250.45-2 (c and d).

The major objective of closure, paragraphs (g)(1) and (2), is to prevent the conversion of huge tracts of productive land to land with limited potential for future use. Meeting this objective requires that the soil of the treated area(s) of a landfarm be returned to its previously existing, ~~e.g.~~ i.e., prior to waste application, condition. New facilities will utilize the soil monitoring background data developed prior to beginning operation. Existing facilities must use the background soil conditions of similar local soils as the basis for comparison unless site data exist that establishes background conditions for the soil of the treated area(s) prior to any waste application. The soil in a landfarm is a filter medium which, when subject to application of waste containing non-degradable contaminants, eventually becomes loaded with such contaminants, especially heavy metals. Left unattended, the contaminants of soil-filter medium will eventually be carried away by surface run-off, or will migrate to groundwater due to natural changes in physical and chemical soil parameters. Therefore, the contaminated soil-filter medium, if determined to be a hazardous waste under Subpart A, must either be decontaminated or disposed of as a hazardous waste.

The Texas Department of Water Resources (TDWR) incorporates a similar approach into some of the permits issued for landfarms. In one case, TDWR requires that final closure shall consist of the removal of all soil to a depth of 12 inches in any area of the disposal site where the soil presents a potential hazard to surface water. This is determined by comparing the results of leaching tests performed on soil from the disposal area and soil from an area that has not had waste applied. A significant increase, over background, of waste materials or degradation products requires removal of the soil.

The note accompanying this paragraph provides for exemption from the soil removal requirement in the situation where a landfarm, because of its special design and/or because of its location, provides long term integrity and environmental protection equivalent to a landfill, as specified in Section 250.45-2. Examples of existing landfarms that might be in this category are the landfarms in California that are required to dispose of Group I wastes (hazardous materials) in Class I disposal sites. Essentially, these landfarms are on landfills and therefore could, if California's Class I disposal sites meet the landfill requirements in Section 250.45-2, be closed in accordance with those requirements instead of paragraphs (g)(1) and (2).

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VII. Appendic~~i~~es

APPENDIX I

Summary of State Regulations Affecting Land Cultivation (1)

APPENDIX I SUMMARY OF STATE REGULATIONS AFFECTING LANDFARMING

State	Pertinent Regulations
California	• There are no specific guidelines or regulations for land cultivation • Spray irrigation guidelines serve as one reference point in evaluating land cultivation applications • The state "Water Reclamation Law" dictates the groundwater quality must be maintained at sites utilizing land disposal of wastewater • Waste for land cultivation must be biodegradable • Group 1 wastes (hazardous materials) must be disposed of in Class I disposal sites
Connecticut	• There are no specific guidelines or regulations for land cultivation • Permits are required for all land disposal operations
Delaware	• There are no specific regulations or guidelines for land cultivation • A permit is required for disposal of waste by land cultivation, just as for any other disposal methods • Review of land cultivation permit applications concentrates on waste characteristics and site characteristics such as soil types and depth to groundwater
Florida	• There are no specific guidelines or regulations for land cultivation • Spray irrigation guidelines are used to some extent as a reference point for nutrient and hydraulic loading considerations related to land cultivation disposal sites

(continued)

State	Pertinent Regulations
Florida (Continued)	
	• Substantially different climatic conditions in different parts of the state make flexible guidelines attractive
Georgia	• There are no specific guidelines or regulations for land cultivation • Permits are not required for land disposal of wastewater if there is no surface discharge. The state reviews plans and specifications to establish the environmental adequacy of all waste disposal methods • Regulations governing spray irrigation facilities prevents the use of spraying without a cover crop
Idaho	• There are no specific regulations or guidelines for land cultivation • Specific spray irrigation regulations requiring that no groundwater mound results and that no salt intrusion be observed on neighboring property is also applied to land cultivation of wastewaters
Illinois	• There are no specific guidelines or regulations for land cultivation • Permits are required
Indiana	• There are no specific guidelines or regulations for land cultivation • Land cultivation has recently received increased emphasis due to groundwater pollution problems which showed up at several sites during the summer of 1976. These sites had operated unsuccessfully the previous years.

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APPENDIX I (continued)

State	Pertinent Regulations
Kansas	• There are no specific guidelines or regulations for land cultivation • Spray irrigation regulations are used for reference in evaluating land cultivation of wastewaters
Kentucky	• Specific land cultivation guidelines are not desired since flexibility in matching wastes and disposal sites is desired. Flexibility is particularly important due to the widely varying terrain experienced with the state • Discharge permits are not required for wastewater land cultivation systems with zero surface discharge, but construction permits are required. Provisions also exist for periodic inspection to ensure proper operation and zero discharge conditions
Maine	• There are no specific regulations or guidelines for land cultivation • Guidelines are currently being prepared for disposal of paper mill sludge by land cultivation • Guidelines have been written for disposal of municipal sewage sludge by land cultivation
Maryland	• There are no specific guidelines or regulations with the exception of certain bacteriological standards which have been set for some food processing wastes • Specific spray irrigation regulations and sludge disposal guidelines aid in the evaluation of land cultivation sites

(continued)

State	Pertinent Regulations
Massachusetts	• There are no specific guidelines or regulations for land cultivation • Certified sanitary landfill facilities must be used for disposal of hazardous waste • Land cultivation requires state approval
Michigan	• There are no specific guidelines or regulations but there are specific procedures required for site investigation prior to granting a permit for land cultivation; monitoring wells are required • Groundwater standards are in the process of being drafted which will be utilized in evaluating future land cultivation sites. All disposal sites will be required to ensure that the neighboring groundwater meets the state standards (which basically will be drinking water standards)
Minnesota	• There are no specific regulations or guidelines for land cultivation • Land cultivation is uncommon except for food processing wastes
Mississippi	• A permit is required from the state for the operation of land cultivation sites; the state must approve each type of waste being disposed at the site • Existing regulations are vague, but there are plans to write specific guidelines for various categories of waste such as oily waste, agricultural waste, etc.

(continued)

APPENDIX I (continued)

State	Pertinent Regulations
New Hampshire	• No specific guidelines or regulations currently exist, but permission to operate a land cultivation facility is required • Permission is granted based on a view of waste composition and site soil types, topography and operating procedures. Permission is granted on a temporary basis contingent on successful test plot results. If test plot application results are successful, a more permanent permission permit would be issued
New York	• There are no specific guidelines or standards of review for land cultivation disposal • The state policy is to discourage land application of toxic waste • Guidelines for spray irrigation are used as an aid in reviewing land cultivation disposal application
North Carolina	• No specific guidelines have been written for land cultivation, but specific evaluation procedures are utilized to evaluate applications • Applications for use of land cultivation disposal requires that a soil scientist and an agronomist review and report on the site to determine appropriate design features and operating procedures • It was indicated that specific regulations are not desired, since flexibility needs to be maintained. In this way, a site appropriate for a specific type of waste can be identified and utlized

(continued)

State	Pertinent Regulations
Ohio	• There are no specific guidelines or regulations for land cultivation • Land application has received little emphasis to date since it is used only sparingly
Oklahoma	• Land cultivation disposal sites are regulated under the "Controlled Industrial Waste Disposal Act, 630S Supp. 1976." This establishes minimum site standards and other factors such as waste storage capacity. Case-by-case analysis is still required to evaluate land cultivation disposal applications • Specific regulatory guidelines were promulgated in response to the large quantities of oily waste requiring disposal (see Table 12)
Oregon	• There are no specific guidelines or regulations for land cultivation • Specific guidelines for municipal wastewater treatment, sludge disposal, and/or spray irrigation are used as a reference point in evaluating land cultivation applications
Pennsylvania	• There are no specific guidelines or regulations for land cultivation • Spray irrigation guidelines are used as a reference for evaluating land cultivation of wastewater • The general policy is to prohibit land cultivation of toxic waste which is not biodegradable

(continued)

State	Pertinent Regulations
Rhode Island	• No specific guidelines or regulations for land cultivation • Off-site disposal of waste requires a permit • Written permission is required if solid wastes are disposed in any way other than landfilling
South Carolina	• Specific guidelines apply to spray irrigation disposal facilities • Specific regulations are written for land farming of cellulosic wastes. Permits are required • Minimum site criteria have been written for hazardous waste disposal • Groundwater monitoring of land cultivation sites is normally required
Tennessee	• There are no specific regulations or guidelines for land cultivation • All types of disposal facilities are required to submit plans for approval. Each site must then obtain an operating registration from the state. Registration is not granted to a site unless the operation is determined to be satisfactory. • Hazardous waste management legislation is in preparation which may have some impact on the types of waste which may be land cultivated • As a general rule, the state does not approve disposal of toxic waste by land cultivation
Texas	• One of the few states which has specific guidelines for evaluation of land cultivation disposal applications. However, these guidelines are fairly general

(continued)

State	Pertinent Regulations
Texas (Continued)	• No permit is required for on-site disposal of waste. However, it is required that such waste disposal be recorded in the property records • The principal focus of the guidelines is to prevent the buildup of toxic materials in the soil. A safety margin is provided between the maximum allowable toxic constituent concentrations and the level at which these constituents may become detrimental to soil productivity (see Table 12).
Vermont	• There are no guidelines or regulations pertaining to land cultivation and there are no specific prohibitions against the use of this disposal method for industrial waste • It is state policy to discourage land cultivation as a disposal method for industrial waste other than food processing waste. Approximately 60 percent of Vermont residents rely on groundwater for their drinking water supply, and therefore, are very sensitive to groundwater pollution potentials arising from land disposal practices
Virginia	• There are no specific guidelines or regulations for land cultivation • Site plans are reviewed to insure that surface and groundwater standards will not be exceeded • There is a general reluctance to utilize land cultivation for disposal of toxic or hazardous waste

(continued)

State	Pertinent Regulations
Washington	• There are no specific guidelines or regulations for land cultivation • State control is exercised principally through NPDES regulatory system, even for sludges • Guidelines have been written for spray irrigation facilities, a relevant feature being that there is a five year limit on spray irrigation at any one site
West Virginia	• There are no specific regulations or guidelines for land cultivation • Land cultivation is seldom used and has received little attention
Wisconsin	• Land spreading of toxic waste is discouraged, although specific regulations have not been written • A possible exception to this general policy would be dilute solution of toxic waste which are biodegradable • A specific permit program exists governing spray irrigation. Information gained from this program can be utilized to help ensure proper design and operation of land cultivation sites

APPENDIX II

Summary of Texas and Oklahoma

Land Cultivation Guidelines

APPENDIX II SUMMARY OF TEXAS AND OKLAHOMA LAND CULTIVATION GUIDELINES

	Guideline (Summary Statement)	
Item	Texas	Oklahoma
• Soils	• Should be deep, prefer high clay and organic content and have large surface area (best soils are classed as CL, OL, MI, CH and OH under the Unified Soil Classification System)	• Should be deep, have large total surface area and have high clay and organic content (best soils are classed as CL, OL, MI, CH and OH under the Unified Soil Classification System)
• Topography	• Prefer surface slopes less than 5 percent, greater than 0 percent	• Slope should be less than 5 percent, greater than 0 percent
• Climate	• High net evaporation, median mean temperature, moderate 24-hr, 25-yr frequency maximum rainfall	• High net evaporation, median mean temperature, moderate 24-hr, 50-yr frequency maximum rainfall
• Surrounding Land Use	• Sparsely populated, or provide buffer and locate downwind from nearby residences	• Sparsely populated, or provide buffer and locate downwind from nearby residences
• Groundwater Conditions	• Avoid shallow potable groundwater. If not possible, provide vegetative cover, avoid high application rates, monitor groundwater quality	• Avoid shallow potable groundwater. If not possible, provide vegetative cover, avoid high application rates, rigidly monitor groundwater quality
• Waste Restrictions	• Not addressed	• Water soluble inorganic industrial wastes should not be land cultivated
• Application Rates	• Minimum waste composition analysis: Cl, PO_4, Total N, Zn, Cu, Ni, As, Ba, Mn, Cr, Cd, B, Pb, Hg, Se, Na, Mg, Ca	• Minimum waste composition analysis: Zn, Cu, Ni, As, Ba, Mn, Cr, Cd, B, Pb, Hg, Se, Na, Mg, Ca, Cl, PO_4, Total N

(continued)

APPENDIX II (continued)

	Guideline (Summary Statement)	
Item	Texas	Oklahoma
• Application Rates	• Determine soil cation exchange capacity (CEC)	• Determine soil CEC if any of the elements in waste composition analysis above are present
	• Total metals application over site life should be less than 50 percent of CEC of top 1 ft of site's soil	• Not addressed
	• If crop grown and harvested at site, total metal application in 30-yr period should be less than 5 percent of CEC	• Not addressed
	• Total N applied in waste, less than 125 lb /ac/yr	• Total N applied in waste, no more than 125 lb /ac/yr, or the maximum amount utilized or assimilated by vegetative cover
	• Annual free water applied in the waste should be less than annual evaporation rate	• Total free water applied should be no more than the net evaporation for time period between applications
	• Not addressed	• Oily waste application rate must be such that soil-waste mixture contains no more than 10 percent oil by weight
	• Not addressed	• Recommended application rate for oily wastes at established (over 6 mo old) sites: - 35 bbl oil/ac/mo - without fertilizer - 60 bbl oil/ac/mo - with fertilizer

(continued)

APPENDIX II (continued)

Item	Guideline (Summary Statement) Texas	Oklahoma
• Operational Restrictions	• All runoff must be contained (use dikes or lined control collection basin) unless discharge permit is obtained. Collection basin should contain 25-yr, 24-hr maximum rainfall	• All runoff must be contained unless discharge permit is obtained (use dikes or lined central collection basin). Collection basin must contain all site runoff from a 50-yr, 24-hr maximum rainfall.
	• Soil pH must be maintained at above 6.5 while the site is active	• Soil pH must be maintained at above 6.5 while site is active
	• Mix waste into soil as soon as possible	• Mix waste into soil as soon as possible
	• Vegetation for human or animal consumption must be analyzed for metals contained in the waste before feeding	• Vegetation for human or animal consumption must be analyzed for metals and any elements in the waste which are known to be concentrated by the plant species before use or sale
• Mixing Frequency	• Not addressed	• Dependent on rainfall. Recommended practice is to mix twice monthly for first 2 months, then once every other month
• Mixing Depth	• Not addressed	• Sludge should be mixed into soil to a depth of 6 to 12 in

BD-30

RESOURCE CONSERVATION AND RECOVERY ACT

Subtitle C - Hazardous Waste Management

Section 304 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

DRAFT

BACKGROUND DOCUMENT

Section 250.45-6 Chemical, Physical, and Biological Treatment Facilities

December 15, 1978

U.S. Environmental Protection Agency

Office of Solid Waste

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft for comment. As new information is obtained, changes may be made in the regulations, as well as in the background material.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Timothy Fields, Jr.
U.S. Environmental Protection Agency
Office of Solid Waste
Hazardous Waste Management Division (WH-565)
401 M Street, S.W.
Washington, D.C. 20460

Legislative Authority

Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (Pub. L. 94-580, hereinafter called the Act), creates a legislative framework to control hazardous waste. Congress has found that such waste presents "special dangers to health and requires a greater degree of regulation than does nonhazardous solid waste" (Sec. 1002(b)(5)). Because of the seriousness of this waste problem, Congress intended that the States develop programs to control it. In the event that States do not choose to operate this program, the U.S. Environmental Protection Agency (EPA) is mandated to do so.

Subtitle C creates a management control system which for those wastes defined as hazardous requires "cradle-to-grave" cognizance, including appropriate monitoring, recordkeeping and reporting throughout the system. Section 3001 requires EPA to define criteria and methods for identifying and listing hazardous wastes. Those wastes which are identified or listed as hazardous by these means are then included in the management control system constructed under Section 3002-3005 and 3010. Those that are excluded will be subject to the requirements for nonhazardous solid waste being carried out by States under Subtitle D under which open dumping is prohibited and environmentally acceptable practices are required.

Rationale

The legislative purpose of Subtitle C of the Act was to provide EPA with the mechanism to not only identify wastes which are hazardous, but to recommend methods of treatment, storage, and disposal which will render such waste nonhazardous.

The Act clarifies this goal under Section 3004 (3)(4) which states that the facility is to be designed, located, and constructed to treat, store, and dispose of hazardous waste in accordance with operating methods, techniques, and practices as may be satisfactory to the Administrator of EPA.[2] Congressional history further emphasizes that, most important of all, Section 3004 will require the disposition of hazardous waste in facilities specifically designed for their disposal, and incorporating safeguards necessary to protect human health and the environment.[3] The Agency (EPA) has documented in its damage files many incidents resulting in human health and environmental damage which could have been prevented if the waste would have been properly treated prior to disposal.[4]

This document specifically addresses chemical, physical and biological treatment of hazardous waste. The Agency considers treatment a preferred means of waste management over disposal techniques such as landfilling, because treatment can detoxify, decrease volume, and in some cases recover raw materials. This in turn reduces the total amount and the quantity of toxic waste entering less preferred methods, such as disposal, thus diminishing the potential for human health and environmental damage.

Treatment techniques vary widely, and thus it is very difficult to write specific standards which apply to all possible chemical, physical and biological treatment systems. In addition, wastes are generally treated by a combination of chemical, physical, and biological systems which not only change for different types of waste, but also varies within a particular industry for identical wastes. Thus, each waste process combination tends to be unique. For these reasons, the Agency wants to encourage a certain degree of flexibility in the matching of treatment processes with waste types.

Since treatment processes are tailored to fit the individual requirements of the facility and the hazardous waste being handled, measures used for reducing emissions or discharges cannot easily be generalized. The Agency's approach is to present general, flexible regulations which will be applicable to all process/waste combinations. General, flexible regulations will also encourage innovation and indirectly will encourage treatment in preference to disposal, since the flexible nature of the regulations will probably make them easier to comply with. The Agency will depend on a case-by-case evaluation of the individual suitability of each process and process/waste combination by the permitting official to provide control. Specific conditions will be added to the permit to implement the findings of his evaluation. He will be assisted in making his evaluation by a manual which will contain detailed technical information on each process and process/waste combination. Data on test results both successes and failures, will be included. This will be updated periodicly as the permitting and monitoring processes yield additional information.

The rationale for most of the regulations are self explanatory. The regulations which provide basic control are those requiring a trial or test prior to permitting and the requirement for an automatic cut-off. The trial will constitute a test of the environmental suitability of the waste/process combination. The test protocol will ensure a thorough evaluation and conditions will be placed on the permit to implement findings of the test. The automatic feed cut-off will be tied to sensors for critual process parameters (pressure, temperature etc.). Therefore, if there is an upset in the normal process, the waste feed will be stopped automatically, eliminating the possibility of emissions or other environmental problems.

Another unreported protective provision requires the removal of hazardous residuals upon closure. This provision ensures that hazardous waste will not remain in the area so as to provide a continuing ~~beyond~~ hazard. Should a facility owner/operator desire to leave hazardous residuals on-site after closure, it will be necessary to obtain a disposal permit and comply with the regulations therefor.

Presented in Appendix I are a series of brief summaries on applications, operations, and design of methods for chemical, physical, and biological treatment.

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[2]Resource Conservation and Recovery Act, U.S. Code, Vol. 42, Sec. 3004 (1976).

[3]U.S. Congress, House, Report of the Committee on Interstate and Foreign Commerce, H. Doc. 94th Cong. 2nd, Sess., 1491, pp. 28, 57.

[4]U.S. Environmental Protection Agency, "Damage Cases," (EPA Docket, 1978).

APPENDIX I

METHODS OF CHEMICAL, PHYSICAL, AND BIOLOGICAL TREATMENT

Carbon Absorption

In..uction

Carbon absorption is a surface phenomenon[1]. It is normally considered plicable where:[2,3,4,5,6] (1) an impurity is in very dilute concentration; (2) an purity is sufficiently valuable to warrant recovery; (3) the waste is partially or ally non-combustible and the waste is toxic to biological growth, such as leachates m landfills; (5) the waste is predominantly inorganic or non-biodegradable, and; the waste is seasonal or periodic.

Carbon in one of the most versatile and economically attractive solid absorbents. her commercially important solid absorbents are acid-treated clays, bentonite, mina, bauxite, and fuller's earth[7].

Carbon absorption can be used as a tertiary treatment stage for removing r..ctory organics following other modes of treatment. When impurity concentration low some waste streams may be treated more economically at their source[8]. rbon absorption, combined with other physical-chemical processes, has been shown be a technically feasible alternative to conventional secondary wastewater treatment; several pilot and full scale physical-chemical plants have been designed[9,10,11]

Theoretical Considerations

The absorption process is a chemical and physical bonding of an absorbate molecule to an absorbent surface. Strong bonding between an absorbate and an absorbent resulting in an irreversible union is referred to as chemical absorption. Weak bonding, typically characterized by Van der Waals' forces, resulting in a union which is generally reversible is noted as physical absorption. It is physical absorption which is most frequently used for the removal of impurities from waste streams.

Feundlich and Langmuir developed the equations most often used to describe absorption equilibrium. The quantity of absorbate that can be tied up by an absorbent is a function of temperature and absorbate concentration. Normally, isothermal conditions are obtained and the amount of impurity absorbed is determined as a function of concentration.

The Feundlich isotherm equation for a single absorbate is:[12,13]

$$\frac{X}{M} = p\,(C)^{1/q}$$

where $\frac{X}{M}$ = Amount of absorbate removed per unit weight of absorbent.

C = Equilibrium concentration of absorbate in solution following absorption.

p, q - Empirical constants

The Langmuir isotherm equation for a single absorbate is:

$$\frac{X}{M} = \frac{ijC}{1 + jC}$$

where $\frac{X}{M}$ = Amount of absorbate removed per unit weight of absorbent.

C = Equilibrium concentration of absorbate in solution following absorption.

i, j = Empirical constants.

This equation assumes that there are a fixed number of available sites, each h equivalent energy on the absorbent surface and absorption is reversible. When rate of absorption of molecules onto the surface of the absorbent is equal to the e of desorption of molecules from the surface, equilibrium is reached. The rate a_orption is the difference between the amount absorbed at the influent concentra- and the maximum concentration that the absorbent can remove at that influent centration. At equilibrium this difference is zero[15].

There are three steps involved in the absorption of constituents from solution porous absorbents: (1) transport of the absorbate through a surface film to the erior of the absorbent; (2) diffusion of the absorbate within the pores of the absorbent; absorption and bonding of the solutions on the interior surface of the absorbent. ps 1 and 2, film and pore diffusion are generally considered rate limiting since ilibrium of non-porous absorbents is rapid[16,17,18].

Several factors which affect absorption are surface area of the absorbent, physical and chemical characteristics of the absorbate, pH and temperature[19,20].

The extent of absorption is proportional to the total surface area that is available for absorption; therefore, as the solid absorbent becomes more finely divided and more porous, greater absorption characteristics normally are reflected[21,22].

Physical and chemical features displayed by the absorbate generally dictate its absorption tendencies. Absorption[23,24]: (1) increases with decreasing solubility of the absorbate in the carrier stream; (2) increases as molecular size of the absorbate decreases; (3) decreases with increasing ionization of the absorbate, and (4) increases with a polar absorbate in a non-polar carrier stream in contact with a polar absorbent and decreases when the carrier stream becomes polar and the absorbent non-polar.

Absorption of an absorbate is affected by the pH of the carrier stream, generally absorption increases for organic absorbates with decreasing pH. This may result from neutralization of negative charges at the surface of the absorbent as the hydrogen ion concentration is increased. This, in effect, reduces hindrance to diffusion and increases the availability of the absorbents active surface. Furthermore, the degree of ionization is governed by pH affecting the absorption of acidic and basic absorbates[25,26].

Temperature variations in wastewater streams only have a similar affect on absorption. Absorption reactions are generally exothermic and, therefore, absorption increases with decreasing temperatures[27].

Process Applicability, Description and Design Considerations

Carbon absorption has been cited for use in removing color, organics, inorganics, taste, and odor [28, 29, 30, 31]. It has been used to treat wastes from food processing, textile, chemical, and pharmaceutical concerns, battery manufacturs (mercury), and Federal Services (Agent Orange contaminated with TCDD (2, 3, 7, 8 - tetrachlorodiben 80-p-dioxin and TNT from munitions waste water).[32]

Mercaptan and inorganic sulfur bearing compounds responsible for taste and odor in wastewater have been successfully removed by carbon absorption [33, 34].

Guisti, et al, have reported a considerable amount of data on the absorption of organics using activated carbon. Organic compounds containing less than four carbons were shown amenable to carbon absorptions as follows: undissociated organic acids, aldehydes, esters, ketones, alcohols, and glycols. The alcohols move ahead of the esters for straight chain compounds above four carbons[35].

The removal of inorganic trace elements such as silver, cadium, chromium, and selenium using activated carbon was shown by Linstedt, et al, to be an effective mthod for removal[36].

Absorption systems are normally composed for three basic components: (1) absorption treatment equipment for the wastewater, (2) carbon reactivation equipment, and (3) carbon and water transport arrangment[37].

Absorption treatment equipment or absorbers bring the wastewater into contact with the absorption media. The absorber consists of an inlet and outlet distributor system and an upper and lower support for the bed of absorption media. The media may be supported on a mechanical grid or on inert catalyst support-balls.

If the bed is deep, intermediate supports may be necessary. Screens may be used instead of support-balls to retain the absorbent from above. Normally, U.S. standard 20 mesh screen size is recommended for particles ranging from 1/16 to 1/8 inch in diameter[38]. The absorbers can be designed for pressure or gravity flow to achieve the desired contact time between wastewater and carbon. Flow rates are generally less than 10 gpm/ft.^{2} of carbon bed. Industrial wastewater generally has contact times in excess of 60 minutes versus domestic wastewater which is about half that. The media bed is usually greater than 10 feet in depth[39].

To ensure uniform distribution throughout the bed, with a minimum amount of flow channeling, sample plenums should be provided, at the inlet and outlet. This can be achieved with coarse support-balls or free volume[40].

Tanks are generally constructed of stainless steel or steel coated with rubber or epoxy to prevent corrosion. Other systems may employ wooden tanks or cement basins, where gravity feed is used[41].

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Membrane Processes

troduction

Membrane processes are seeing more and more application in industrial waste team treatment. Features which make membrane processes appealing for industial use include[1,2]: (1) separation of dissolved materials from one another or om the waste stream without a phase change, (2) a physical barrier in the form a membrane between the product and the waste stream without a phase change, less energy consumption than either vaporization or crystalization, and (4) only all temperature changes in product and waste stream.

Membrane processes are typified by a fluid containing two or more components contact with one side of a semi-permeable boundary and the other side is in contact th a fluid that receives the component that transverses the boundary. The boundary membrane is a mass of polymer chains containing interstitial spaces through which lecules or ionic species can pass[3]. The membrane phase is usually heterogeneous nature. Physically it is a dry solid, a solvent-swollen gel or liquid that is immoized[4]. The degree of cross-linkage determines the extent of inhibition that takes ce with respect to certain species transferred through the membrane. The driving rce may be an electrical potential as in electro-dialysis or a hydrostatic pressure in reverse osmosis[5].

REVERSE OSMOSIS

Theoretical Considerations

Reverse osmosis is one of several membrane processes which is becoming more popular as a method for treating and/or recovering various species found present in industrial waste streams.

This is accomplished when two solutions of different solvent activity are separated by a semi-permeable boundary or membrane. Fluid transport through the membrane occurs in the direction of lower chemical potential until a thermodynamic equilibrium across the membrane is reached[6]. The pressure head across the boundary is the osmotic pressure. Osmosis or osmotic pressure is a function of both temperature and pressure and results from the unequal bombardment of a semi-permeable boundary by solvent molecule. This unequal bombardment is due to the presence of solute molecules on one side of the membrane. Thus, the differences in solvent pressure increases with increasing amount of solute[7]. By applying an external pressure to overcome the osmotic pressure, the chemical potential levels are reversed and the flow through the membrane is in the opposite direction to the lower chemical potential[8,9]. The efficiency of the membrane to transport solvent is a measure of production or flux. Flux is the amount of solvent recovered per unit time per unit area of membrane[10]. Mechanisms where selected species move across a membrane include[11,12]: (1) molecular sieving, where there is a difference in solvent and solute molecule size and flow is restricted to certain species based on size of the membrane; (2) diffusion, where the flow of solvent is dependent ressure gradient across the membrane and the flow of solute is determined oncentration gradient across the menbrane, and/or (3) dissolution of solute, ydrogen bonding between the solute and the membrane increases the amount e available for diffusion. Thus, alcohols, amines, amides, and carboxylic hich are capable of donating and accepting protons permeate membranes better esters, aldehydes, ketones and sulfones which can only accept protons[13].

nce a concentration gradient is established and the flow of solvent proceeds, eased concentration of solute at the membrane surface can cause several detri- effects such as: (1) decreased reverse osmosis solvent-flow driving force nal pressure due to increased local osmotic pressure; (2) increased solute ration in the product due to concentration polarization; (3) decreased membrane to increased concentration of various waste constituents at the membrane s; and (4) precipitation of soluable salts and particulate matter on the membrane due to the effects of concentration polarization. Concentration polarization atio of solute concentrated at the membrane surface to the solute concentration ffluent waste stream. The concentration potential is proportional to the re- of product. High product recovery can be maintained at low concentration tion by recycling the effluent waste stream and/or by increasing turbulence e membranes[14].

olute rejection is the ratio of the concentration differences of that specie the membrane to the bulk concentration of that specie present in the influent tream. Normally, solute rejection conforms to the following rules[15]:

(1) rejection increases as ion valence increases; (2) rejection is greater for dissociated species than for partially dissociated species; (3) salts are more strongly rejected than their acid or base form; (4) high molecular weight, water soluble organics are strongly rejected, and; (5) undissociated low molecular weight organic acids are slightly rejected whereas their salts are strongly rejected.

Process Applicability, Description and Design Considerations

Reverse osmosis has been used: (1) to treat dilute pulping waste[16]; (2) to treat or recover soluble organic chemicals[17,18]; (3) to remove phosphorous and nitrogen containing compounds[19,20]; (4) to desalt brackish water[21,22]; (5) to recover metals from plating and metal finishing wastes[23]; (6) to treat textile and petro-chemical waste[24]; (7) to remove pesticides[25]; and (8) to remove precipitant ducing chemcials[26].

There are basically four types of reverse osmosis premeators: (1) plant and frame; (2) tubular; (3) spiral wound; and (4) hollow fine fiber[27,28,29]. The most widely used membranes for reverse osmosis applications are cellulose acetate and polyamide. The polyamide membrane has an advantage in that it is more chemically and physically stable than the cellulose acetate membranes. However, cellulose acetate membranes have a higher water permeability rate and lower compaction characteristics which in the past have made it the membrane of choice[30]. The active surface of the membrane has a thickness of 3 to 2500 angstrom[31,32,33]. The pH range for the cellulose acetate membrane, to prevent membrane hydrolysis, is 3 to 8[34,35]. The polyamide membrane can be operated at a somewhat higher pH of 5 to 11[36].

Temperature, pressure, and concentration (within limits) determine the rate permeability or flux through a membrane. Operating temperature and pressure normally 0 to 32 $^{\circ}$C and 50 to 1500 PSE, respectively[37, 38, 39, 40]. From 15 30 $^{\circ}$C, water flux increases about 3.5% per degree increase. Similarly, as ssure increases, the separation of solute increases. However, if both temperature pressure are not controlled within the limits of operation for a particular mem- ane, filter deterioration is accelerated. At temperatures above 30 $^{\circ}$C most mbranes become unstable showing poor selectivity and loss of strength, while essive pressure can cause membrane compaction affecting membrane efficiency life[43].

The flow rates through reverse osmosis units are on the order of 2.5 to ,000 gallons per day. Flux through these units range from 7 to 12 gallons/day/ are feet of membrane for cellulose acetate and polyamide membranes[44, 45, 46] namic membranes formed from zirconium oxide, fulvic acid, and polyacrylic acid ve fluxes on the order of 100 to 200 gallons/day/square feet of membrane[47, 48].

In order to promote membrane life and prevent flux decline, due to impaction fouling, waste streams can be pretreated prior to reverse osmosis. Generally, treatment schemes involve: (1) suspended solids and precipitating compounds moval; (2) temperature and pH control; and (3) disinfection to prevent the growth organisms on reverse osmosis equipment. In those cases where the concentration of lloidal matter and precipitate is not excessive, flux decline can be prevented by riodic membrane cleaning and/or backwashing without extensive pretreatment[49].

ELECTRODYIALYSIS

Theoretical Considerations

Electrodialysis is a process whereby ionic components in solution are separated through semi-permeable, ion selective membranes employing an electrical potential gradient as the driving force[50,51].

When chemical compounds are dissolved in solution, positively charged cations and negatively charged anions form. In the presence of an electric field, cations migrate towards the negatively charged cathode while anions migrate in the opposite direction, toward the positively charged anode. By alternating cation-exchange membranes (only permeable to cations) and anion-exchange membranes (only permeable to anions) across the electric field it is possible to concentrate ions between a pair of membranes leaving the solution ion-free between the adjacent pair[52].

The amount of current carried by an ion in solution is generally proportional to its size. Small cations such as hydrogen, proceed through the solution at a higher velocity and, therefore, carry a greater current than would larger cations or anions such as potassium or chlorine. The transference number is that fraction of the current carried by an ionic species[53].

The flow of solution through the unit creates a velocity gradient between the membranes and becomes static at the boundary layer of each membrane. Ion movement through the solution near or at the boundary layer is only by electrical transfer and diffusion. However, near or at the center, ions are transferred electrically, by diffusion and by physical mixing[54].

The selectivity of the membrane affects the transference number of the ion. Ions X^+ and Y^- each have a transference number of 0.50 in solution, because the on-exchange membrane is only selective for X^+, the transference number is y 1.0 for X^+ and 0.0 for Y^-. Similarly, the transference number of Y^- respect to the anion-exchange membrance is 1.0 and 0.0 for X^+. Since Y^- carries 50% of the current in solution (transference number being 0.50 in tion) but 100% of the current when passing through the anion-exchange membrane sference number being 1.0 in the anion-exchange membrane) and if one faraday lectricity passes through the membrane and solution, then 0.5 gram equivalents Y^- would be transferred to or away from the membrane surface and 1.0 gram ivalents would be transferred through the anion-exchange membrane. This results depletion of Y^- on one side of the anion-exchange membrane and a concentration Y^- on the other. This is the desired effect with respect to electrodialysis process. ever, if the current density (amps/square feet) is increased to the point where completely depleted on one side of the membrane and totally concentrated on other, concentration polarization results. At this point, hydroxide ions form from ionization of water and pass through the anion-exchange membrane. This in turn eases the pH of the solution in the Y^- concentration zone and can lead to the ipitation of calcium carbonate or magnesium hydroxide on the surface of the brane. In addition, dimensional changes in the anion-exchange membrane can r from the passage of hydroxide ion through the membrane. Also, the increasingly water at the surface of the membrane increases the resistance of the membrane increasing the energy requirements for the process[55]. Concentration polari- n can be limited by controlling the rate of current density to concentration in ilute stream and by achieving smaller boundary layer thickness through hydro- mic channel design[56].

Process Applicability, Description and Design Considerations

Electrodialysis systems have been employed[57,58,59]: (1) for desalination of brackish water and whey; (2) to treat and/or recover constituents from metal plating and finishing wastes; (3) to recover heavy metals such as chrome, lead, mercury, copper, and silver; (4) to treat battery manufacturing waste; (5) to treat wood pulp wash water; (6) to treat glass etching solutions; (7) to denitrify agriculture run-off; (8) for demineralization; and (9) to recover organic chemicals.

The ion-exchange membrane used in electrodialysis must have good perm-selectivity for ions of opposite charge, a low water transport number, be a reasonably, good electrical conductor and be physiochemically stable[60]. Commercial membranes have the appearance of a sheet of plastic and generally consist of cross-linked polystrene. The attached groups on the polymer are what gives the membrane its selective characteristics. A ploymer with sulfonate groups ($-SO_3H$) attached would be a cation membrane, ionizing to form a mobile counter-ion of hydrogen (H^+) and a fixed negative charge ($-SO_3^-$). The polymers of an anion membrane may have a quarternary ammonia group ($-NR_3^+OH^-$) attached to it. Upon ionization it would produce a mobile counter-ion hydroxyl group (OH^- and a stationary positive charge ($-NR_3^+$)[61,62].

A stack of these membranes terminated at each end with an electrode and plate comprises an electrodialysis system. The membranes and electrodes are compressed between the end plates and resembles a plate-and-frame filter press. One section of the system consists of a cation and anion membrane in that order. The compartment between the membranes is the desalting zone while the compartment adjacent to the cation and anion membrane on the cathode and anode side respectively are con-ration zones. The unit or cell pair is about 0.1 inch thick and consists of a cation brane, a desalting zone, an anion membrane and a concentration zone[63].

Flow through the unit is critical in controlling polarization. This can be ac- plished by using small channel spacings to contain and direct the flow, high ulation velocities, and turbulence promoters[64].

Spacer design determines flow patterns through the unit. the tortuous path oys a coiled spacer arrangement which provides a longer resistence time for olution. High linear velocity and presssure drop are necessary to reduce con- ation polarization in this type of unit[65]. The flow velocity for the tortuous system ranges from 0.33 to 1.6 feet/second[66]. Sheet flow spacer design con- of an open frame with a plastic sheet separating the membranes. The plastic serves to promote turbulence in the unit. Flow velocity for the sheet flow n ranges from 0.17 to 0.33 feet/second[67].

Commercial stack size for electrodialysis systems range from 0.25 feet^2/ er with 4.95 feet^2 of membrane/stack to 21.52 feet^2/spacer with over 25,000 of membrane/stack. At 20-50% salt removal, large stacks have a capacity 0,000 gallons/day[68]. The total capacity of installed electrodialysis facilities estimated to be greater than 20 x 10^6 gallons/day[69].

Operation of electrodialysis systems are generally conducted as: (1) continuous with stacks arranged in parallel or series; (2) batch with recirculation; and ed and bleed continuous flow where influent concentration is adjusted with ict[70,71].

Ancillary equipment should be lined or coated with plastic to avoid stray rical currents and the introduction of metal ions into the system[72].

To prevent process plugging and membrane fouling, influent to the electrodialysis system should be pretreated to check suspended matter and the possibility of salt precipitation. For those waste streams which are low in these substances, pretreatment can be minimized by periodic cleaning and/or backwashing of the unit[73].

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Filtration

Introduction

Filtration units for the removal of impurities present in industrial effluents can be utilized: (1) in combination with oxidation-reduction precipitation; (2) in combination with flocculation-sedimentation; (3) as a pretreatment for more sensitive physicochemical processes; or (4) as an individual unit operation.

Types of units include deep granular filters (single medium, dual media, and multimedia) and precoat filters (diatomaceous earth and perlite). Granular filter media usually consists of sand, crushed anthracite coal, diatomaceous earth, perlite or combinations thereof. In the past diatomaceous earth and perlite filters have found a variety of applications in treating industrial waters[1].

Theoretical Considerations

The process variables and mechanisms involved in particulate matter removal by a filtration unit exhibit complex relationships. Process variables include[2]: (1) filter media grain size, shape, and density; (2) filter media porosity; (3) media headloss characteristics; (4) filter bed depth; (5) filtration rate; (6) allowable headloss; (7) influent characteristics; (8) filter bed charge; and (9) fluid characteristics. Process variables 1, 2, 3, 4, 5, and 9 are used as design criteria for determining the clear water headloss through the medium. Process variables 7, 8, and 9 are necessary in understanding the biological and chemical properties of the waste stream to be filtered. Influent characteristics such as: (1) suspended solids concentration; (2) floc or particle size and distribution; (3) floc strength; (4) floc or particle charge; and (5) the charge associated with the filter media will affect the length of the filter run, chemical dosage (when applicable) and/or the filter

ency[4,5]. Removal mechanism for filtration processes are[6,7,8]: (1) strain-
echanical and/or chance contract); (2) sedimentation; (3) inertial impaction;
terception; (5) chemical absorption (bonding and/or chemical interaction);
ysical absorption (electrostatic forces, electrokinetic forces and/or van der
s forces); (7) adhesion and adhesion forces; (8) coagulation-flocculation; and
ological growth. Removal mechanisms 1 through 5 are physical or mechanical
ure, while 5 through 9 are related to the chemical and surface characteristics
suspended matter and the filter bed. Physical mechanisms are related to
as physical parameters of the filter medium, such as grain size, porosity,
epth. Particle charge, chemical compositions, and chemical additions are
sary factors to describe mechanisms involving chemical and surface character-
[9,10].

Precoat filters remove solids by mechanical straining whereby a cake of solids
on the influent side of the filter media. Depending on particle size removal
ids in deep granular filters may be by mechanical straining (large particles)
ombination of transport and attachment mechanisms (small particles). The
port mechanisms brings the particle from the bulk solution to the surface of
edia by gravitational settling, diffusions, interception, and/or hydrodynamics.
is affected by such physical characteristics as filter media, filtration rate,
emperature, and the density and size of suspended particles. Attachment
nisms may involve electrostatic interaction, chemical bridging or specific
ption. These are affected by the chemical characteristics of the influent and
ter media. These mechanisms for removal in deep granular filters may take
simultaneously but as the filter run progresses, the dominance of both the

transport and attachment mechanisms may change. This changing of removal mechanisms can affect effluent quality and the headloss characteristics of the filter[11,12]

Hydraulic flow through a porous filter medium generally follows Darcy's Law for laminar flow in a clean filter bed. As the void spaces available for flow becomes clogged due to the accumulation of particulate matter on the filter surface, the flow velocity through the voids increases. If the filtration rate is to be constant, an increase in energy to overcome frictional losses within the filter is necessary. This is considered a headloss or a decrease in the total energy of the water across the filter bed. At the point when the headloss affects effluent quality, system economics, and/or desired flow rate, the filter unit must be removed from the system and the media cleaned or replaced[13].

cess Applicability, Description and Design Considerations

Filtration systems are generally used in conjunction with other unit operations processes for the removal of suspended solids, flocculated organics, and inorganic ipitates. Specific systems have been cited for removal of iron oxide, scale, and grease from steel mill rolling process wastewater and trace inorganic allics[14,15,16].

The critical segment of a filtration unit is the medium. The medium should such physical and chemical characteristics as to allow it to[17]: (1) hold a large tity of filtered matter; (2) provide good effluent clarity; and (3) be readily ned by backwashing.

Common sand specifications for deep granular filters are a depth of 24 to 30 es with an effective grain size of 0.45 to 0.55 mm and a uniformity coefficient eater than 1.65. Normally, an anthracite-sand filter will include 12 to 24 es of anthracite and 6 to 16 inches of sand. A typical dual media filter, designed low about 6 inches of intermixing during backwashing, would employ 12 inches lter sand (effective size 0.5 to 0.55 mm, uniformity coefficient less than 1.65) 12 inches of crushed anthracite coal (effective size 0.9 to 1.0 mm, uniformity ficient less than 1.8)[18,19]. A multimedium filter would generally use 3 inches rnet (effective size 0.2 to 0.6 mm, uniformity coefficient less than 1.0), 12 es of sand (effective size 0.4 to 0.8 mm, uniformity coefficient 1.2 to 1.6), 15 inches of anthracite (effective size 1.0 to 2.0 mm, uniformity coefficient to 1.8)[20]. Typical flow rate for both dual and multimedium filters is 6 gpm/ t. of filter bed and ranges from 2 to 12 gpm/sq. ft. of filter bed[21,22,23].

r units can either employ pressure or gravitational flow.

Filter operation cycle averages one day, but can vary from approximately 0.5 to 2.0 days, at which time the filter unit is taken out of service and back-washed[24,25]. High velocity backwash normally results in a 15 to 30% expansion of the media at a flow rate of 15 to 19 gpm/sq. ft. of filter bed[26]. In cases where additional bed agitation is necessary to free filter medium of particulate matter, high velocity water jets have been shown successful. The jets should be 2 to 3 inches above the level of expansion with a flow located 2 to 7 gpm/sq. ft. of filter bed at 45 to 75 psig. The distribution system may either be fixed pipe or rotating arm[27].

The underdrain system supports the filter medium, distributes the backwash water, and prevents loss of filter media. A layer of graded gravel over the under-drainage system is necessary to prevent loss of filter medium where influent orifices are larger than grain size[29]. Design parameters for manifold and lateral systems to accommodate wash rates of 4 to 22 gpm/sq. ft. of filter bed are[30]: (1) diameter of perforation 1/4 to 1/2 inch; (2) spacing of perforations 3 to 12 inches; (3) spacing of laterals 3 to 12 inches; (4) ration of cross-sectional area of manifold to the sum of the cross-sectional area of the laterals served 1.75 to 2.0; (5) ratio of sum of the area of the orifices to the total filter area 0.0015 to 0.005; and (6) ratio of lateral length to its diameter less than 60.

The wash water gutter should be designed to carry the maximum wash rate with 2 to 3 inches of free fall into the channel at the upper end[31].

Precoat filtration utilizes a thin layer (1/16 to 1/8 inch) of diatomaceous earth or perlite which is wasted at the end of each filter cycle[32].

The tank or precoat unit is either pressure or vacuum driven. The unit consists of a septa which supports the filter medium and directs filter effluent to a collection manifold[33]. Septum arrangement is basically of two designs: (1) vertical leaf filters h have a number of flat septa closely spaced on a filtrate collection header; and ylindrical septum filters where the septa are arranged horizontally[34,35]. About o 0.2 pounds of diatomite or perlite makes up the filter bed[36]. Filter cycles ery short due to the hydraulic compression of solids on the precoat. Longer runs can be promoted by adding filter aid or body feed during the filtration d. The mixing of solids and filter aid results in a more porous filter cake hus a longer filter cycle[37]. The desired length of a filter cycle is 24 hours at continous attendance would be unnecessary for manual operations[38]. Pressure s also have a longer filter cycle over vacuum units due to higher available pres- (headloss through a vacuum filter typically being 20 feet as opposed to 100 feet ressure units)[39]. The filtration rate is generally from 0.5 to 2.5 fpm/sq. $ft.^2$ ter bed with an optimum body feed of 25 to 200 mg/liter. This, however, may set by higher power costs when comparing vacuum pressure precoat filters.

FOOTNOTES

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Coagulation, Flocculating, and Precipitation

Introduction

The removal of many impurities from industrial waste streams can be accomplished by coagulation and flocculation, or precipitation. Many impurities which are physically too small or chemically stable in the carrier stream will not gravitationally settle. Unit operations such as coagulation, flocculation and precipitation have been successfully employed to aid in the separation of impurities from their liquid vehicle. The application of natural or synthetic agents with or without pH adjustments can be used to promote settling. The aggregation of impurities into settleable colloids involves two distinct steps: (1) the transport of particles to effect interparticle contact; and (2) particle destabilization to permit attachment when contact occurs.[1] Coagulation is the affect of both transport and destabilization while flocculation applies to only transport.[2]

Theoretical Considerations

Coagulation is concerned with the aggregation of unstable colloids. Unstable or irreversible colloids owe their apparent state to charge and solvation effects.[3,4] The charge associated with most colloidals in waste streams is negative. The magnitude of which is frequently affected by pH and ionic content of the carrier stream. Since the primary charge on the particles is counter balanced by the carrier stream, an electric double layer exists at every interface between a particle and the carrier liquid. This results in an ionic concentration gradient with an increase in the concentration of carrier stream ions at the surface of the particle, decreasing with increasing distance from the surface. Thermal agitation causes these carrier ions to diffuse so that the two competing processes (diffusion vs. electrostatic attraction) can spread the charge in the carrier liquid over a diffuse layer establishing the ionic concentration gradient as described[5].

Chemical coagulants can bring about destabilization of colloids by four different mechanisms[6]: (1) diffuse layer compression; (2) absorption to produce charge neutralization; (3) enmeshment in a precipitate; and (4) absorption to allow interparticle bridging.

Ions of different charge (counter-ions) to the primary charge of the colloid are attracted while those of similar charge are repelled. Destabilization of a colloid is brought about by charge neutralization at the surface of the colloid by increasing the concentration of counter-ions in the waste stream. The coagulant effectiveness of these ions tends to increase with increasing charge[7,8].

Colloid-carrier liquid interaction can affect the ability of a coagulant to neutralize colloidal charge and thus bring about destabilization. Therefore, carrier liquid molecules which are firmly bound to the colloidal particle must be removed if a direct coagulant-colloid bond is to form[9]. This is accomplished by adding coagulants which have a greater affinity for the colloid than does the carrier liquid and in sufficient quantities to promote neutralization.

Rapid precipitation of metal hydroxides ($AL(OH)_3$, $Fe(OH)_3$, $Mg(OH)_2$ or metal carbonates ($CaCO_3$) can enmesh colloidal particles in their precipitates as they are formed. Coagulants such as metal oxide or hydroxide (CaO or $Ca(OH)_2$) and metal salts ($AL_2(SO_4)_3$, $FeCl_3$) if used in sufficient concentration can produce this effect. The greater the amount of colloidal particles in the carrier liquid, the lower the amount of metal coagulant required to accomplish its removal.[10]

High molecular weight polymers (synthetic organics, activated silica) destabilize colloidal particles by bridging. Generally, anionic polymers provide greater economical treatment even though the impurities in the waste stream are also negatively charged. This is accomplished by functional groups on the polymer whsich are absorbed onto the surface of the particle forming a polymer-particle complex. Interaction between polymer-particle complexes results in bridging and thus destabilization [11, 12].

Interparticle contact can occur by several mechanisms: (1) contact by thermal motion or perikinetic flocculation, often termed Brownian motion or Brownian diffusion; (2) contact resulting from bulk fluid motion or orthokinetic flocculation, as in stirring; and (3) contacts resulting from rapidly settling particles overtaking and colliding with more slowly settling particles [13].

Precipitation is the formation of an insoluble product from formation ionic species whose concentration is such that their solubility product is exceeded. A metal salt (MA) in a very dilute solution can be assumed to be completely ionized. The solubility(s) of MA can then be expressed as

$$S = [M+] = [A-]$$

and the solubility product (Ks) is:

$$Ks = S^2 = [M+]\ [A-]$$

The final concentration of the cation [M+] in solution is dependent on the concentration of the union [A-] in solution. Temperature, ionic strength, and the presence of other dissolved species can alter the solubility equilibrium. [15]

Since the hydroxide or oxide salt of a metal is generally insoluble, precipitation is accomplished and dependent on proper pH control.

Process Applicability, Description and Design Considerations

Coagulation and flocculation or precipitation have been shown applicable for (1) the removal of suspended solids;[16,17] (2) treatment of leachate from landfills and wastes containing toxic substances;[18] (3) dye color removal from textile wastewater;[19] (4) removal of organic content and color from spent vegetable tanning solution;[20] (5) metals removal;[21,22,23,24] (6) phosphorus removal;[25,26,27] and (7) treatment of paint industrial wastewater.[28]

Coagulation in a flowing, dispersed system is more enhanced than by Brownian motion alone. Although turbulent flow increases the rate of coagulation for micron size particles, it also breaks up larger size particles (approximately 100 mm) and impedes sedimentation.[29] Coagulating dispersed particles in a flocculator has another disadvantage in that the flow field is not homogenous. A possible alternative to this is for coagulation to occur in a turbulent pipe transporting in the dispersion directly to the sedimentation tank.[30]

Sedimentation units are generally rectangular or circular in shape with horizontal or incline flow.[31] Circular tanks have diameters from 40 feet to 100 feet, with depths of 7 to 12 feet.[32,33,34] Rectangular units have a maximum length and width of 300 feet and 80 feet respectively.

Length to width ratios of 3:1 and 5:1 are common with a width to depth ratio of 2:5.[35,36] Loading rates have been cited from 200-900 gpd/sq. ft. with rates exceeding 600 gpd/sq. ft for flow rates greater than 1.0 mgd.

Detention times for sedimentation tanks normally ranges from 0.25 to 4.0 hours, with little increase in the degree of sedimentation occuring after 2 hours.[41,42,43,44,45,46,47,48]

The detention time for flash or rapid mixers with turbine or flash mixing is in the order of 2 to 5 minutes with times as low as 10 seconds being cited.[49,50]

Inorganic coagulant dosage has been shown to be 145 to 175 mg/l. While organic flocculant dosage is generally less than inorganic (20 to 60 mg/l) the chemical cost is higher.[51,52,53] In large plants, lime can be reused by recalcination of spent lime sludge driving the cost of this inorganic coagulant even lower.[54]

Flocs with good settling properties have been produced in 10 to 30 minutes.[55,56] In all cases, chemical reagent dosage for coagulation, flocculation, and precipitation should be determined by jar testing and whenever possible by pilot plant studies.

Chemical precipitation is based upon the addition of a chemical reagent to precipitate the desired or chemically plausible amount of hazardous component. Solubility product knowledge is sufficient for design of simple waste streams. However, as the waste stream becomes more complex several factors must be considered:[57]

(1) Simultaneous precipitation of several compounds, and co-precipitation;

(2) Complexation by ammonia, cyanide, polyphosphates, tartrate, oxalate, and other materials; and

(3) Metals which exhibit amphoterism, e.g., aluminum

and chromium which have minimum solubility at a definite pH.

Precipitation does not require complex system design or control for most applications. The operating mode is either batch or continous depending on the type and size of the waste stream to be treated. Waste streams requiring long reaction times or processes producing small or intermittent flows are appropriate for batch operations, whereas, large streams with uninterrupted flow may require continous systems.

Equipment types generally include:

(1) Influent Equilization- Holding tanks or basins with agitators are used in continous feed processes to create a more uniform constant stream to the reactor;

(2) Reagent Storage - The physical and chemical properties of the reagent dictates the type of storage facility to be used. Caustic solutions, for example, may be stored in open or closed tanks while quicklime is kept in waterproof silos, hoppers, or bags. Feed rate and delivery schedules form the bases for determining storage capacity;

(3) Feed and Delivery- Liquids and slurries or reagents or waste streams are delivered to the reaction vessel by pumps while solid reagents require conveyors and dispensors, and ancillary equipment such as lime shakers; and

(4) Agitation and Reaction- The reaction vessel or tank design generally follows the same criteria as discussed earlier. Tanks used for precipitation with subsequent flocculation and sedimentation may have a conical base used as a settler. Tanks may be round, square, or rectangular and may be built above or below ground. Agitation is mild, so that particle agglomeration is not inhibited, utilizing propeller or turbine type impellers.

Construction materials vary with types of chemical reagents and waste stream characteristics. In addition, the expected service life, operating temperature, physical strength, flow rate, and mechanical abrasion must be considered when selecting such materials.

At ambient temperatures examples of recommended materials for handling different acids and alkalies are:[59]

(1) Concentrated sulfuric acid (75%-95%) can be handled with lead while more dilute solutions (10%) may require only rubber;

(2) Hydrochloric acid at all concentrations-rubber and sodium hydroxide concentrated - rubber or stainless steel;

(3) Dilute sodium hydroxide can be accommodated with carbon steel or cast iron; and

(4) Calcium hydroxide can be handled with stainless steel, rubber, or carbon steel.

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Ion Exchange

[illegible]duction

The swapping of one ion for another or ion exchange has been used for the [illegible]val of hazardous impurities and the recovery of valuable constituents found [illegible]ent in industrial waste streams[1,2].

Design and selection of resins allow the ion exhcnage system to be tail[illegible]ed [illegible]pecific absorpton applications[3]. The process is stable, predictable and operates [illegible]a high degree of efficiency in most cases[4,5,6]. Resins are normally regenera-[illegible]n site using basic, acidic and salt solutions and/or regenerable nonaqueous sol-[illegible][7]. Ion exchange is economically competitive with other treatment processes [illegible]rms of capital investment, operation and maintenance[8]. This fact, plus the [illegible]r advantages mentioned above makes ion exchange a unit operation worth consid-[illegible]g when treating an industrial waste.

Ion exchange processes, however, are not without drawbacks. Normally, the [illegible]e stream must be pretreated to ensure that the influent to the ion exchange vessel [illegible]ee of suspended solids to prevent particulate fouling of the resin bed[9]. Other [illegible]lems associated with the system are resin losses and mechanical failures that [illegible]lt in operational shutdown[10]

Theoretical Considerations

Ion exchange is a process whereby ions of similar charge in a solution are exchanged for ions held by electrostatic forces to charged functional groups on the surface of a solid immersed in that solution[11].

The nature of the functional groups determines the exchange capacity, exchange equilibrium, and the selectivity of the ion exchange resin[12,13]. Functional acid groups such as sulfuric ($R-SO_3H$), phenolic (R-OH), carboxylic (R-COOH), and phosphonic ($R-PO_3H_2$) are cation exchangers or those resins capable of exchanging cations. Functional groups for anion exchange resins are primary amine ($R-NH_2$), secondary amine (R-R'NH), tertiary amine ($R-R'_2N$) and the quaterary ammonium group ($R-R'_3N^+\bar{O}H$). Both cases, the R represents the resin and the R' an organic ...dical such as the methyl group[14,15].

The charge carried by the functional group is balanced by a counter charge ...ssessed by the resin maintaining electroneutriality. The driving force is due to concentrational differences between the ions in solution and the ions in the resin[16,17]. The exchangeable ions of an acidic cation resin may be either hydrogen or some monovalent cation such as sodium, whereas the exchangeable ion for a basic anion resin may be the hydroxide ion or some other monovalent anion. The exchange between the ions in solutions and the ions in the resin will continue until equilibrium is attained. Thus, there are two characteristics typified by an ion-exchange reaction: (1) the reaction always involves an equivalent transfer of ions; and (2) every exchanger will be selective for one ion over another[18].

The rate at which ions are exchanged between the solution and the resin is controlled by one of two diffusional transport processes: (1) film diffusion or the diffusion ns across a hypothetical film of solution surrounding each particle of exchange

, and (2) pore diffusion or the diffusion of ions through the interstitial pores

e resin particle itself[19].

The selectivity of a resin for the exchange of ions is dependent upon ionic ge and ionic size, the former being the more significant. Thus, for typical ns and cations found in wastewater, the following order of selectivity would be ectively[20]:

$$PO_4^{3-} > SO_4^{2-} > Cl^-$$

$$Th^{4+} > Nd^{3+} > Ca^{2+} > Na^+$$

Normally, ions of higher ionic charge are preferentially exchanged for thos of charge. Some exceptions are as follows[21]:

$$SO_4^{2-} > I^- > NO_3^- > CrO_4^{2-} > Br^-$$

When ions are of equal charge, the ion with the smallest radius in solution eld more tightly by a resin. Thus, for the alkali metals and the alkaline arth als the order of selectivity is respectively[22]:

$$Cs^+ > Rd^+ > K^+ > Na^+ > Li^+$$

and

$$Ba^{2+} > Sr^{2+} > Ca^{2+} > Mg^{2+} > Be^{2+}$$

Similarly, for monovalent anions the order of selectivity is :

$$CNS^- > ClO_4^- > I^- > NO_3^- > Br^- > CN^-$$

$$HSO_4^- > NO_2^- > Cl^- > HCO_3^-$$

$$CH_3COO^- > OH^- > F^-$$

Factors which affect the rate of exchange and/or the selectivity of the resin are mixing, flow rate, resin particle size, solution concentration, and resin cross linkage. The rate of exchange increases as the flow rate and/or the mixing increases and the resin particle size decreases. The rate of exchange and the selectivity of the resin and the rate of exchange are inversely proportional to the cross linkage of the resin[24, 25].

It is the selectivity and rate characterists of ion exchange resins which can often be exploited to handle specific hazardous waste streams with a high degree of efficiency.

Progress Applicability, Description and Design Consideration

Ion exchange processes have been employed in the past to treat waste streams for the removal and recovery of: (1) heavy metals such as mercury, chrome, aluminum, gold, silver, platinum, manganese, palladium, zinc, and nickel[26,27,28]; (2) color and minerals[29,30]; (3) soluable organic compounds[31,32]; (4) nitrogen and phosphorus[33,34,35,36,37] and (5) radioactive isotopes.[38]

The treatment of industrial wastes can be somewhat complicated by the presence of materials or conditions which may clog, attack or foul resins. Suspended solids and other matter can clog a resin bed, inhibiting flow and reducing the efficiency of ionic transfer.[39] Strong oxidizing agents such as nitric acid can attack resin crosslinks having a detrimental effect on performance.[40] The pH of the waste stream has been shown to have a considerable affect on the exhange characteristics on various resins. The optimum range being 4 to 8.[41,42,43] Generally, resins are stable at temperatures to 100^{o} C or higher.[44,45]

For ease of regeneration and maintenance, ion exhange systems should be built in duplicate. This allows one unit to be taken off line while one unit remains active. Exchangers are usually constructed as vertical cylinders with top to bottom flow. Exchangers usually range in depth from 2 to 6 feet.[46,47,48] Depending on the resin, 50 to 100% of the packed bed height is allowed for expansion.[49,50,51] All tanks and internal parts which come into contact with the strong acid or alkali regenerant should be lined or coated with resistant materials, such as phenolic or vinyl chloride polymer. The plastic coatings are generally about 0.01 inches in thickness while hard rubber liners are about 0.2 inches in thickness.[52,53] The flow rate through the exhanger is normally 5 to 10 ft/sec.[54,55,56,57] Head loss through a pressurized exchanger is approximately 1 to 2 feet with a pressure loss of a few pounds per square inch.[58,59]

Conductivity or pH is frequently used to monitor the performance of low exchange systems.[60] While the waste stream is being treated monitoring should be directed at those species of interest. If a number of different species are being removed simultaneously, monitoring should be conducted on those species which are known to be the least strongly bound to the resin.

This can be accomplished by using electrochemical monitors, such as ion selective electrodes or by simple color tests available in kitforms. During the regeneration phase of ion exchange, conductivity or pH may be more than adequate.[62]

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Oxidation-Reduction

Introduction

Redox or oxidation-reduction reactions are characterized by a loss of electrons (oxidation) or a gain of electrons (reduction). Organic oxidation-reduction reactions include not only complete electron transfer but the transfer of any hydrogen species other than the proton or any oxygen species other than an oxide or the hydroxide ion[1].

The purpose of such a redox reaction is to convert potentially hazardous chemical substances to less harmful or more desirable species. The most effective oxidants with respect to cost, handling, process compatability, and treatment efficiency are ozone, permanganate, chlorine and chlorine dioxide[2].

Theoretical Considerations

Those substances which function as an electron acceptor are considered oxidizing agents while a reducing agent is any material which serves as an electron donor. Thus, depending on the oxidation state of the agent and the reaction conditions, a given element can assume either role.

Reactant concentration, temperature, system composition, and impurities play a primary part in reaction kinetics. However, due to the atypical characteristics of most industrial waste streams, kinetic relations should be determined experimentally.

The use of catalysts such as silica, clays, metal ions, and activated carbon may be beneficial in promoting reaction pathways of lower activated energy thus accelerating reaction rates[3].

One of the most influential parameters in redox reactions is the pH. The rate of oxidation may be affected by pH as a result of one or more of the following effects: (1) changes in the free energy of the overall reactions; (2) variations in the reactivity of constituents; and/or (3) special hydroxide ion or hydronium ion catalysis.

General trends of organic compounds with respect to oxidative reactivity is as follows[4]: (1) high reactivity-phenols, aldehydes, aromatic amines, thioalcohols, thioethers; (2) medium reactivity-alcohols, alkyl-substituted aromatics, nitro-substituted aromatics, unsaturated alkyl groups, carbohydrates, aliphatic ketones, acids, esters, and amines; and (3) low reactivity-halogenated hydrocarbons, saturated aliphatic compounds, benzene.

Process Applicability, Description and Design Considerations

Redox reactions have been used for the: (1) oxidation of cinnabar (HgS) in acid minewaters[5]; (2) reduction of mercury and lead compounds[6]; (3) treatment of textile wastes[7]; (4) oxidation of phenols and reduction of chemical oxygen demand[8,9]; (5) treatment of metal finishing wastes[10,11,12]; (6) treatment of wastewater with oxy-aromatic and heterocyclic aromatic compounds[13]; oxidation of weak black liquor from pulp mills[14], and (7) radioactive contaminants[15].

Ozone is an effective treatment for industrial wastes due to its powerful oxidizing potential and lack of adverse side reactions. Present disadvantages relate mainly to the cost and efficiency of ozone generating equipment making it only economical on a large scale, and/or closed systems. This can be examplified by comparing the theoretical production of 1058g of ozone produced per kilowatt hour (kW-hr) of electrical energy with that of most industrial generators of only 150g/kW-hr[16]. The most efficient application of ozone is in a closed system where the ozone has immediate contact with the waste stream. Several mechanisms are employed to promote maximum contact of ozone and waste stream.

The Otto partial-injector system utilizes a head drop across the face of the injector to mix the ozone with the solution as it passes through the injector at about 14 ft. of head. The ozonated solution moves to an upflow reactor where oxidation takes place prior to discharge[17].

A rapidly rotating propeller is used to draw ozone through its porous base while mixing it with the waste solution. The Kerag system employs this action at the bottom of the reaction column where oxidation takes place[18].

A third method uses an ozone-solution misdirection in conjunction with a porous diffuser at the bottom of the contact chamber to mix and promote oxidation[19].

Permanganate treatment of industrial wastes has the added advantage over ozone of being easier to feed and monitor. The disadvantage is in separating the insoluable hydrous manganese dioxide. Potassium permanganate is physically a dark purple solid and chemically very reactive. It has been used for the destruction of organic residuals, such as, aldehydes, mercaptans, phenols, and unsaturated acids.[20] Permanganate dosages range from 0.5-2.0 ppm (as KMnO) depending on the waste stream being treated and the operating conditions. This can be controlled somewhat by adjusting the pH (decreasing dosage with increasing pH) or by the addition of a suitable catalyst. In systems which employ activated carbon as a treatment step, oxidation should take place prior to absorption due to reduction of the permanganate by the carbon.[21]

Hydrogen peroxide is another highly reactive oxidizing agent used to remove chlorine (following chlorination treatment) and iron. In processes where post treatment of the wastewater involves distillation or crystallization all unspent peroxide must be removed because these techniques tend to concentrate the unused reagent.[22]

Chlorine has been used in alkaline solutions for the oxidation of cyanide. The use of chlorine or chlorine dioxide for treatment of waste streams high in organic content should be joined with carbon absorption to prevent chloronated hydrocarbons from entering the environment. The toxic and highly unstable nature of chlorine and chlorine dioxide makes handling the storage somewhat precarious when in the gas form. However, both are stable once in solution. Generally, the oxidative potential of chlorine is still widely used due to its cost effectiveness, availability, oxidizing power, and adaptability.[23]

Base metals (i.e., iron, aluminium, and zinc), sulfur dioxide and sulfite, and ferrous sulfate are reducing agents which have found some applicability in hazardous waste treatment. Reducing agents however, may introduce new ions into the process stream which can result in further treatment requirements.[24]

Of those agents only sulfur dioxide a gaseous, high toxic irritatent requires special care in handling.[25]

Construction materials must be chosen for each design process to protect personnel and to ensure equipment ~~file~~ life.

Construction materials for dry chlorine are steel, stainless steel, cast iron, wroughtiron, copper alloys, nichel alloys, and lead. Wet chlorine, however, can only be handled at low pressure in chemical stoneware, glass, or porcelain by high silica iron, monel metal and Hostalloy.[27]

Steel and other common structural metals can be used under dry conditions for storing sulfur dioxide. In the presence of moisture lead, type 316 stainless steel, and plastics (i.e., ABS, PVC polyester, and epoxy glass) are recommended.[28]

Storage of oxidation and reduction agents should be in cool, well ventilated areas. Vent location is dependent on the agent since some gas agents are heaver than air. Agents which are highly reactive when contacted by various organics, moisture or other agents should be segregated and stored in fireproof areas.

Many oxidation and reduction reactions are sensative to pH. Monitoring and control of the system is therefore achieved by pH control and by use of oxidation/reduction electrodes. Temperature control is also important and may require heat exchange equipment or additional detention time to reduce heat from oxidation reactions which are generally exothermic.[29]

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Activated Sludge

Introduction

The activated sludge process utilizes a flocculated suspension to accumulate and store a bio-mass. The microbial population may be specifically adapted or acclimated to handle certain toxic organic and inorganic wastes; however, shock loading or high accumulation through absorption or bio-concentration of these substances may result in process failure[1,2].

The use of air or pure oxygen in an activated sludge process is[3]: (1) to supply the metabolic oxygen requirement of the heterotrophic treatment organisms, and (2) to produce mixing within the reaction vessel. Thus the transfer of gases through the various phases within a reactor is critical to the removal of colloidal and dissolved substances for which biological processes are designed[4].

Theoretical Considerations

The mass transfer scheme of a gas being dissolved in a liquid occurs in four steps[5]: (1) the movement of gas through the vapor phase to the gas-liquid interface; (2) the passage of the gas through the gas film of the gas-liquid interface; (3) then the passage through the liquid film of the gas-liquid interface; and (4) the dispersion of the gas throughout the bulk of the solution. In quiescentor stagnant conditions the rate limiting step is considered the diffusion of the gas through the bulk of the solution. If the solution is sufficiently agitated by mechanical or forced air mixers, the rate limiting step comes the rate of transfer through the gas-liquid interface[6].

Since the constituents which make up air are non-reactive in water, with the xception of carbon dioxide, their respective solubilities are directly proportional to their partial pressure. As the concentration of impurities, the concentration of substances which react with the gas, and the temperature of the liquid increase the solubility of the gas in the liquid decreases. Thus the solubility of oxygen in waste-water is generally less than 95% of that in pure water[7].

Once the oxygen is in solution it can be absorbed by the biosphere and utilized in the detoxification and degradation of the matter present in the waste stream.

ocess Applicability, Description and Design Considerations

Activated sludge systems have been cited for: (1) the removal of heavy metals m waste streams [8,9,10]; (2) detoxification of bleached kraft mill effluents [11,12]; the treatment of feedlot runoff [13]; (4) the treatment of complex plastics manufacturing stes [14]; and (5) the treatment of industrial wastewaters in general [15].

The three basic systems for aeration and gas transfer are compressed gas, pirators, and mechanical agitators [16,17].

Compressed air systems are of two types, diffused air or dispersed-air systems. a diffused air system, the air is normally filtered, to prevent fouling, then passed rough porous plates or tubes, porous membranes or wound fibers or metallic filaents [18]. For a diffused air system, the reactor depth and width is usually restricted 15 and 30 feet respectively. An air feed rate of 3 cfm per lineal foot of reactor 20 to 30 scfm/1000 cu. ft. of tank volume is necessary to provide a transverse locity of 1.5 fps in order to accomplish vertical transverse roll [19,20]. To prevent tivated sludge flocs from settling, a velocity of 0.5 fps across the reactor bottom necessary [21].

Oxygen-transfer efficiencies of 12% or more have been shown for compressed-r systems, corresponding to a transfer rate of approximately 1.8 lb/(hp)(hr) under andard rating conditions. More frequent rates occuring in wastewater are 0.5 - 8 lb/(hp)(hr).

Dispersed-air systems include both impeller or turbine dispersion devices d stationary devices such as orifices, spargers, and shear devices. Turbine or peller dispersion systems maintain an air feed rate of 0.2 cfs per square foot of actor area with an oxygen transfer efficiency up to 25% or about 2.5 lb/(hp)(hr) [22].

Air aspirator systems are either mechanical or hydraulic in nature. Mechanical ors are hollow-blade impellers or vortex generating devices which move with ent force to discharge atmospheric air into the solution. A transfer rate of ..5 lb. oxygen/(hp)(hr) are common for mechanical aspirators. Hydraulic pirators utilize a venturi tube or similar device to create a low-pressure condition he waste being pumped through it. This in turn draws atmospheric air into the n. For atmospheric air systems, oxygen transfer rates can be as low as 1 lb. s per horsepower hour. However, hydraulic aspirators operating with compressed ı have rates as high as 6 lb. oxygen/(Hp)(hr)[23].

Mechanical aerator systems include surface aerators and aerator pumps[24]. e aerators are either the horizontal axis brush type or the vertical axis turbine Typical power requirements for mechanical aerators is 0.50 to 1.0 hp/1000 cu. reactor volume[25]. The transfer rate of brush aerator is about 3.5 - 5.0 lb. n/(hp)(hr). Aeration pumps are normally turbines associated with a draft tube. aste is pumped over a weir or through a set of vanes by the turbine which is d near the surface of the solution. Turbine type aerators have a transfer rate - 7.5 lb/(hp)(hr)[26,27].

Typical aeration tank dimensions for activated sludge reactor channels range 0 to 17 feet in depth, 15 to 33 feet in width, and 30 to 100 feet in length[28,29]. liquor volatile suspended solids maintained in the reactor ranges from 500 to mg/l[30,31,32,33].

The sludge age or mean cell residence time for activated sludge units can be an 0.25 days or greater than 34.0 days[34,35,35,37]

Activated sludge reactors have displayed detention times ranging from 0.5 to

38, 39, 40, 41
hours

Since industrial wastes are generally atypical with chemical oxygen demands
some cases exceeding ten times that of domestic wastewater, pilot plant studies
›uld be conducted in order to determine loading criteria, reactor type, sludge
›duction, oxygen requirements and effluent characteristics.

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Resource Conservation and Recovery Act

Subtitle C - Hazardous Waste Mangement

Section 3004 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

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BACKGROUND DOCUMENT

Section 250.46 Standards for Special Wastes

a. Cement Kiln Dust Waste

b. Utility Waste

c. Phosphate Rock Mining, Beneficiation, and Processing Waste

d. Uranium Mining Waste

e. Other Mining Waste

f. Gas and Oil Drilling Muds and Oil Production Brines

U.S. Environmental Protection Agency

Office of Solid Waste

December 15, 1978

This document provides background information and support for regulations which are designed to protect the air, surface water, and groundwater from potentially harmful discharges and emissions from hazardous waste treatment, storage, and disposal facilities pursuant to Section 3004 of the Resource Conservation and Recovery Act of 1976. It is being issued as a draft to support the proposed regulations. As new information is obtained, changes may be made in the regulations, as well as in this background material.

This document was drafted to reflect information received and Agency decisions. EPA made changes in the proposed Section 3004 regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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Table of Contents

1. RCRA Mandate and Authority

The Congress of the United States, via Section 3004 of Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976 (Pub. L. 94-580), mandates that the Administrator of the U.S. Environmnental Protection Agency promulgate regulations establishing performance standards applicable to owners and operators of hazardous waste treatment, storage and disposal facilities as may be necessary to protect human health and the environment. These standards are to include, but need not be limited to, requirements respecting: (1) operating methods, techniques, and practices; (2) location, design, and construction; and (3) contingency plans for effective action to minimize unanticipated damage that might occur at these facilities.

All provisions of this Act (including Section 3004) must be integrated with the Clean Air Act (42 U.S.C. 1857 and following), the Federal Water Pollution Control Act (33 U.S.C. 1151 and following), the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135 and following), the Safe Drinking Water Act (42 U.S.C. 300f and following), the Marine Protection Research, and Sanctuaries Act (33 U.S.C. 1401 and following) and such other Acts of Congress as grant authority to the EPA Administrator. A stated purpose of the above requirement was to avoid duplication to the maximum extent possible. Such integration, however, is to be effected only in a manner consistent with the goals and policies expressed in RCRA and the above-listed Acts.

This document provides the background for regulations to be promulgated under this framework of authority. Rationale is provided for the special wastes concept and for the specific regulations for facilities that treat, store, and disposel of individual special wastes.

2. <u>Rationale for Section 250.46 Special Waste Standards</u>

Upon enactment of RCRA, the primary focus of the regulatory effort was toward control of the toxic and otherwise hazardous residues from production and subsequent air and water pollution control processes associated with the manufacturing industries. However, in the course of preparing the Subtitle C regulations, it became clear that additional wastes would enter the control universe by virtue of their characteristics when compared to the characteristics of hazardous wastes developed under Subpart A. For some of these wastes, the Agency has very little information with respect to composition and characteristics, the degree of hazard posed by the wastes, the effectiveness of current or potential waste management technologies, and the technical and economic practicability of imposing the Subpart D standards on facilities managing these wastes. The limited information that the Agency does have, however, indicates that these wastes occur in very large volumes, that they generally do not move far from the point of generation, that the hazard levels appear to be low and that they are not generally amenable to the control techniques developed in Subpart D.

3. <u>Rationale for Designating Wastes as Special</u>

In the foregoing Section, the rationale for a "special waste category was presented. In this section, the rationale for designating specific wastes as special" is discussed. The Agency chose to designate wastes as "special" based on the following criteria:

1. Lack of information on waste characteristics
2. Lack of information on the degree of environmental hazard posed by disposal
3. Lack of information on waste disposal practices and alternatives
4. Very large volumes and/or large numbers of facilities
5. Limited movement of wastes from point of generation
6. Few, if any, documented damage cases
7. Apparent technological difficulty in applying current Subpart D regulations to the waste
8. Potential high economic impact if current Subpart D regulations are imposed

By and large, criteria (1), (2), and (3) are the driving force in the decision - making process, although the other conditions are met to some degree in each case.

4. <u>Identification of Regulatory Options</u>

Options available to the Agency for dealing with these wastes when they are hazardous include:

1. Apply all Subpart D regulations to special waste facilities in the same manner as other facilities.

2. Apply only procedural regulations such as manifest and reporting requirements monitoring regulations, access control requirements, and in a few cases, some tailored control regulations designed to minimize specific hazards.

3. Exempt special waste facilities from Subpart D regulation until more information can be gathered.

5. <u>Analysis of Regulatory Options and Identification of Chosen Regulatory Option</u>

Option 1 has the advantage that <u>all</u> hazardous wastes are subject to the regulation; thus removing the need for EPA to defend why certain wastes are singled out for special treatment when inadequate management of them might pose a hazard to human health and the environment. On the other hand, due to a lack of information, the Agency is unable to adequately assess the hazards posed, or the technological or economic practicability of imposing the Subpart D regulations By implementing Option 1 now, the Agency could be imposing substantial economic burden on the economy for little or no net environmental benefit. Thus, option 1 was rejected.

Option 3 eliminates the potentially high economic impact and allows time to investigate the hazards posed and to tailor any necessary regulations. It does not, however, provide a mechanism to gather information on movement, volumes, potential damages, and so on. Further, there are no regulations at all to provide basic protection, such as access control.

Thus, Option 2 was chosen by the Agency. The limited regulations were chosen for inclusion based on the following criteria:

1. Provides protection from known or strongly suspected hazards
2. Limits direct access to the wastes
3. Causes data to be gathered and reported on volumes, characteristics, movement, and extent of environmental hazard posed by current management practices, i.e., monitoring data
4. Does not impose costly technical and financial requirements until further information on their necessity and practicality can be gathered.

These limited regulations will be implemented by rule, i.e. ,eligible facilities complying with the regulations will be considered as having a permit under Subpart E (permit regulations). Additionally, eligible facilities must comply with the notification requirements of Section 3010 and Subpart G.

Only facilities or processes within facilities which handle the "special" waste only, are eligible for this status. For example, land disposal operations which mix "special wastes" with other hazardous wastes, will not be eligible.

6. Rationale for the Application of Specific Subpart D Regulations to Special Waste

This section will discuss which of the Subpart D regulations are incumbent on special waste facilities, to what extent, and why. The other regulations were not included because they were not thought to be necessary to carry out the limited control program previouwly discussed. It is not practical to discuss each of the Subpart D regulations here, so only those chosen are included. Most of the regulations are similar for each of the "special" wastes. There are, however, some requirements which are applicable only to one waste. These are pointed out in the next section.

General Facility Standards. Special wastes are generally exempt from the general facility standards (250.43), except those dealing with waste characterization samples. The other general facility standards concern treatment, storage, and disposal, which impose high impacts and which are not necessary for data gathering purpose or to control access. However, the waste sampling requirements are necessary because waste characterization information is essential to devising substantive standards.

General Site Selection (apply to new sources only)

The general site selection standards provide basic prohibitions on siting of facilities in areas where the facility could readily harm the environment or the environment could readily harm the facility. Thus, they constitute a very basic level of protection and the Agency believes they should be observed in locating new facilities. These standards will not be imposed on existing facilities for the present due to the impracticability of relocating existing wastes.

Security. Fences, signs and controlled access are the requirements for security. Such standards provide a basic protection by limiting unauthorized and unknowing access to the wastes. Economic impacts of instituting these controls are not prohibitive even for the large volume wastes.

Manifest System, Recordkeeping, and Reporting. The purpose of the manifest system is to safeguard the transportation of wastes from one location to another, usually from the jurisdiction of one company to another. Most special wastes are disposed on site, due to the volumes involved. In cases where there is insufficient land on site, or the site is located in a wetland or a floodplain, the waste is transported nearby to a facility owned by the generator or by a contractor acting as an agent of the generator. The waste is transported either by pipeline or by truck to a site which is usually less than ten miles away. However, where the waste is treated or disposed off site, the manifest system is a toll which provides basic assurance that the waste leaves the generator and arrives at the disposal site. The cost is minimal, thus, manifests will be required for hazardous special wastes shipped off site.

The recordkeeping requirements include keeping track of the waste, its location, analyses of the waste, monitoring data, visual inspections, closure requirements, and operating information. As discussed elsewhere, special wastes are to be exempt from contingency plan and training requirements and, therefore, the recordkeeping requirements related to these activities are not necessary. The other records are necessary for reporting purposes.

The reporting requirements include potentially damaging incidents, problems with monitoring systems, monitoring data, and notice of closure. Also included is an annual report covering volumes, sources and types of waste received, and methods of disposal and treatment. While there are unlikely to be any potentially damaging incidents in special waste facilities, the occurrence of any such incidents would be cause for concern and should be reported. Because special wastes which are classified as hazardous are likely to fail the toxicity standard, it is important that monitoring data be provided and that problems with the monitoring system be corrected. Also, if the waste is classified as hazardous, care will need to be taken regarding closure of the facility.

Information of this type is essential if the Agency is to prepare substantive regulations to cover these wastes. Thus, all of the reporting requirements will be mandatory for special wastes.

Visual Inspections. The visual inspection Section requires daily inspection and recording of the physical condition of the facility. Visual inspections are a low cost way of providing general oversight of operations for any kind of facility and are often incorporated as a good operating practice. They can also be used to provide an early warning of possible public health and environmental problems. The Agency believes all facilities should carry our such inspections.

Closure and Post Closure. The Agency has little information on useful closure procedures for "special" waste facilities and thus has decided to defer the technical standards for implementing closure. To gather information on possible environmental problems, however, the Agency will require special waste facilities to comply with the post closure monitoring requirements.

Groundwater and Leachate Monitoring. As previously discussed, gathering of information for future development of regulations is a primary function of the limited special waste regulations. Information on groundwater pollution is absolutely essential to that task and thus the groundwater monitoring regulations mus be observed by special waste facilities. Most special waste facilities on the other hand have not been designed to permit leachate monitoring and thus these requirements have been deferred.

Groundwater monitoring data is required to be taken no more frequently than quarterly, depending on the size of the site, so the retention of four data sets per year does not appear overly burden some and yet is expected to provide necessary data for regulation preparation.

However, in the case of gas and oil drilling muds and oil production brines, EPA does not feel that the imposition of groundwater monitoring requirements would be appropriate.

7. Rationale for the Application of Additional Subpart D Regulations to Some Special Waste

In addition to the above standards and associated rationales, which apply to all special wastes, there are other standards which are being applied to phosphate mining, beneficiation, and processing waste; and uranium mining waste. These additional requirements and associated rationales are presented below.

(1) Location of waste deposits shall be recorded on reference maps which shall be maintained through the operating and post-closure periods.

Rationale

EPA requires that the disposal locations of hazardous waste be known through this recordkeeping requirement to assist in the evaluation of and response to any environment or health-threatening situations which might arise subsequent to disposal.

In the special case of wastes involving very high annual volumes handled and having relatively uniform chemical composition, such as overburden, phosphatic clays (slimes), waste rock, tailings and gypsum, the Agency believes that such waste locations after disposal can best be identified in relation to operation and reclamation plans and maps established as a matter of normal mining and processing activities at the site.

Retention of such records beyond the period of active operations is needed, in addition, to allow the permitting officials to judge the adequacy of closure plans as regards land use.

(2) Land reclaimed by filling with these special wastes shall be used for residential development only where provisions have been made to prevent alpha radiation exposure from Radon 222

inhalation from exceeding background levels by 0.03 Working Level Units and gamma radiation from exceeding background levels by 5 micro-Roentgens/hour. The possible need for special constriction methods for structures on such reclaimed land shall be identified to any future land owner(s) by recording a stipulation in the deed of the reclaimed land.

Rationale

Mining and other activities which displace or disturb naturally occuring deposits of Radium 226 may present increased potential hazard to health due to a resulting increased concentration of Radium 226 or removal of shielding overburden.

Unnecessary distribution of Radium 226 in the form of products, by-products and wastes containing Radium may also occur. Known areas of concern include the use of mineral area, mined areas, and waste disposal piles for residential development or for other uses where prolonged human exposure might result in a statistical increase in the risk of cancer.

While not all areas of concern may be addressed directly by these regulations, some avoidance of undesirable adverse effects from the disturbances to radium bearing formations is possible though a performance standard incorporating the level of protection needed.

For existing structures on phosphate related mineral lands in Florida, the EPA's Office of Radiation Programs has drafted guidelines, which, although subject to change upon final adoption, provide the conceptual background for minimizing human exposure to artificially increased radiation from the radioactive decomposition of Radon gas associated with the natural occurrence of Radium 226.

The Agency has therefore incorporated the level of protection at 0.03 Working Level Units above background. The level of 0.03 is, however, at the threshold of statistically significant incresed health effects and may be too high for this purpose. Comments received indicate that a level of 0.02 Working Level Units including background may more protective of human health. Additional comments on this subject are requested.

Research studies sponsored by EPA's Office of Radiation Programs indicate that special construction methods for buildings will lead to decreased trapping of Radon, and are to be recommended for residential development on mineral-related land in Florida. It seems reasonable, in the presence of uncertainties in the predictive relationship of radium 226 levels in soil to the exposure of humans to Radon in buildings, not yet constructed on reclaimed land, to alert future land owners of the possible risk by identifying the need for special construction methods in some instances by a stipulation to the deed of the reclaimed land .

Where no measurement of Radon levels inside structures is possible, a more useful measure of potential exposure may be through a direct measurement of Radium levels in the soil in terms of picocuries per gram.

However, under Subpart D, performance standards for the management of these special wastes as are determined hazardous under Subpart A shall be established. Ongoing studies within EPA have not yet addressed management of the special wastes in sufficient detail.

These proposed regulations make use as a measure of human exposure the level of gamma radiation at 5 micro-Roentgens/hour above background. Support for such a choice is based upon the figure of 6 R/hr. for gamma exposure to be normal background for unmineralized regions within Central Florida (as determined by EPA). To allow for radiation level raiation in different mining areas, a level of one-fourth the hourly extrapolation (from the safe level of 170 millirems/yr.) above background was chosen.

(3) Building products manufactured from hazardous special waste shall not be used if the products cause alpha radiation exposure from Radon 222 inhalation to exceed background levels by 0.03 Working Level Units, or gamma radiation to exceed background levels by 5 micro-Roentgens per hour. Purchasers of waste and of products manufactured from waste shall be advised of this requirement by the seller.

Rationale

The use of building products manufactured from radium containing waste, such as phosphate slag, may contribute to an entirely unnecessary health risk.

Performance levels chosen are based upon general health risk estimates, as described above for residential development, but may need specific evaluation based upon the proposed use.

The requirement placed by the Agency upon the seller is a reasonable one in view of past incidents involving the use of radioactive tailings as fill.

(4) Analysis required under Section 250.43-8(c)(5) shall also include determination of Radium concentration in picocuries/gram.

Rationale

Analysis for radium concentration of the waste in picocuries/gram should be related to the radium level in picocuries per liter of any groundwater or leachate sample analyzed since the radium is a major constitutent of the waste.

(5) In the case of phosphate rock mining, beneficiation, and processing waste, analysis required under Section 250.43-8(c)(6) shall also include the following:

(i) Radium, picocuries/gram

(ii) Phosphate, mg/liter

(iii) Fluoride, mg/liter

Rationale

Selection of the parameters Radium, Phosphate and Fluoride in the comprehensive analysis of any groundwater or leachate sample was based upon the fact that these are expected major contaminants and should be related back to the waste's chemical composition. These parameters are also specified as being of concern in monitoring under the NPDES permit program. Methods of analysis for these parameters are available.

(6) In the case of uranium mining waste, analysis required under Section 250.43-8(c)(6) shall also include the following:

(i) Radium, picocuries/gram

(ii) Thorium. picocuries/gram

(iii) Processing reagents, mg/gr.

(iv) Molybdenum, mg/gr.

Rationale

Choice of these parameters for analysis under the groundwater and leachate comprehensive analysis is based upon the fact that they are likely to be major characteristic pollutant parameters in the waste. Thorium and nolybdenum are often associated with uranium deposits and should be determined in the background determination both because they themselves are toxic ions and because they may be increased in concentration by mining activities.

Environmental concerns for processing reagents present in leachate above the 5 ppm level support the inclusion of processing reagents specific to the site in the analysis. The presence of such reagents in samples may allow a cleaner separation of natural background from man-caused contamination.

(7) In the case of uranium mining waste, as part of closure of disposal facilities, the site shall be reclaimed so as to support plant life indigenous to the surrounding area and shall be revegetated with such plant life.

NOTE: Other plant life may be substituted if the substitute species provide an equivalent degree of stability to the soil.

Rationale

To parallel the closure requirements imposed on landfills under Section 250.43-7, a cover requirement is established for the larger areas disturbed during waste disposal operations in mining. It is expected that this requirement shall present little or no additional burden in view of existing State and local laws for reclamation of mining sites.

The note also highlights EPA recognition of local variations, while stressing the special need for site stability due to the possibility of flood or injury from collapse or movement of waste disposal piles.

8. Wastes Which Were Considered, But Were Not Selected for Designation as Special Wastes

Dredge Spoils

Certain dredge spoils may be hazardous if the source is a water body near a heavy concentration of industry. Also, in future, dredging may be undertaken simply to remove a pollutant rather than for navigational purposes. For example, dredging of the James river to remove Kepone and of the Hudson River to remove PCB's have been proposed. The Agency has concluded, however, that the volumes of dredge spoil likely to be hazardous from navigational dredging is small and that dredging for pollution control purposes will produce sludges which must be controlled to prevent secondary pollution.

Therefore, dredge spoils have not been granted "special" status.

Sewage Sludge

Sewage sludge has also been considered as a "special" waste when hazardous. It occurs in fairly large quantities, is generally of a relative low hazard level when hazardous at all, and it would create an economic burden if Subpart D controls were imposed. On the other hand, the Agency knows quite a lot about the characteristics of and hazards posed by sewage sludge. Thus, the Agency has detemined that substantive regulations can be written now to control sewage sludge disposal. However, since the normal sludge source, publicly owned treatment works (POTW's), is already heavily regulated under the Clean Water Act (CWA), the Agency has decided to regulate sludge disposal under the same Act (Section 405 CWA). By design, regulations prepared under Section 405 will provide an equivalent degree of control for hazardous sewage sludges as would be afforded by the Subpart D regulations.

9. EPA Studies on the Establishment of Substantive Requirements for the Designated Special Wastes

The agency is commencing studies of the designated special wastes with the goalof proposing substantive requirements, where warranted, in the future. This work will be done partially by EPA and partially by contact. The following information will be gathered:

- 0 waste characteristics and degree of hazard
- 0 quantities generated and transportation patterns
- 0 methods of treatment and disposal used and environmental acceptability
- 0 alternative methods of treatment and disposal and environmental acceptability
- 0 cost of alternative methods
- 0 possible alternative regulatory approaches
- 0 economic and environmental impact analyses of the regulatory alternatives

The limited requirements imposed by the current regulations will assist in the gathering to information as will the publication of an Advance Notice of Proposed Rulemaking (ANPR), which will solicit data and comment. It is possible that not all of the above study phases will be necessary, since we may find some wastes to be non-hazardous.

BD-32

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BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

REGULATORY ANALYSIS

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been drafted pursuant to Subtitle C of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document.

Comments in writing may be made to:

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Hazardous Waste Management Division (WH-565)
Office of Solid Waste
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Washington, D.C. 20460

Regulatory Analysis

1. Statement of the Problem

EPA has compiled over 400 case studies of the harmful consequences of inadequate hazardous waste management. These cases include incidences of surface and groundwater contamination, direct contact poisoning, various forms of air pollution and damage from fires and explosions. Nationwide, half of all drinking water is supplied from groundwater sources and in some areas contamination of groundwater resources currently poses a threat to public health. EPA studies of a number of generating industries in 1975 showed a total of 90% of the potentially hazardous wastes generated by those industries to be managed by practices which were not adequate for protection of human health and the environment.

Subtitle C of the Solid Waste Act as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), creates a regulatory framework to control hazardous wastes. The proposed rules are part of a series of seven required to implement the hazardous waste management program.

This Subtitle is designed to regulate hazardous waste management using a pathways approach. This approach regulates the path and destination of any waste found to be hazardous without particular attention to the source. This approach is basically different from that used to regulate air and water pollution where sources are more easily identified and where specific standards can be written and adjusted to each industry.

Subtitle C requires that standards be established for generators, transporters and facilities which treat, store or dispose of hazardous wastes. The link that will make these separate standards a system of hazardous waste control is the manifest system that is required. The manifest system will make possible tracking of individual waste loads from the generator to the ultimate destination of the hazardous waste.

It is EPA's responsibility under this Subtitle to develop through these standards and the manifest system an overall, national system of hazardous waste control. This system is intended by Congress to be implemented through the States where possible. For this purpose, EPA must develop guidelines for judging the equivalency of State programs to Federally written standards and for allocating grant funds to eligible State programs. Implementation of the hazardous waste program through the States can increase the effectiveness of limited Federal resources and thereby better protect public health and the environment.

Any regulatory program as large and new as the hazardous waste program can be expected to require many adjustments on the part of the regulated community. In particular, the requirement that generators of hazardous waste must manage their wastes in an environmentally sound manner will create large new demand for adequate hazardous waste management capacity. EPA must take into account the need for more hazardous waste management capacity as it develops this regulatory program because public health and the environment will not be well protected if one of the real results of the program is to shut down most of the facilities currently available. However, the interim status period is reviewed as a buffer for capacity creation in the program start-up period.

In summary, the purpose of the regulations under Subtitle C has been to develop an overall, national hazardous waste control program to protect public health and the environment. This program is to be implemented through the States where possible and has to be responsive to the indirect, interactive effects of regulation on an interrelated network of generators, transporters and hazardous waste facilities.

2. Description and Selection of Alternatives

General

The Subtitle C regulations are intended to present a comprehensive hazardous waste control program and as such there are some issues relating to all sections of the Subtitle and some alternatives possible for the program as a whole. There are other issues and alternatives which are relevant to individual sections of the program such as to generator or facility standards only. As far as possible, alternatives will be described under the section in which they are most relevant. However, two broad issues relevant to the entire program will be described in this section. They are: (1) provision of general standards vs. standards that are specific to an industry; and (2) phasing of the Subtitle C program.

To date, environmental regulation has generally been written on an industry-specific basis. RCRA requires that standards be written for generators, transporters, treaters, storers and disposers of hazardous waste, with no specific direction provided that would vary those standards by type of generator. The development of industry-specific standards was nevertheless considered in the design of the Subtitle C program.

In the course of this consideration, it was determined that most wastes classified as hazardous would entail similar management. This would be true not only for the financial and administrative requirements of the program, but also with respect to performance, design and operating standards for treatment, storage and disposal facilities. However, it was also determined that some wastes could be handled with differing facility design and operating standards or differing administrative requirements, and still

meet environmental and public health standards. Further, there were some wastes for which insufficient data were available to determine appropriate management techniques. The proposed rules thus allow for the following: (1) general standards applicable to all wastes for transportation, treatment, storage and disposal; (2) specific provisions in the treatment, storage and disposal regulations for different or less stringent design and operating standards to be used by permit writers in the preparation of permits for specific waste types and facilities as long as the overall health and environmental standards are met; (3) deferral of applicability of the treatment, storage and disposal standards for selected waste categories until information is gathered and assessed to determine how they can best be handled (i.e., mining waste, utility waste, dredge spoils, oil drilling brines and muds, gypsum piles, cement kiln dusts and uranium mill tailings); and (4) specific provisions for generators of small quantities of hazardous waste, most retailers and farmers.

Although there is no explicit authority in the Act for phasing of the regulations, phasing was considered as a possible alternative during development of the program. One method of phasing would be to use a classification of degree of hazard to regulate the most hazardous wastes first and to gradually include less hazardous wastes. However, it was determined that degree of hazard is a function of the state of the waste in its management cycle as well as of the intrinsic properties of the waste, and that it is mismanagement of the waste which presents the greater problem. Priority action on permit applications could more accurately reflect the phasing that would be desirable rather than a classification of waste type regardless of disposal method.

Phasing could also be done by industry grouping or SIC code grouping, or by including the largest generators first and gradually including the smallest using successively smaller wastestream size definitions of a generator. However, any possible phasing of regulatory authority would have precluded control over large quantities of hazardous waste for significant periods of time. Further, no phasing of regulatory authority was permitted by the Act.

<u>Hazardous Waste Definition</u>

Section 3001 provides a means for determining whether a waste is hazardous for the purposes of the Act, and, therefore, whether it must be managed according to the other Subtitle C regulations. Section 3001(b) provides two mechanisms for determining whether a waste is hazardous: a set of characteristics of wastes and a list of particular hazardous wastes.

Specific criteria were used both for selecting particular characteristics and for listing particular wastes. Three criteria were then used for refining this candidate set of characteristics: that the characteristic could provide a general description of the property or attribute rather than appearing merely as a list of sources; that the likelihood of a hazard developing if the waste were mismanaged is sufficiently great; and that a reliable identification or test method for the presence of the characteristic is available. Use of this last criterion has lead EPA to describe each characteristic by specific testing protocols, including interpretation instructions. Where this was not possible, (e.g., reactivity) the characteristic is set out as a description readily recognizable by persons working in the field (e.g., "readily capable of detonation at normal temperatures and pressures") together with a test protocol available in cases of uncertainty.

Under these criteria, several groups of characteristics were developed. These groups are:

a. Ignitability, Corrosivity, Reactivity

b. Limited Toxicity (EP* with 10X SDWA Primary Drinking Water Standards)

c. Radioactivity and infectiousness

d. EP* with standards for organics

e. Genetic, aquatic, and phytotoxic bioassays

For each of the groups of characteristics above, a number of alternatives were considered. EPA could have: adopted the group of characteristics as a means of identifying hazardous waste; used the group of characteristics in developing lists of hazardous wastes; or deferred adoption of the characteristic pending further study. Adopting a group of characteristics as a means of identifying wastes causes generators of waste with such characteristics to be responsible for making the determination of hazard. Many generators would find it prudent to test to determine the exact character of his waste unless he accepted its hazardousness and complied accordingly. For this reason it is important to consider the burden such testing could place on generators.

*The Extraction Procedure (EP) is a laboratory procedure developed by EPA to estimate the potential mobility of a waste in an uncontrolled landfill or open dump environment.

Making a group of characteristics part of EPA's listing effort would remove much of the testing burden from generators. Not all of the testing burden would be shifted off to the generators on to EPA however. A procedure would be necessary for showing that a particular waste was not hazardous, despite being listed by EPA. This procedure would be available to generators seeking to avoid coverage by the regulations and would require some testing.

A decision to study a group of characteristics further would result in more information becoming available to EPA on which to decide the efficacy of testing methods and of hazard levels. Based on information received, EPA could either include the group of characteristics as a means of identifying hazardous wastes or work to improve the efficacy of the testing methods.

Only the first two groups of characteristics (i.e., ignitable, corrosive, reactive and limited toxicity) have been chosen as waste identification characteristics. These characteristics are relatively simple, the tests are well developed and recognized by the scientific community, inexpensive to test, and they cover a large proportion of the total amount of hazardous waste EPA believes should be controlled. Generators will not be required to know the characteristics of wastes outside the characteristics in these two groups for purposes of determining if the wastes are hazardous. However, it was also decided that hazardous wastes could be listed due to characteristics in any of the groups including the characteristics of infectiousness and radioactivity. Retaining the power to list wastes deemed hazardous in the Administrator's judgement, regardless of which characteristics they might have, was necessary to maintain control over those wastes which, through experience, were known to be hazardous but for which no efficacious testing procedure could be devised.

The last two groups of characteristics (i.e., EP with standards for organics and genetic, aquatic and phytotoxic bioassays) have been included in an ANPRM to obtain more information to improve EPA's understanding of the efficacy of testing for these characteristics. At the present time, EPA does not believe these areas of testing to be sufficiently developed to permit large-scale, reliable testing of wastes.

Generators

Section 3002 of RCRA requires EPA to set standards for generators of hazardous waste. Four major issues were considered in deciding what constitutes a generator under this section. The first is what lower limit on the amount of hazardous waste produced should be included in the definition of a generator. The second and third concern whether to include retail establishments and farmers as generators and what type of special provision might be necessary if they are included. Last, the frequency and type of reporting requirements to place on generators were also considered.

There are several reasons for setting a lower limit on the definition of a generator. While there is some evidence of damage due to small quantities of hazardous waste, most damage cases studied by EPA involved large quantities. Further, there is substantial evidence that co-disposal of small quantities of hazardous waste with municipal solid waste is in most respects as environmentally acceptable as disposal of such quantities at a hazardous waste facility. Exclusion from the regulations of very small hazardous waste producers would eliminate the paperwork burdens of manifests, reporting and recordkeeping on hundreds of thousands of insignificant producers. An exclusion would also free limited EPA and State resources to deal more effectively with larger generators which EPA studies have shown to produce a preponderant majority of the total amount of hazardous waste generated.

In considering excluding small generators from S3002 requirements, it was found that low quantity generators were affected most greatly (administrative cost per unit) by the section. The determination was made to establish an exclusion to reduce this burden. The cutoff for the exclusion presented the problem of balancing environmental benefit and economic cost. Several cutoff levels were considered: 27 lbs., 100 kgs., 250 kgs., and 1000 kgs. For 100 kgs., between 50 and 60 percent of the manufacturing generators (SIC 20-39) would be excluded where 99.5% of the waste would still be covered.

For 1000 kgs., the exclusion rate would be increased to 85%, and the waste covered would be reduced to between 92% and 93%. In light of these figures, a cutoff lower than 100 kgs. appears unnecessary because environmental protection seems adequate where only one-half of one percent of the waste is out of the system.

Perhaps a more important factor for determining where to set the cutoff level is the co-disposal issue. EPA has determined that the ratio of non-hazardous waste to hazardous waste in a sanitary landfill (Subtitle D of RCRA) carries significant impact at 1:1 to 3:1. If one assumes that all excluded generators produce the maximum (100 kg./month), the ratio of that waste when disposed in a sanitary landfill would have a ratio of 25:1 or 30:1. If the cutoff is 1000 kg./month, the ratio will be 3:1 or 4:1. The latter approaches the dangerous level defined by the Agency. One final determinant is the number of damage incidents of the excluded hazardous waste at non-hazardous waste facilities. It has been found that 5% of damage cases involved waste amounts under 100 kg., but 25% involved 1000 kg. or less. As a result of the data for these three criteria, the Agency has chosen the 100 kg. per month figure as the cutoff. Both the benefit to the generators and the remaining environmental protection was deemed adequate at that level.

Likewise, four alternatives for retail establishments were considered: (1) no special provisions; (2) no reporting requirements for retail generators and special notification arrangements for gas stations; (3) exemption of generators having contracts with voluntarily licensed haulers; and (4) defer coverage under Subtitle C and study. Due to the very high numbers of retail establishments and the small quantities of hazardous waste produced by these establishments, EPA decided not to require reporting by retail generators except for waste oil generation (including gas stations) over which special controls are necessary to mitigate the burden this entails, special arrangements will be possible to allow gas stations and other waste oil generators to notify EPA or an authorized State of their generator status through a major oil company or State independent retailers association. This will allow large numbers of almost identical generators to notify at less cost than would be possible if they notified individually. It was further decided that any waste oil generator having a contract that would transfer responsibility to a voluntarily licensed hauler or facility owner/operator would not be a generator pursuant to Section 3002. This transfer of liability will not reduce the effectiveness of the generator standards because the necessary control will still exist. A decision to transfer such responsibility significantly reduces the administrative cost to a very small producer of hazardous wastes.

With respect to including farmers as generators, the three alternatives considered were: (1) no special provisions; (2) exclude farmers who have arrangements with their pesticide suppliers which are acceptable to EPA; and (3) exclude farmers due to control under FIFRA. EPA decided waste pesticides and waste pesticide containers were the only significant hazardous waste produced by farmers and those would be better controlled under FIFRA than RCRA. Farmers will not be generators pursuant to Section 3002 of RCRA.

Section 3002(6) of the Act requires reports to EPA (or an authorized State) at such times as the Administrator deems necessary. Three major alternatives were considered for reporting. A quarterly summary of all wastes generated was considered for each generator. Instead of quarterly summaries a single annual summary was also considered along with the additional requirement that manifests sent by but not returned to a generator would be reported. The third alternative requires the same annual summary; however, manifest exceptions need only be reported quarterly.

EPA believes the annual summary with the quarterly manifest exception reporting requirement provides adequate information. More frequent reporting would be more costly without providing sufficient additional information to justify the cost. The generator reporting standard chosen therefore requires all generators to provide annual summaries of hazardous wastes handled and quarterly reports of unreturned manifests.

Transporters

Section 3003 of the RCRA requires that EPA establish a system which controls the transportation of hazardous waste. Five of the following six major issues were resolved, and the regulations were proposed on April 28, 1978. The primary issue centered on the proper relationship between the EPA requirements and the Department of Transportation's authority. Other considerations included provisions for the complexity of the manifest requirement, additional safety provisions, a permit program for haulers, minimum insurance coverage for spills, and reporting requirements in the event of a spill. Major alternatives to each of these issues are discussed below.

It was determined that the role of DOT in the regulation structure should be as great as possible. Transporters perceive DOT as the regulatory authority, and their resources and expertise in this area surpass EPA's. Therefore, independent EPA regulations would not be a wise action. An alternative would be to allow DOT regulations to remain unaltered. Their program for the transportation of "hazardous material" would cover the bulk of "hazardous waste" as defined in Section 3001. This alternative is acceptable; yet, EPA could also adopt DOT regulations, providing enforcement powers for both agencies and extending the coverage of the regulations to intrastate commerce. Another alternative would be to influence DOT to make their regulations compatible with RCRA before EPA adoption. In those instances where the agency finds DOT authority lacking, EPA could write supplemental regulations. Writing supplemental regulations would add flexibility, and adoption of the DOT regulations would allow transportation experts to handle the problems directly and would reduce confusion by being more efficient. In light of these considerations, the Agency began by attempting to pursuade DOT to alter their regulations and after all possible agreeable changes were developed, EPA adopted them. EPA has only written supplementary regulations in those instances where there is no authority under DOT regulations.

With respect to manifest requirements, the Agency is establishing a manifest requirement for transporters under the "cradle-to-grave" system. The two options would be to require a specific manifest which must accompany the waste at all times or to allow flexibility where it can be shown that a DOT shipping paper carries data equivalent to a manifest. A rigid system would provide for close control and the ability for tight enforcement. A flexible approach would reduce the burden on the transporters (e.g., in a railroad where a computer system has been established) but would provide the same basic data. The Agency has chosen to allow for an alternative delivery document where no manifest is with the vehicle and equivalent information is carried. The system will provide a similar degree of control and information.

EPA was faced with an opportunity to provide for safety provisions greater than those already adopted. If these provisions were considered important, this could be accomplished by referencing the DOT motor carrier safety regulations or developing similar EPA regulations. It was determined that

EPA does not have adequate capability to implement or enforce the regulations, so no action was taken. Likewise, the Agency weighed the establishment of a permit program for haulers of hazardous waste. After the ICC ruled that wastes are probably not within their authority, EPA determined that no action would be taken on this issue.

An additional area of coverage would be the requirement that transporters have adequate insurance in the event of a spill. Such a regulation could be unnecessary because coverage presently exists. However, the Agency determined that due to information limitations, the issue merits further consideration. The Agency chose to study the issue; a report has been contracted and is due in December. If it is determined that spill insurance should be an Agency consideration, we will write regulations which should reduce the burden on the municipalities who often bear the burden of spill cleanup.

Lastly, EPA considered the issue of spill reporting regulations. Taking no action would result in less regulation. Making the transporter responsible for spill reporting would provide for greater environmental protection and would expand EPA's information base. Such regulations were written because they were deemed a reasonable approach to the issue.

Facilities and Permits

Section 3005 of RCRA requires the establishment of a permit program for hazardous waste facilities. Section 3004 requires standards on which the permits will be based. As will be discussed below, Section 3005 and the State delegation program under Section 3006 are being integrated with proposals for the NPDES and UIC program under Parts 122, 123, 124 and 128 of the Code of Federal Regulations. Therefore, the bulk of this discussion will focus on alternatives considered under Section 3004. Several major issues arise under the sections of RCRA dealing with facilities standards and permitting. Among these are the question of what type of standards to write for facilities, several questions concerning which facilities are subject to the standards, and the question of a priority system and coordination for permitting activities. Financial requirements will be discussed separately in the next part of this analysis.

EPA considered these different ways to write standards for facilities. The first way would set ambient standards for air quality, water quality and for other relevant factors. These standards would be set at levels known to be safe. It is not always possible to know why a standard of this type has been exceeded, that is, the source of the pollutant is difficult to determine, and consequently this type of standard is difficult to enforce. Also, it is difficult to set safe levels for the thousands of substances that might be found in hazardous waste.

The second type of standard would prescribe limits on hazardous waste management activities. This type of standard can be enforced but would tend to hold technology stagnant along the prescribed limits. The third type of standard would directly regulate pollutant releases from a given source. Although new technology can be encouraged, such a standard is generally limited because a hazardous waste disposal site often discharges from several points and so would be impossible to regulate as a single, given source.

EPA has decided to combine the strengths of each of those types of standards by using a mixed structure for the facility standards. The approach selected defines human health and environmental standards which will be the final determinant of a particular facility's acceptability. In addition to these human health and environmental standards will be design and operating standards which provide measurable criteria. If a facility is found to violate the human health and envrionmental standards despite compliance with the operating standards, a reasonable schedule will be designed to bring the facility into compliance with both standards. The operating standards will be used as the primary enforcement tool. The health and environmental standards will be used as an operating mechanism only when deemed necessary by the enforcing authority.

The question of how to regulate inactive hazardous waste management sites has been pivotal in the development of the program. In general, EPA regulations will require far more care at hazardous waste management facilities than has been common in the past. To apply the same standards to inactive sites that will be applied to new and existing sites would force large numbers of old or abandoned sites into non-compliance. In addition to the technical and economic problems encountered in any attempt to enforce new standards on inactive sites, the legal question of expost facto lawmaking is raised. Instead of either strictly applying the RCRA regulations to inactive facilities or completely exempting such facilities from coverage EPA has decided to use the imminent hazard powers of Section 7003 to act in instances were some threat to public health or the environment is presented.

To integrate the Subtitle C facility standards and permitting activities with BAT Toxics/Pretreatment Standards and NPDES permits several alternatives were considered. Five categories of potential permittees were identified: Off-site hazardous waste management facilities, facilities subject to upcoming BAT Toxics/Pretreatment standards but currently without NPDES permits, facilities with NPDES permits and subject to upcoming BAT Toxics/Petreatment standards, facilities not subject to BAT Toxics/Pretreatment standards but currently possessing NPDES permits, and other facilities.

For those categories subject to NPDES permit revision, renewal or new permit issuance it would be possible to conduct Subtitle C permit granting activities according to NPDES schedules. These categories could also be made subject to Subtitle C recordkeeping, reporting, monitoring and manifest requirements upon promulgation of these general requirements and granted permits gradually according to NPDES schedules.

Due to limited resources for permitting of hazardous waste management facilities and the procedural constraints on permit granting, a priority system for permitting was necessary. Granting Subtitle C permits according to NPDES schedules and priorities where possible could eliminate duplicate contacts with permitting authorities. Facilities seeking permits could present the necessary materials for both hazardous waste and NPDES permits at the same time although the permits could remain separate.

EPA decided the priorities for hazardous waste facilities permitting will be in the same order as the categories listed above. Off-site hazardous waste management facilities will be the highest priority because it is expected that large numbers of generators will choose off-site management due to economies of scale rather than operate their own permitted facilities. EPA also believes this approach is necesssary to avoid delays in the creation of new off-site hazardous waste management capacity which will be essential to protect human health and the environment. The second priority will be those facilities seeking NPDES permits for the first time under the BAT Toxics/Pretreatment standards. These facilities will soon be required to have similar EPA permits and it would be wasteful to both the permitting authorities and the permit seekers to prepare twice for permits at a single facility. The third priority will be those facilities with NPDES permits and soon subject to the BAT Toxics/Pretreatment standards. These will be handled on a basis similar to the second priority group but somewhat later as their permits are revised through NPDES. The fourth priority group will be those facilities with NPDES permits but not subject to the unpcoming BAT Toxics/Pretreatment standards and they will be reviewed for Subtitle C permits as their NPDES permits are renewed. The fifth priority group will be all other facilities, those on-site but without any current or prospective requirement for an NPDES permit.

During interim status (before a permit is issued but following the notification required by Section 3010 and application for a permit), it was determined that an abbreviated set of design and operating standards would apply.

Financial requirements under the Act are required by Section 3004(6) of the Act. This Section calls for requirements respecting ownership, continuity of operation and financial responsibility for hazardous waste management facilities as may be necessary or desirable. Four areas for financial requirements were identified: assuring funds for site closure, funds for post-closure site monitoring and maintenance, site life liability, and post-closure liability and remedial action. Requirements for post-closure monitoring and maintenance, and post-closure liability and remedial action, pertain only to disposal facilities because no hazardous wastes will remain at treatment or storage facilities after proper closure. The major choices facing EPA for each of these areas were whether to set requirements leading to private arrangements; to seek additional legislative authority to establish a government administered fund; or to defer and conduct further studies before rulemaking.

Precedents are numerous for requiring a facility to set aside sufficient funds to assure proper closure. Both nuclear power plants and strip-mining operations are required to set aside sufficient funds before operation to assure site restoration. EPA decided a requirement to set aside before operation the full amount necessary to close a site was not burdensome, would in most cases guarantee adequate closure and could be done through the private arrangement of a trust fund.

Assuring funds for post-closure site monitoring and maintenance would require a far greater commitment of resources than assuring funds for closure. Monitoring and maintenance at disposal facilities must be conducted for twenty years post-closure in accordance with technical facility requirements under Section 3004. Monitoring and routine maintenance are predictable expenses and can be estimated even for a period twenty years. A fund sufficient to pay for twenty years of post-closure monitoring and maintenance would be on the order of a few hundred thousand dollars depending on the facility size. EPA has decided that creation of such a fund for each disposal facility, with payments made into it throughout the operating life of the facility, is necessary to assure that the activities of monitoring and maintenance will be carried out after closure. Expenditures for these essential activities can be planned and will have to be paid regardless of any requirement to establish a fund to pay them. The requirement will only assure that the funds are available before operations cease. This requirement also can be fulfilled through the private arrangement of a trust fund.

To assure adequate financial responsibility for liability during site operation, EPA examined the several forms such financial responsibility might take. EPA decided to accept any evidence of financial responsibility (e.g., insurance, mutual assessment organization or self-insurance with limits) at the level set by EPA for all facilities. EPA is working to assure availability of some form of financial responsibility to all firms with environmentally acceptable facilities.

Financial responsibility for post-closure liability and remedial action post-closure is more difficult to assure than similar responsibility during site operation. Creation of a fund sufficient to pay insurance premiums for any significant period after closure of a disposal facility would result in a fund many times larger than that required for post-closure monitoring and maintenance. Such insurance premiums could be very difficult to predict and there is strong evidence the required insurance would not be availalbe. In light of such obstacles, EPA decided to reserve authority to require post-closure financial responsibility for liability and remedial action and for this one area of financial requirements is investigating the possibility of a government administered fund.

Notification

Section 3010 requires all generators, transporters, and facility operators to notify the Administrator of their hazardous waste management activities. The Agency was faced with the option of whether or not to publish regulations under this section. It was decided to publish regulations in order to disseminate information to a wider group of interested persons, to clarify specific requirements, and to standardize data formats. These regulations have been proposed in the Federal Register. Two issues arise out of this decision to write regulations: the degree of flexibility in notification reporting procedures and the level of confidentiali maintained by the Agency.

A stringent approach to the filing question would require each place of operation to file a comprehensive, mandatory notification form which must be submitted to a central agency. Although such a system would provide a high degree of control, the Agency has adopted several provisions for flexibility. Under the present policy, each generator need not file an application as long as a central firm identifies each place of operation. Instead of a mandatory form, minimum guidelines for filing will be offered with an optional standard form available. Furthermore, no testing is required to prove whether or not a waste is hazardous. In addition, each applicant is allowed an additional ninety days for the identification of toxic waste because of the potential burden of the test (EP). The Agency believes that these procedures will provide an adequate amount of coverage at a reasonable level of cost. The option of allowing the states to be notified in lieu of the Agency has been rejected because of the questions surrounding the legality of Limited Interim Authorization for states to conduct notification activities before the effective date of authorization under Section 3006(c).

Provisions for confidentiality would protect trade secrets but would make it more difficult for the public to obtain a clear identification of hazard levels. In order to balance those concerns, EPA has established a confidentiality procedure which puts the burden on the notifier to demonstrate the need for confidentiality if the public request access to data.

3. Economic Consequences

General

The economic impacts of Subtitle C regulations were analyzed for three major sets of alternatives consolidated from the choices considered under Sections 3001, 3002, and 3004 of RCRA. Each alternative thus represents a "menu" of provisions in a number of different regulations. Table 1 summarizes the variable parameters of each of the three options that have been analyzed.

The analysis of these alternatives have been necessarily qualitatively in many cases. For example, costs of compliance have been quantified for those industry segments EPA believes will be most affected by the regulations, but the effects of these costs on prices, output, employment and plant closures have been determined judgmentally. Increased generator demand for hazardous waste management capacity was examined quantitatively where possible for its effects on the overall network of facilities supplying this capacity, and some judgmental conclusions were reached regarding desirable capacity levels.

The three options evaluated are described in the following sections.

In effect, each major option is a trade-off of varying degrees of public health and environmental protection on the one hand, and scope of program coverage and subsequent cost on the other. Option C was considered far less protective

Table 1

Hazardous Waste Regulatory Alternatives

	Option A	Option B	Option C
3001 H.W. Identification			
H.W. Characteristics	Ignitable Corrosive Reactive Radioactive Toxic	Ignitable Corrosive Reactive Lim. Toxic	Ignitable Corrosive Reactive
No. H.W. Listed	~90	~158	~30
Amt. H.W. Controlled (MT) (1)	56,100,000	34,400,000	20,400,000
3002 H.W. Generators			
Size Exemption	<100 kg/mo.	<100 kg/mo.	<1000 kg/mo.
No. of Generators (2)	520,000	255,000	133,000
Pesticide Users	102,000	10,000	-0-
Retailers	212,000	63,000	-0-
Transport Manifest	Yes	Yes	DOT only
Reporting Frequency	Qtrly.	Annual w/ Qtrly. Exceptions	Annual
Records Retention	3 yrs.	3 yrs.	1 yr.
3003 H.W. Transporters			
Emerg. Spill Reports	Yes	Yes	No.
No. of Transporters	10,000	10,000	Substantial Decrease
3004 Facility Standards			
Special Wastes Controlled	Yes	Limited	No
Dist. to Water Wells	500'	500'	250'
LF Soil Permeability (cm/sec)	$< 10^{-7}$	$< 10^{-7}$	$< 10^{-6}$
LF Volatiles Banned	< 78 mm Hg	< 78 mm Hg	None
Groundwater Mon/Reporting	Qtrly.	Qtrly.	Annual
Financial Requirements			
Site Life Liability	$5M	$5M	$2M
Post-Closure Monitoring	40 yrs.	20 yrs.	10 yrs.
Post-Closure Liability	Yes	No	No
No. of Disposers	31,000	30,000	12,000
Economic Impact			
Annual Cost (3)	$1786M	$630M	$501M
No. of Product Lines	69	69	69
% Product. Value > 2%	24	9	8
0.5-2%	26	20	19
< 0.5%	19	40	42
No. Sectors w/at least one plant closure (50% or more chance)	10	8	6
No. Sectors w/labor losses (50% or more chance)	15	8	7

(1) SIC 20-39 only
(2) Does not include special wastes
(3) 17 industries only

of public health and the environment than was deemed desirable while Option A was considered too costly and uncertain in scope. To reduce overall uncertainty and cost and yet still be protective of public health and the environment, Option B is the option reflected in the proposed rules.

Option A

Option A is the most comprehensive set of provisions in terms of public health and environmental protection. It corresponds to the status of the regulations ca. spring 1978. In Option A, the greatest quantity of potentially hazardous waste is controlled, with the definition keyed to testing against all the characteristics considered, including toxicity and radioactivity. The number of generators is significantly larger than in Option B, and quarterly reporting is required. Additionally, post-closure monitoring is required for 40 years under Option A. Post-closure liability insurance is also required.

The major categories of requirements and their corresponding expected incremental costs and cost ranges are, in millions of dollars:

Activity	Annual Cost	Low	High
Technical Requirements	$264	149	597
Financial Requirements	1060	511	1576
Recordkeeping/Reporting	41	39	77
Monitoring/Testing	261	170	516
Administration	97	96	187
Training	32	22	55
Contingency Planning	31	18	50
	1,786	1005	3058

The costs presented above are only for the seventeen major industry groupings studied by EPA as significant generators of hazardous waste. These industry groupings are: textile mill products, inorganic chemicals, organic chemicals (partial coverage), pesticides, explosives, petroleum refining, rubber, leather tanning and finishing, metals smelting and refining, electroplating and metal finishing (partial coverage), special machinery manufacturing, electronics components, and batteries.

These seventeen industry groupings were divided into 69 industry segments of which 24 were projected to experience high economic impact (compliance costs higher than 2% of annual sales). Of these, ten industry segments were identified as likely to experience some plant closures and job losses. They are:

Electroplating

Wool Fabric Dyeing and Finishing

Knit Fabric Dyeing and Finishing

Mercury Cell Chlorine

Chlorobenzene

Leather Finishers

Mercury Smelting and Refining

Secondary Copper Smelting

Secondary Lead Smelting

Secondary Aluminum Smelting

The incremental economic impact of hazardous waste management regulations on transporters in any option is expected to be relatively insignificant due to current DOT regulations.

Option B

Option B is the result of a detailed program review and options analyze which were conducted in the early summer of 1978. The degree of uncertainty in program scope and cost is reduced from Option A by limiting use of hazardous waste characteristics, and increased use of specific listings of hazardous waste in the definition process. Actual program scope and cost are reduced by exempting certain classes of hazardous waste generators, limiting the reporting requirements, eliminating certain financial responsibility provisions, and by reducing the requirements on certain high volume wastes pending further analysis and evaluations.

The major categories of requirements and corresponding incremental costs and cost ranges under Option B for the 17 major industry groupings studies are (in millions of dollars):

Activity	Annual Cost	Low	High
Technical Requirements	$258	145	581
Financial Requirements	121	92	153
Recordkeeping/Reporting	14	13	26
Monitoring/Testing	104	68	206
Administration	70	69	135
Training	32	22	55
Contingency Planning	31	18	50
	630	427	1206

The changes in reporting requirements lower expected annual reporting costs from $41 million to $14 million. Changes in the financial requirements lower the expected annual costs of those requirements from $1060 million to $121 million. Together those two changes result in expected cost reductions of $966 million.

Despite significant differences in costs between Option A and B, it is expected that not much difference in impacts will be experienced by the most impacted industry segments. Under Option B eight industry segments (Option A segments excluding chlorobenzene and knit fabric dyeing and finishing) can be considered likely to experience some plant closures and job losses. However, total costs are significantly reduced, as is the degree of uncertainty on the regulated community.

Option C

Option C is the least protective of public health and the environment and the least costly of the options analyzed. It aims to further reduce requirements on small hazardous waste generators by raising the size of the exemption to 1000 kg. per month. In this option, storage up to 1 year does not need a permit. In addition, there is no toxicity characteristic in this option; site life liability insurance is decreased from $5 million to $2 million; and post-closure monitoring is required for only 10 years.

Activity	Annual Cost	Low	High
Technical Requirements	$249	139	562
Financial Requirements	65	56	76
Recordkeeping/Reporting	8	7	13
Monitoring/Testing	75	49	149
Administration	53	52	102
Training	26	18	45
Contingency Planning	24	15	40
	$501	$336	$987

Other Studies and Results

EPA has studies in progress on several other industry groupings in addition to the above mentioned seventeen. These industry groupings include: electric services, service stations, pulp and paper mills, soil preparations and crop services, certain segments of the chemicals industry, metals and minerals except petroleum and industry supplies. Each of these industry groupings has special circumstances which may require special consideration once EPA completes its technical and economic studies.

As a result of work done in impacts of the regulations on hazardous waste management capacity certain conclusions are possible. An economic incentive will exist for a major shift from on-site hazardous waste management to off-site hazardous waste management due to economics of scale in larger facilities. If sufficient capacity can be created off-site, incremental compliance costs can be reduced. Without sufficient new off-site capacity a serious shortfall of acceptable hazardous waste management capacity is likely to occur in the short run. The possibility of such a shortfall with its probable adverse environmental consequences, has influenced EPA decisions regarding the pace of implementation, and has resulted in a system of implementation priorities as described earlier. Additionally, the interim status period can be viewed as a safety value for capacity creation in the program start-up period.