Manual

Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge

U.S. Environmental Protection Agency
Office of Water Enforcement and Permits
Washington, D.C. 20460

DECEMBER 1989

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 19 1989

MEMORANDUM

OFFICE OF WATER

SUBJECT: Final Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge

FROM: James R. Elder, Director
Office of Water Enforcement and Permits

TO: Water Management Division Directors
Regions I-X

The purpose of this memorandum is to present to you the final Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge.

The guidance document, as you may recall, was originally sent out in draft form in September, 1988. Comments from Regions, States and other users of the document were solicited and received over a one-year period. This final form of the document, reformatted to make it more readable, incorporates those comments.

The purpose of the document is to provide: 1) a compilation of existing Federal and State requirements for sludge; 2) a compilation of existing federal and State guidance; and 3) recommendations for permit writers to consider writing into permits on a case-by-case basis using their best professional judgment. In keeping with the Sewage Sludge Interim Permitting Strategy, we have recommended that permit writers require more frequent monitoring of the pollutants for which numeric limits have been proposed for the proposed Part 503 regulations. In developing permit limits for POTWs, we recommend that the primary source of information should be the Case-by-Case Guidance and not the proposed technical standards, unless the permit writer can independently establish their appropriateness. The language in the guidance on this issue tracks the discussion in the Interim Permitting Strategy.

We are presenting you with a typewritten, xeroxed copy of the final document. In the near future, the document will be published in a typeset, printed version that will be distributed to Branch Chiefs, States and other interested parties.

If you have any questions about the Cbc Guidance or sludge permitting in general, please call me at (FTS) 475-8488, or have your staff contact Martha Segall at (FTS) 382-2696.

Attachment

cc: Martha G. Prothro
Susan G. Lepow
Michael J. Quigley

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 19 1989

OFFICE OF
WATER

MEMORANDUM

SUBJECT: Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge

FROM: James R. Elder, Director
Office of Water Enforcement and Permits

TO: Users of the Guidance

This manual provides Regional and State permit writers with technical guidance on the development of best professional judgment (BPJ) sludge permit conditions to be incorporated into permits in the interim before the 40 CFR Part 503 technical sludge standards are promulgated.

The 1987 amendments to the Clean Water Act require that prior to the promulgation of the sludge standards, EPA must "impose sludge conditions in [NPDES] permits issued to publicly owned treatment works [POTWs]... or take such other measures as the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge." Thus, the amendments direct EPA to protect the environment from improper use and disposal practices prior to promulgation of the technical standards.

To implement the Clean Water Act requirements, EPA has developed a program outlined in the document entitled "The Sewage Sludge Interim Permitting Strategy" (September 1989). The interim program utilizes existing experience, expertise and permitting processes to focus permitting efforts on the facilities which, based on the available information, are thought to present greater risk. The Interim Permitting Strategy includes standard permit conditions, monitoring requirements, and State/EPA coordination in the permitting process. In addition, the Interim Permitting Strategy notes that case-by-case permit requirements will need to be developed for certain POTWs. This may mean more frequent monitoring or other site specific conditions such as management practices or numeric limitations developed on a case-by-case basis.

The Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge ("Cbc Guidance") is the technical companion to the Interim Permitting Strategy and is designed to assist permit writers in developing these additional case-by-case conditions. The manual presents: 1) a compilation of existing federal and State requirements for sludge; 2) a compilation of existing federal and State guidance; and 3) case-by-case recommendations for permit writers to consider as appropriate. It is important that the permit writer ensure that existing federal and State requirements are incorporated into permits issued to POTWs. Use of the Cbc Guidance will ensure that these requirements are included in permits and should help to promote timely compliance with the 40 CFR Part 503 technical sludge regulations when issued. In addition, compliance with the monitoring requirements specified will provide information on sludge quality and the use and disposal practices at the POTW and help identify potential problems.

The Cbc Guidance may be used by Regional and State permit writers to assist them at arriving at appropriate permit conditions and by the Region in reviewing State-issued permits. EPA and States may take further action beyond that specified in the guidance, where appropriate to protect public health and the environment and where a basis for the requirement can be established. This document should provide permit writers with the tools necessary to develop sound and defensible permits during the interim period.

NOTICE

This document has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Comments on a previous draft of this document were provided by EPA's Sludge Permitting Workgroup. These reviewers included EPA Regions, a number of States, EPA's Office of Research and Development, and representatives of a number of EPA Headquarters Offices with an interest in sludge use and disposal. The efforts of these reviewers are greatly appreciated. In particular, we want to thank Bob Bastian, Al Rubin, Joe Farrell, and Chuck Henry for their generous contributions. We would also like to thank those who commented on the September 1988 draft.

CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND USE OF THIS GUIDANCE

Section 405 of the Clean Water Act (referred to as the Act) requires that EPA regulate the use and disposal of sewage sludge to protect public health and the environment from any reasonably anticipated adverse effects of these practices. In the Act, Congress directs EPA to develop technical standards for sludge use and disposal options and to incorporate these standards into National Pollutants Discharge Elimination System (NPDES) permits issued to Publicly Owned Treatment Works (POTWs) under Section 402 of the Act. EPA has proposed an initial round of technical sludge standards (40 CFR Part 503) which are expected to be promulgated in 1991. Congress also specified that sewage sludge use and disposal practices be regulated immediately. This mandate initiated EPA's development of an interim program (Sewage Sludge Interim Permitting Strategy) to control sludge use and disposal until all the necessary regulations are completed.

The purpose of this guidance document is to provide technical information and assistance to EPA permit writers in developing interim sludge requirements on a case-by-case basis. The guidance provides information on existing regulations for use in developing sludge permit conditions. It also recommends additional permit conditions that are based on current Federal guidance as well as State requirements and/or recommendations. Permit writers may consider including these additional conditions in permits on a case-by-case basis exercising their best professional judgment. Separate chapters (5-9) address each major sludge use or disposal option and summarize all Federal and State requirements as well as recommendations. This guidance document also describes monitoring and reporting requirements as well as standard permit conditions for inclusion in all new or reissued POTW permits. Although this guidance document is addressed to EPA permit writers, the information it contains should also be useful to State permit writers for developing sludge permit conditions and identifying potential sludge use or disposal problems.

EPA intends this guidance to serve as the primary reference for writing interim, case-by-case sludge requirements for POTWs. The need for writing interim sludge requirements will continue until final promulgation of applicable technical sludge standards at 40 CFR Part 503. Even after promulgation of the standards, BPJ limits may be needed to address pollutants or management practices of concern at a particular POTW that are not addressed in the technical standards. In addition, the first round of technical standards may not address the disposal option employed by a particular POTW. For example, sludge lagoons and other methods of surface disposal where

sludge is retained for less than a year, which are addressed in Chapter 9 of this guidance, were not covered in the first round of technical standards as proposed. For these situations, this guidance will continue to be useful for permit writers.

The recommendations contained in this manual have been carefully reviewed for consistency with the forthcoming technical regulations (40 CFR Part 503). This guidance is intended to help the permit writer identify and address, through permits, existing or potential problems with sludge use or disposal, in the absence of promulgated technical standards. The guidance is not intended to supplant the 40 CFR Part 503 standards or implement them before they are final. In developing permit limits for POTWs in the interim, the primary source of information for permit writers should be the Case-by-Case Guidance. Information from other sources, of course, may be considered and evaluated by the permit writer in the exercise of his or her best professional judgment.

The proposed 40 CFR Part 503 standards are currently undergoing revision in response to the public comments recieved and peer review undertaken during the 180 day comment period. These inputs, as well as the results of the National Sewage Sludge Survey, may result in final standards that are significantly different from the proposal. In light of these circumstances, reliance on the proposed standards should be limited. Permit writers should not rely on the proposed numeric limits in 40 CFR Part 503 in developing case-by-case sludge conditions unless they can establish independently the appropriateness of such conditions based on the circumstances of the particular sludge practice at issue. Any sludge conditions other than those based on existing regulations, must have a sound technical basis that is explained in the permit's fact sheet.

Under the Sewage Sludge Interim Permitting Strategy, EPA may defer to State implementation of the Interim Strategy pursuant to a State/EPA agreement. When a State has assumed responsibility for implementation of sludge requirements, EPA must review and approve permit conditions for those POTWs which are considered permitting priorities. This guidance document can be used by EPA Regional Offices for that purpose and, where appropriate, to develop supplemental requirements. (See "Sewage Sludge Interim Permitting Strategy" in Appendix A for a fuller explanation of the procedures for coordinating State/EPA permitting activities.)

Because of the multi-media impacts of sludge disposal and a history of a fragmented approach to sludge regulation, writing interim sludge limits will require a great deal of coordination among EPA offices and between EPA and the States. For example, determining appropriate permit conditions for incinerators will require cooperation and support from EPA and State air program officials. Similarly, determining what conditions to place in a permit for a POTW that disposes of

its sludge in a landfill will require cooperation and support from EPA and State solid waste programs. This guidance document provides guidance on how, when, and with whom to coordinate (see Appendix G for contacts in State and Regional solid waste and air program offices).

1.2 HISTORY OF SLUDGE REQUIREMENTS IN THE CLEAN WATER ACT

Over the past 15 years, Congressional concern with the proper use and disposal of sewage sludge has lead to increased attention in the Clean Water Act ("CWA"). In the Federal Water Pollution Control Act Amendments of 1972, Congress prohibited the disposal of sewage sludge to navigable waters without a permit (Section 405). It also directed EPA to issue regulations governing the issuance of permits that would apply "each criterion, factor, procedure, and requirement applicable to a permit issued under Section 402 [NPDES]...." Thus, initially Congress provided for the regulation of sewage sludge in the same manner as other pollutant discharges to navigable waters.

In the 1977 amendments to the CWA, Congress expanded its concern about sewage sludge disposal beyond discharges to navigable waters. The focus of these amendments was to encourage the beneficial use of sludge, i.e., to treat the growing amounts of sewage sludge as a resource rather than a disposal problem. To this end, Congress directed EPA in Section 405(d) of the CWA to issue regulations that would identify: 1) use and disposal options; 2) factors to be taken into account in determining the measures and practices applicable to each option; and 3) concentrations of pollutants in the sludge that interfere with each option.

The 1977 amendments prohibited POTWs from disposing of sewage sludge by any method in which Section 405 standards were established unless in compliance with such standards, but did not require that the standards be implemented through Federally enforceable permits. In an amendment to Section 307(b), Congress also explicitly linked sewage sludge disposal to the pretreatment program by allowing for removal credits (i.e., credits given to industrial user for pollutant removals achieved by the POTW) for toxic pollutants treated by a POTW, although credits could be granted only if this would not result in violation of the sewage sludge use and disposal requirements under Section 405. (See Section 54 of the CWA of 1977, P.L. 95-217)

The sludge use and disposal standards envisioned in the 1977 amendments to the CWA led to the promulgation of 40 CFR Part 257 (under the joint authority of the CWA and the Resource Conservation and Recovery Act). 40 CFR Part 257 (see Appendix D) established standards for cadmium, PCBs, and pathogens in sludge applied to land and established general management standards for solid waste landfills. Currently, these are the only sludge disposal standards

promulgated under the authority of Section 405(d) of the CWA. (Other regulations promulgated by EPA, however, govern various aspects of sewage sludge disposal. These are described later in Chapter 2)

With the passage of the Water Quality Act of 1987 (P.L. 100-4) ("WQA"), Congress reaffirmed its intent to have EPA comprehensively regulate the use and disposal of sewage sludge. Congress again called for the promulgation of technical standards, and in Section 405(d)(2) placed new emphasis on identifying and limiting those toxic pollutants in sewage sludge that may adversely affect public health or the environment. It also enacted strict deadlines for compliance with these standards: within one year of promulgation unless construction of new pollution control facilities is necessary, in which case compliance is required within two years. Congress further required that EPA implement the technical standards through NPDES permits issued to POTWs and other treatment works treating domestic sewage unless the standards were already included in a permit issued under other Federal programs listed in Section 405(f)(1) or under State programs approved by EPA as adequate to ensure compliance with Section 405. Congress also directed EPA to begin immediate regulation of sewage sludge use and disposal. The 1987 amendments state that:

> Prior to the promulgation of the regulations required by paragraph (2) [technical standards], the Administrator shall impose conditions in permits issued to publicly owned treatment works under Section 402 of this Act or take such other measures as the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge.
>
> [Section 405(d)(4) of CWA added by the WQA of 1987.]

Thus, even before promulgation of the technical standards, EPA must begin to address sewage sludge use and disposal in NPDES permits issued to POTWs. It must also identify other measures that may be appropriate to ensure environmentally sound sludge disposal practices.

1.3 IMPLEMENTATION OF THE WATER QUALITY ACT OF 1987

EPA activities to fulfill the Congressional mandate under Section 405 can be divided into two parts. One part involves the development of technical standards to regulate sewage sludge use and disposal and the other involves the establishment of administrative procedures for incorporating these technical standards into permits.

Recent activities to establish technical standards have resulted in the proposal of two new regulatory packages. In 1988, EPA's Office of Solid Waste proposed new regulations (40 CFR Part 258) for operation and maintenance of municipal landfills which would cover codisposal of sewage sludge with municipal solid waste. In 1989, EPA's Office of Water Regulations and Standards proposed regulations (40 CFR Part 503) which identify sludge quality requirements as well as management practices for sewage sludge use or disposal by means of land application, distribution and marketing, sludge-only monofills, incinerators, and surface impoundments.

To provide a mechanism for including the technical limits in permits, EPA promulgated regulations designed to incorporate sewage sludge use and disposal requirements into permits as required under Section 405(d) of the Clean Water Act. On May 2, 1989, (published at 54 FR 18716), EPA issued final revisions to the regulations contained in 40 CFR Part Parts 122 and 124 which identify permit requirements under Section 402 of the Clean Water Act. These regulations require inclusion of sludge conditions in National Pollutant Discharge Elimination System (NPDES) permits issued to municipal sewage treatment works. The regulations also authorize issuance of permits to facilities which do not discharge wastewater under the NPDES program. In general, these regulations which already addressed discharges of water, were expanded to cover the sludge generated as a by-product of wastewater treatment operations.

EPA also promulgated regulations for State sludge management programs (40 CFR Part Parts 501 and 123) (published at 54 FR 18716; May 2, 1989). These regulations specify procedures for States to receive approval to implement sludge management programs in lieu of the Federal program. In order to receive program approval, a State must demonstrate adequate legal authority and administrative procedures to issue permits and determine compliance with and enforce Federal and State sewage sludge regulations and requirements.

To carry out the congressional directive to take immediate steps before promulgation of technical regulations, EPA has developed a "Sewage Sludge Interim Permitting Strategy" (1989) (see Appendix A). EPA's Interim Permitting Strategy: 1) discusses the identification of permitting priorities; 2) identifies minimum permit requirements; and 3) describes how EPA and the States will coordinate interim permitting and other activities. The major goal of the interim program is to identify and control known or potential problem facilities and target these facilities for more site-specific permit requirements, thereby facilitating compliance with the technical standards once promulgated. This will be accomplished by: 1) ensuring that all NPDES permits issued or reissued to POTWs after February 4, 1987 contain certain minimum conditions, including a requirement that the permittee comply with all existing Federal regulations governing the use and disposal of

sewage sludge, and with applicable 40 CFR Part 503 technical standards when promulgated; 2) requiring POTWs to perform sludge monitoring and reporting; and 3) providing case-by-case permit conditions for POTWs which have been identified as a priority for sludge permitting (i.e., pretreatment POTWs and POTWs whose sludge or sludge use and disposal practices have the potential to adversely affect the public health and environment).

1.3.1 LEGAL BASIS FOR INTERIM SLUDGE REQUIREMENTS

EPA's legal authority to include sludge requirements in NPDES permits for POTWs before promulgation of technical standards comes directly from Section 405(d)(4) of the CWA. As explained in the previous section, Congress clearly intended that EPA begin regulating sewage sludge use and disposal immediately, prior to and in the absence of promulgated technical standards. Also, as noted throughout this chapter, EPA's authority to take interim measures is very broad and includes taking any measure "the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge." Thus, EPA has a responsibility to identify and address problems caused by contaminated sludge or poor disposal practices. EPA's authority under Section 405(d)(4) is flexible enough to address known problems with sewage sludge use or disposal that may fall outside the core objective to include interim sludge limits in new or reissued POTW permits. For example, this authority allows the modification of existing permits to address sludge disposal problems.

Where existing Federal regulations apply to a particular sewage sludge use or disposal practice, Section 405(d)(4) of the CWA gives EPA the authority to implement the requirement through NPDES permit conditions (which may simply be a matter of incorporating those requirements by reference). In addition, 40 CFR Part 122.44(b)(2) requires that permits include standards under Section 405(d). (This means that the 40 CFR Part 257 requirements, which were promulgated under the joint authority of RCRA and Section 405 of the CWA , are to be implemented through NPDES permits unless sufficiently covered in another permit.)

In addition to the Clean Water Act, there are several other Federal laws that provide authority for regulating various aspects of sewage sludge disposal. These include the Clean Air Act (CAA); Subtitles C and D of the Resource Conservation and Recovery Act (RCRA); the Marine Protection, Research, and Sanctuaries Act (MPRSA); and the Toxic Substances Control Act (TSCA). POTWs already are under an obligation to comply with existing Federal regulations. Nevertheless, placing Federal regulations in the POTW's NPDES permit reinforces the importance

of compliance for purposes of the Clean Water Act and helps to ensure that sludge disposal practices will not threaten public health and the environment. It also provides a more direct link to pretreatment controls which are an important means of improving sludge quality. Table 1-1 lists current Federal regulations that directly apply to sludge use and disposal. Permit writers should consult with the program offices responsible for implementing these programs to see if NPDES permit conditions aimed at improving sludge quality and disposal practices would help ensure compliance with the existing requirements.

By providing for interim sludge permit conditions before promulgation of the technical standards, Congress clearly indicated that reliance on the status quo would be insufficient. For most, if not all priority POTWs, existing Federal requirements will not be enough to provide for protection of public health and the environment. Where permit conditions based on existing regulations are insufficient to protect public health and the environment from adverse effects that may occur from toxic pollutants in sewage sludge, permit conditions should be developed on a case-by-case basis using best professional judgment ("BPJ") to fulfill the statutory standard.

Using best professional judgment to develop interim sludge requirements follows the same general principles used in developing best professional judgment effluent limits in NPDES permits. Permit conditions developed using BPJ are based on the sound technical opinion of the permit writer after consideration of all reasonably available and pertinent data or information. Unlike the technology-based BPJ effluent limits governed by the criteria in 40 CFR Part 125.3(c), however, BPJ sludge limits are health-based, i.e., designed to protect public health and the environment from the adverse effects of toxic pollutants in sewage sludge.

While BPJ authority gives the permit writer considerable flexibility in developing sludge requirements on a case-by-case basis, it also places a burden on him or her to show that the permit conditions are based on a sound technical analysis and designed to protect public health and the environment. Like other permit conditions, interim sludge requirements may be subject to legal challenge; therefore, the need for the permit condition and the basis for its establishment should be clearly defined and documented (e.g., in the fact sheet for the permit).

1.4 PERMITTING REQUIREMENTS AND RECOMMENDATIONS

This guidance sets forth the existing Federal requirements in each of the major sludge use and disposal practices. However, for many disposal options or situations, Federal requirements have not been promulgated. Therefore, this guidance also includes recommendations for each disposal

TABLE 1-1

SLUDGE MANAGEMENT REGULATIONS OF THE ENVIRONMENTAL PROTECTION AGENCY

Coverage	Reference	Application
Polychlorinated Biphenyls (PCBs)	40 CFR Part 761	All sludges containing more than 50 milligrams per kilogram
Ocean Dumping	40 CFR Part 220-228	The discharge of sludge from barges or other vessels
New Sources of Air Emissions[1]	40 CFR Part 60	Incineration of sludge at rates above 1,000 kilograms per day
NESHAPs Mercury and Beryllium	40 CFR Part 61	Incineration and heat drying of sludge
Cadmium, PCBs, Pathogenic Organisms	40 CFR Part 257	Land application (including distribution and marketing) of sludge, landfills,[2] storage lagoons
Extraction Procedure Toxicity[3]	40 CFR Part 261 Appendix II	Defines whether sludges are hazardous

Source. *Use and Disposal of Municipal Wastewater Sludge* (EPA 1984).

[1] Revisions to this part were proposed on April 18, 1986 (51 FR 13424). EPA expects to issue a final rule in mid-1988. Additional limits on air emissions may apply to particular facilities based on a State Implementation Plan (SIP). SIPs are codified at 40 CFR Part 52. Other air regulatory programs that may limit emissions include National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), New Source Review Standards (40 CFR Part 51.18) and Prevention of Significant Deterioration (PSD) (40 CFR Part 52.21).

[2] Municipal Solid Waste Landfills will be regulated under 40 CFR Part 258 when regulations are promulgated late in 1990.

[3] Regulations are expected to be promulgated in late 1989 where EP toxicity test will be replaced by TCLP test.

practice. These recommendations are provided to assist permit writers in developing contaminant limits and management practice requirements on a case-by-case basis to protect public health and the environment from adverse effects that may occur from toxic pollutants in sewage sludge. Recommended contaminant limits and management practices are based on Federal guidance and/or widely applied State requirements or guidelines. Specific recommendations based on State regulations or guidelines alone were adopted after consideration by a work group and in light of comments received from outside parties.

Table 1-2 lists all pollutants for which Federal or State limits or guidance have been identified for sludge use or disposal. Limits are not recommended for all these pollutants. It is also important to note that permit writers are not restricted to addressing these pollutants in writing BPJ limits. If a particular pollutant is causing or threatening to cause a disposal problem, the permit writer may place a limit for it in the permit. As a general rule, only pollutants of concern (i.e., those which exceed or potentially exceed the level appropriate to protect public health and the environment), whether addressed in Federal or State guidance or regulations, should be limited in the permit.

Generally, EPA permit writers should also include any applicable State requirements, unless they are less stringent than what is required by Federal regulation (since Federal requirements must be included as a minimum). This will help minimize disruption to existing State programs, especially during the interim phase of implementing Section 405. Again, the permit writer should use best professional judgment in applying State requirements and recommendations. While incorporation of State requirements would be appropriate in most cases, permit writers should do as much as possible to ensure that whatever requirements they adopt can be reasonably defended.

1.5 DEVELOPMENT OF THIS GUIDANCE

The Office of Water Enforcement and Permits (OWEP) formed a Workgroup on Sludge Permitting Issues to assist in developing policy and guidance materials. The Workgroup included representatives from: EPA Headquarters offices with experience in regulating or providing guidance on sludge use and disposal (including the Office of Water Regulations and Standards (OWRS), Office of Municipal Pollution Control (OMPC), Office of Research and Development (ORD), Office of Solid Waste and Emergency Response (OSWER), and other offices); all 10 EPA Regional Offices; and several States (New Jersey, Iowa, Wisconsin, Connecticut, Missouri, California, and Kansas). The Workgroup reviewed and commented on drafts of policy and guidance and participated in key early decisions about such issues as permitting priorities,

TABLE 1-2

TOXIC POLLUTANTS* SPECIFICALLY ADDRESSED IN THIS GUIDANCE

Pollutant	Federal Regulation	Federal Guidance	State Requirements	503 Proposed
Aldrin			X	X
Aluminum			X	
Arsenic	X[4]	X[5]	X	X
Barium		X[5]	X	
Benzene			X	X
Benzo(a)-pyrene				X
Beryllium	X[6]		X	X
Bis(2-ethyl-hexyl)-phthalate				X
Boron			X	
Cadmium	X[4,9]	X[5]	X	X
Carbon Monoxide	X[6]		X	
Chlordane			X	X
Chlorine		X[1]		
Chromium	X[4]	X[5]	X	X
Cobalt			X	
Copper	X[4]	X	X	X
Cyanide		X[3]	X[3]	
2,4-D		X[5]		
DDD/DDE/DDT			X	X
Dieldrin			X	X
Dimethyl-nitrosamine				X
Dioxin			X	X
Endrin		X[5]	X	
Flounde		X[5]	X	
Heptachlor			X	X

(Continued)

* In addition, pathogen reduction standards will apply to land application and to distribution and marketing. See 40 CFR Part 257, Appendix II.

[1] *Process Design Manual for Municipal Sludge Landfills* (EPA 1978) recommends monitoring for these parameters at landfills.

[2] *Process Design Manual of Land Application of Municipal Sludge* (EPA 1983) recommends monitoring for these parameters at land application sites.

[3] State monitoring and reporting requirements for sludge and compost (EPA 1987).

[4] Proposed revisions to the new source performance standards for sewage sludge incinerators (40 CFR Part 60) would require initial testing for these metals.

[5] Maximum Groundwater Contaminant Limits from 40 CFR Part 257 Appendix C. Appendix C also provides maximum contaminant limits for coliform bacteria, ^{226}Radium, ^{228}Radium and gross alpha radiation.

[6] National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR Part 61).

[7] Sewage sludge containing over 50 mg/kg PCBs must comply with TSCA (40 CFR Part 761).

[8] National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50).

[9] 40 CFR Part 257.

TABLE 1-2
(Continued)

Pollutant	Federal Regulation	Federal Guidance	State Requirements	503 Proposed
Heptachlor Epoxide			X	
Iron		X[2]		
Lead		X,X[5]	X	X
Lindane		X[5]	X	X
Lithium			X	
Manganese			X	
Mercury	X[6]	X,X[5]	X	X
Methoxychlor		X[5]	X	
Mirex			X	
Molybdenum			X	X
Nickel	X[4]	X	X	X
Nitrogen Compounds	X[8]	X[2]	X	
Nitrates		X[5]		
Oil & Grease			X	
Organics			X	
Phenols			X	
Pesticides			X	
Phosphorus		X[2]	X	
Potassium			X	
PCBs	X[7]	X	X	X
Radium		X,X[5]	X	
Radon		X	X	
Selenium	X[4]	X[5]	X	X
Silver		X[5]	X	
Silvex		X[5]		
Sodium			X[3]	
Total Hydrocarbons				X
Total Org. Carbon		X[1]		
Toxaphene		X[5]		
Trichloro-ethylene				X
Uranium		X	X	
Vinyl Chloride			X	X
Zinc	X[4]	X	X	X

* In addition, pathogen reduction standards will apply to land application and to distribution and marketing. See 40 CFR Part 257, Appendix II.

[1] *Process Design Manual for Municipal Sludge Landfills* (EPA 1978) recommends monitoring for these parameters at landfills.

[2] *Process Design Manual of Land Application of Municipal Sludge* (EPA 1983) recommends monitoring for these parameters at land application sites.

[3] State monitoring and reporting requirements for sludge and compost (EPA 1987).

[4] Proposed revisions to the new source performance standards for sewage sludge incinerators (40 CFR Part 60) would require initial testing for these metals.

[5] Maximum Groundwater Contaminant Limits from 40 CFR Part 257 Appendix C. Appendix C also provides maximum contaminant limits for coliform bacteria, radium-226, and gross alpha radiation.

[6] National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR Part 61).

[7] Sewage sludge containing over 50 mg/kg PCBs must comply with TSCA (40 CFR Part 761).

[8] National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50).

[9] 40 CFR Part 257.

appropriate monitoring and other permit requirements for non-Class I POTWs, and the basis for developing technical guidance for writing interim limits.

With assistance from OMPC and EPA Regional Offices, OWEP gathered and summarized information on the technical requirements and guidelines of State sludge programs for use in this guidance. Upon distribution of the draft guidance in September 1988, States were asked to review information and submit any revisions or corrections to OWEP. Appendix E presents the summaries that were revised to reflect this new information. These tables are designed for quick reference and to direct permit writers to the source of State information. Appendix E reflects the fact that it was not always possible to distinguish between requirements and recommendations. The permit writer should be aware of this and should consult with State officials during the course of a permit's development or review to clarify and distinguish State requirements from State recommendations.

Similar efforts were undertaken to summarize current Federal requirements and guidance and summarize other technical literature on sludge use and disposal. Based on the data collected, OWEP developed draft permitting requirements and recommendations. These were reviewed by and discussed with staff in OSWER, the Office of Air and Radiation (OAR), the Air Enforcement Division of the Office of Enforcement and Compliance Monitoring (OECM), OMPC, and OWRS to ensure consistency with requirements of other EPA program offices and with the forthcoming proposed technical standards under 405(d). OWEP then submitted a draft of this guidance document to the Workgroup for review and comment. EPA released the guidance in draft final form in September 1988 to States, Regions and interested parties for use in writing POTW permits. The present guidance has been revised in response to comments received since the release of the draft final.

REFERENCES

EPA 1978. Process Design Manual for Municipal Sludge Landfills. U.S. Environmental Protection Agency, EPA-625/1-78-010, October 1978.

EPA 1983. Process Design Manual for Land Application of Municipal Sludge, U.S. Environmental Protection Agency, EPA-625/1-83-016, October 1983.

EPA 1984. Use and Disposal of Municipal Wastewater Sludge. U.S. Environmental Protection Agency, EPA 625/10-84-003, September 1984.

EPA 1987. State Requirements for Sludge Management, U.S. Environmental Protection Agency, Office of Municipal Pollution Control and Office of Water Enforcement and Permits, Washington, D.C., 1987 (Revised 1989).

CHAPTER 2
APPLICABILITY OF THIS GUIDANCE

This chapter explains the scope of this guidance document and EPA's Sewage Sludge Interim Permitting Strategy. It also refers permit writers to other guidance documents that might be useful for addressing specific problems not covered by this guidance. In addition, it provides information on coordinating with other offices on the development of permit conditions when the publicly owned treatment works' (POTW's) sludge use or disposal practice may already be regulated under other programs. Finally, it explains the relationship between sludge permitting and the pretreatment program.

2.1 FACILITIES COVERED

Based on the language of Section 405(d)(4) of the Clean Water Act (CWA), EPA's Interim Permitting Strategy focuses on POTWs with National Pollutant Discharge Elimination System (NPDES) permits. Certain minimum requirements, such as compliance and notice provisions and monitoring requirements, apply to all new and reissued permits for POTWs. (See Chapter Four and Appendix A). Ideally, permit writers should evaluate the need for sludge requirements in all NPDES permits issued to POTWs. However, in the face of limited resources, EPA has identified a subset of all NPDES POTWs which need to be targeted for more comprehensive permit coverage. The Interim Permitting Strategy calls this group of POTWs "Class I sludge management facilities" (this term is synonymous with the "priority" POTW designation used in the earlier draft of the Interim Permitting Strategy).

Class I facilities are: all POTWs that are required to have an approved pretreatment program, any other facility with known or suspected sludge problems, and any POTWs using sludge incineration unless evidence exists to demonstrate absence of existing or potential problems (see Part III, Sewage Sludge Interim Permitting Strategy in Appendix A for discussion of "Class I" POTWs). These facilities will need additional case-by-case sludge conditions unless the permitting authority determines, based on information about the facility's sludge quality and use or disposal practices, that the sludge is already adequately controlled. This guidance is primarily directed to the Class I sludge management facilities.

2.2 FACILITIES NOT COVERED

The following types of facilities are not covered by the Interim Permitting Strategy: non-NPDES POTWs (i.e., POTWs that do not discharge their effluent to surface waters), Federal facilities, sewage sludge treatment or disposal facilities that are not connected to wastewater treatment works, privately owned sewage treatment works (including individual septic systems and septage treatment facilities where septage is trucked in, treated, then land applied), and industrial facilities that treat domestic sewage as part of their wastewater treatment activities. However, these other facilities may cause adverse effects to public health or the environment through sludge use or disposal practice. The CWA provides EPA with broad authority to take interim measures to address environmental or public health problems created by sludge quality or practices at these other facilities. Permit writers should be mindful of the potential need for greater control at these other facilities and may use this guidance where appropriate to address environmental concerns in a permit.

This guidance document focuses primarily on sewage sludge generators, i.e., POTWs. However, effective regulation of sewage sludge to prevent adverse environmental or public health effects may require controls at the ultimate disposal site as well. Permit conditions that address both aspects of sewage sludge control can be developed when the POTW controls both generation and disposal of sewage sludge. A POTW that generates sludge, but is not the end user or disposer of the sludge presents a more difficult situation since the POTW may not be able to easily or effectively ensure compliance with use or disposal requirements placed on the end users. For example, this could occur when a small POTW transports its sludge to an incinerator owned and operated by another POTW, or when a POTW sends its sludge to a privately owned solid waste landfill.

Since the technical standards authorized by Section 405(d) of the CWA will apply to users and disposers of sewage sludge as well as generators, determining how best to regulate end users that are not also generators is a significant issue. As a general rule, this guidance recommends that the less control the POTW or permit authority has over the end use, the more stringent should be the permit requirements regulating sludge quality. As reflected in the recommendations in this guidance, permit conditions can be developed and applied to a POTW to help assure compliance with use and disposal requirements by end users. For example, POTWs can be required to label sludge products to inform the user of safe use practices and limitations that apply to use of the product. In addition, the permit can prohibit the POTW from disposing of its sludge at a facility not in compliance with applicable Federal requirements (e.g., a landfill that does not comply with 40 CFR Part 257). EPA does not plan to institute a widespread regulatory program for end users as part of its

Interim Permitting Strategy. However, if problems due to the misuse of sludge by end users occur and they cannot be addressed through POTW permit conditions, the Regions should use their authority under Section 405(d)(4) of the CWA to take action to address the problem.

2.3 PRACTICES COVERED

This guidance document addresses five sludge use and/or disposal methods, each the subject of a separate chapter:

- o Landfilling (Chapter 5);
- o Land application (Chapter 6);
- o Distribution and marketing (Chapter 7);
- o Incineration (Chapter 8); and
- o Surface disposal (Chapter 9).

The disposal methods of landfilling, incineration and surface disposal require further explanation to define how these practices are specifically addressed by this guidance. An explanation of each is provided below.

2.3.1 LANDFILLING

Guidance in Chapter 5 includes information on two types of landfills which may accept sewage sludge; sludge-only monofills and solid waste codisposal landfills. Both are currently governed by 40 CFR Part 257. EPA has proposed that in the future, monofills will be covered by 40 CFR Part 503 and co-disposal landfills will be covered by 40 CFR Part 258. These landfills may also be regulated under State Subtitle D solid waste programs. Therefore, POTW permit writers and solid waste offices should coordinate permit development and issuance to ensure that landfilled POTW sludge is disposed of in an environmentally sound manner and that the landfill accepting the sludge complies with existing requirements (e.g., 40 CFR Part 257) and is not endangering public health and the environment. As a general rule, this guidance recommends allocating responsibility for regulating landfilled sludge (through permit conditions or enforcement actions) based on the relative proportion of sludge in the landfill. Thus, when a POTW uses a sludge-only landfill (monofill) for disposal, the POTW permit writer would determine appropriate permit conditions to prevent the landfill from harming public health or the environment. If the POTW sends its sludge to a landfill that accepts wastes other than sewage sludge (co-disposal), the permit writer should consult with the appropriate solid waste office on necessary measures when the sludge is a large

proportion of the landfill (e.g., more than 30 percent) and generally defer to the solid waste office if the sludge is only a small proportion of the landfill's volume (e.g., under 30 percent). These guidelines are intended to prevent duplication of effort while making sure that NPDES permit writers fulfill their responsibility under the CWA to take measures to protect public health and the environment from problems caused by sludge disposal.

2.3.2 INCINERATION

Guidance in Chapter 8 covers incinerators that accept primarily sewage sludge. Many of these facilities are subject to regulation under various Clean Air Act programs. Therefore, it is particularly important for permit writers to determine the current requirements applicable to the facility for possible incorporation into permit documentation, and to work with air program offices to develop appropriate permit conditions. If the permit writer determines that the incinerator is already permitted such that it is not causing a problem to public health or the environment, the permit writer may incorporate the existing permit into the NPDES permit. This procedure reduces the duplication of effort.

The guidance does not address municipal waste incinerators that may accept small amounts of sewage sludge. Since sewage sludge is sufficiently different from other municipal waste to discourage most municipal incinerators from accepting it, the instances in which a POTW sends its sludge to a municipal waste incinerator should be rare. In this situation, the permit writer should take reasonable steps to ensure that the POTW does not send its sludge to a facility that is not in compliance with existing requirements.

Disposal of the ash generated during the incineration will not be discussed in this guidance (or in the 40 CFR Part 503 sludge technical regulations) but will continue to be covered under 40 CFR Part 257 (or 40 CFR Part 258 when promulgated) as a solid waste.

2.3.3 SURFACE DISPOSAL

A recent EPA survey of Solid Waste Disposal Facilities identified 197,500 surface impoundments, of which 1,938 contain municipal sewage sludge (EPA 1986). EPA also has information suggesting that some communities use surface impoundments for extended periods of time suggesting that the practice is the community's method of disposal. In the proposed 40 CFR Part 503, the Agency defined a "surface disposal site" as an area of land on which only sewage sludge is placed for a period of one year or longer. The one year time period is used to differentiate

surface disposal from treatment or temporary storage. During interim implementation and in the first round of technical standards, EPA does not intend to address temporary sludge storage practices (e.g. less than one year) or treatment processes. When used for long term storage or disposal, however, surface impoundments may endanger the environment due to the same types of problems created by poorly sited or operated landfills. As a general rule, the permit writer should consider imposing conditions if sludge is held in a surface impoundment for more than one year (see 54 FR 5824-25 for a discussion of the differences between landfills, surface impoundments, non-agricultural land application to dedicated land, wastewater treatment lagoons, etc.).

2.4 PRACTICES NOT COVERED

2.4.1 OCEAN DISPOSAL

Ocean disposal of sewage sludge is not covered in the proposed technical standards and is not covered in this guidance document. Ocean disposal of sewage sludge is regulated by the Marine Protection, Research, and Sanctuaries Act (MPRSA) (40 CFR Part Parts 220-228). EPA's Office of Marine and Estuarine Protection currently issues permits pursuant to the sludge disposal requirements of the MPRSA. In November 1988, Congress passed the Ocean Dumping Ban Act (PL100-688), amending MPRSA. Among other things, the purpose of the amendment to this Act is to terminate the ocean-dumping of sewage sludge by December 1991. At that time, POTWs that currently ocean dispose of their sewage sludge will have to implement land-based sludge management alternatives, which will be subject to the jurisdiction of the CWA. If applicable sludge standards have not been promulgated, permit conditions will have to be developed on a case-by-case basis. In the interim, NPDES permits still must include boilerplate standard conditions, e.g., notice of changed disposal practice and a compliance provision (which includes a reopener that would allow the NPDES permit to be modified upon promulgation of the technical standards). State and Regional permit writers should work with the POTWs and MPRSA authorities during this interim period to assess the quality of the sludge and assist the POTWs in developing appropriate land-based disposal methods.

2.4.2 SLUDGE STORAGE

EPA does not intend to address temporary sludge storage practices (e.g. less than one year). However, the Agency does intend (as included in the proposed 40 CFR Part 503) to regulate "surface disposal sites." These are impoundments or areas of land on which only sewage sludge is placed for a period of one year or longer. The one year time period is used to differentiate surface

disposal from treatment or temporary storage. This guidance document does not cover temporary storage practices such as sludge lagoons and other surface impoundments where sludge is held less than one year. Currently, EPA has no evidence to suggest that short-term storage presents an environmental threat warranting national concern. Nevertheless, EPA has the authority to address problems created by short-term storage practices if warranted at a particular site. When a permit writer suspects that problems with storage practices exist, he or she should include conditions to address the problem in the facility's permit. Problems may occur, for example, at storage lagoons holding sludges with high levels of contaminants, lagoons that are regularly emptied and replenished, or those located at sites with particularly important or vulnerable ground-water or surface water resources.

2.4.3 SLUDGE TREATMENT PROCESSES

Prior to the ultimate use or disposal of sewage sludge, POTWs generally use a combination of biological, chemical, physical, and thermal processes to treat the sludge. These treatment processes are designed primarily 1) to increase the solids content of the sludge by reducing its water content and 2) to stabilize the sludge by reducing or eliminating pathogens, odors, and volatile solids. Advantages of such treatment include an improvement in the characteristics of the sludge for a particular use/disposal practice, an increase in the economic viability of using a particular practice, and a reduction in the potential for public health, environmental, and nuisance problems. Chapter 3 briefly describes the various treatment processes, their advantages and disadvantages, and how they may affect final sludge quality or disposal options. Except in two situations covered by existing Federal regulations (pathogen reduction requirements and NESHAPs) this guidance does not cover or prescribe particular sludge treatment processes.

2.4.4 SEPTAGE DISPOSAL

Septage, or the pumpings from septic tanks, is a concentrated waste that may introduce significant pollutant loads to the environment (particularly ground-water) when disposed on land. While the trend has been toward discharging septage into POTWs for treatment, various land disposal methods are still practiced. Under some existing Federal regulations, as well as under the proposed 40 CFR Part 503 technical standards, septage disposal practices are subject to the same standards as sewage sludge disposal practices. Currently, land disposal of septage is governed by 40 CFR Part 257. State and local law may also regulate septage disposal. However, septage disposal is outside the scope of this guidance. Also, as with other facilities or practices that are generally outside the scope of the existing NPDES permit program, septage disposal is not

specifically addressed in EPA's Interim Permitting Strategy. Nonetheless, EPA has the authority to address known problems with septage disposal. For guidance, permit writers should refer to EPA's Handbook on Septage Treatment and Disposal (EPA 1984).

2.4.5 DISPOSAL OF HAZARDOUS WASTE

Neither the interim nor the long-term sewage sludge disposal program under Section 405 of the CWA will govern sewage sludge that constitutes hazardous waste, as determined in accordance with the RCRA regulations (40 CFR Part 261). Instead, these sludges will continue to be regulated under Subtitle C of RCRA (40 CFR Part 264/265).

Sewage sludge is not a listed hazardous waste. Moreover, available evidence from characteristic tests suggests that POTW sludges are unlikely to be a characteristic hazardous waste. However, the non-hazardous nature of POTW sludge cannot be assumed, and as sludge generators, POTWs are required under 40 CFR Part 262.11 to determine whether or not their sewage sludge is a hazardous waste by virtue of its characteristics.

A solid waste may be a characteristic hazardous waste if it exhibits characteristics of ignitability (40 CFR Part 261.21), corrosivity (40 CFR Part 261.22), reactivity (40 CFR Part 261.23), or EP toxicity (40 CFR Part 261.24). Permit writers should require the POTW to submit the results of any characteristic tests that have been run on the POTW's sludge. Although sewage sludge conceivably could exhibit the characteristics of ignitability, corrosivity, or reactivity, most concerns about sewage sludge have focused on EP toxicity. Therefore, this guidance recommends that permit writers include conditions in Class I permits requiring the POTW to conduct an EP toxicity test if factors are present indicating a likely EP toxicity problem (e.g., POTW receives significant loadings of pollutants covered by the test) and the POTW does not have current data showing that the sludge is not a hazardous waste. (Note: EP toxicity test will change to Toxicity Characteristic Leaching Procedure (TCLP) test when the TCLP regulations are promulgated in final. See discussion, Chapter 5).

If a POTW sludge turns out to be a hazardous waste but is not currently being regulated under RCRA, the permit writer should notify the RCRA office, which will be responsible for regulating sludge generation and disposal. The permit writer need only include the standard sludge conditions (e.g., notice requirements, compliance provision) in the POTW's NPDES permit. (Note: Where appropriate, these standard provisions may be added in conjunction with the effort currently

underway to reopen permits of POTWs that are RCRA "permit-by-rule" facilities to add corrective action requirements.)

2.5 RELATIONSHIP BETWEEN SLUDGE PERMITTING AND THE PRETREATMENT PROGRAM

Reducing the amount of pollutants entering a POTW typically reduces the amount of contaminants in sewage sludge. A major goal of the national pretreatment program is to ensure that non-domestic discharges to a POTW do not interfere with the POTW's chosen sludge use or disposal practice. Further, an objective of the pretreatment program is to improve opportunities for the reuse and recycling of municipal effluents and sludges. POTWs that are required to have approved local pretreatment programs and those that experience recurring sludge contamination problems may have to develop or recalculate local discharge limits for their users in order to reduce the pollutants in the sludge to acceptable levels. (See 40 CFR Part 403.5(c).) Therefore, if the POTW cannot meet current sludge requirements because of high contamination levels, the permit writer could consult with the pretreatment approval authority to consider requiring the POTW to develop additional local limits. Additional information about detecting and remedying sludge contamination problems can be found in two EPA guidance documents available from the Office of Water Enforcement and Permits (OWEP): Guidance Manual for Preventing Interference at POTWs (September 1987) and Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program (November 1987).

REFERENCES

EPA 1984. Handbook on Septage Treatment and Disposal. U.S Environmental Protection Agency, Municipal Environmental Research Laboratory, EPA 625/6-84-009, October 1984.

EPA 1986. Subtitle D Study Phase I Report. U.S. Environmental Protection Agency, EPA 1530/SW/86-054, October 1986.

CHAPTER 3
OVERVIEW OF SLUDGE TREATMENT PROCESSES AND THEIR EFFECT ON SLUDGE PROPERTIES

3.1 INTRODUCTION

The following section provides a brief discussion of sludge treatment processes. The processes are outlined here since many NPDES permit writers have not been responsible for sludge regulation in the past, and may be unfamiliar with sludge management practices. Processes used to dewater, stabilize, and condition the sludge may directly effect sludge quantity and quality, while the type of wastewater treatment techniques used, such as chemical coagulation or lime addition, will effect sludge characteristics and contaminant levels.

The quality of a sludge that does not comply with use or disposal guidelines can sometimes be improved by more careful sludge processing or by the use of different treatment processes. In other cases, users of the POTW will need to improve the pretreatment of their wastewaters or the POTW may need to employ different use or disposal options.

3.2 SLUDGE TREATMENT ALTERNATIVES

Several techniques are commonly used to process sludge before ultimate use or disposal. Some of the more widely used processes are discussed briefly below. For more detailed descriptions, see the EPA Process Design Manual for Sludge Treatment and Disposal (EPA 1979).

3.2.1 THICKENING

Thickening is generally the first process in a solids processing train. It increases the solids content of sludges by removing some of the water. Thickening typically increases the solids concentration in the sludge two to ten times, thus reducing the volume of sludge to be treated in subsequent processes to one-half to one-tenth the original volume. Because sludge processing and disposal costs are greatly affected by sludge volume, thickening can significantly reduce capital and operating costs of subsequent operations.

Process equipment that may be used to thicken sludge includes gravity thickeners, dissolved air flotation thickeners, centrifuges, gravity-belt thickeners, and rotary screen thickeners. Sludges

from primary, biological, and chemical wastewater treatment can be blended and mixed in common thickeners or thickened separately.

3.2.2 STABILIZATION

Stabilization processes decrease volatile solids, offensive odors and pathogens in wastewater sludges. Offensive odors are lessened by decreasing the volatile content of sludges or by changing the sludge properties so that the sludge decomposes less rapidly. Some stabilization processes, especially aerobic and anaerobic digestion, also substantially reduce the quantity of suspended solids in the sludge. Stabilization technologies include anaerobic digestion, aerobic digestion, composting, lime treatment, and chemical fixation.

Anaerobic Digestion

Anaerobic digestion is a biological process that is widely used in municipal wastewater treatment plants to stabilize sludge. The process is accomplished by maintaining the sludge at elevated temperatures for about 10 to 30 days in the absence of free oxygen. The organic matter in the sludge is biologically decomposed and the pathogen content is reduced. The volatile content of the sludge is typically reduced by about 50 percent, which in turn reduces the sludge volume by about 30 percent.

The two operational temperature modes of anaerobic digestion are mesophilic (90 to 95°F) and thermophilic (120 to 135°F). Thermophilic digestion requires a much shorter solids retention time thus reducing the required digester capacity by about 50 percent. Thermophilic digestion also reduces the pathogen content more than mesophilic digestion.

Aerobic Digestion

Aerobic digestion of sludge is similar to the activated sludge treatment of wastewater. Both of these processes rely on biological treatment under aerobic conditions. The capital costs of aerobic digestion systems are typically much lower than the capital costs of an anaerobic digestion system. Because a large amount of energy is required to provide oxygen for biological activity, aerobic digestion is typically used in smaller plants where the reduction in capital costs more than compensates for the increased energy requirements. Aerobic digestion is also generally easier to operate by a small project staff.

Lime Treatment

Adding lime to raw sludge to raise the pH to 12 or greater for two hours decreases the concentration of pathogens and other organisms in the sludge and inhibits decomposition. However, as the pH of the sludge drops after lime stabilization, biological decomposition will resume, producing offensive odors.

The advantages of lime addition include lower costs and simplicity of operation. Nonetheless, sludge remains stabilized only as long as the high pH is maintained. Disposal costs are also increased because the large quantity of lime added to the sludge increases sludge volume.

Chemical Fixation

In the chemical fixation process, chemicals are added to solidify the sludge mass, render it inoffensive, and decrease the leachability of metals. Although there is no decrease in volume, the sludge is made stable. Chemical fixation is best performed after dewatering, which reduces the volume of sludge requiring final disposal.

The process is carried out by adding chemicals to a sludge, producing a colloidal solid that "sets" into a semi-rigid mass. The product can be handled as a solid material that can be landfilled, or used for landfill cover.

3.2.3 CONDITIONING

Sludge conditioning refers to physical and chemical methods for altering the properties of sludge to improve its dewatering characteristics. In general, the goal is to transform the hydrophilic, gel-like solids into a porous material that will release water. Proper conditioning improves the efficiency of the dewatering process. The two methods most commonly used are the addition of chemicals and heat conditioning.

Chemical Conditioning

Common chemicals used before dewatering include inorganics, such as lime and ferric chloride, and high-molecular-weight organic polymers. Chemical conditioning is widely practiced.

Heat Conditioning

The process involves heating sludge in a closed reactor to temperatures of 300 to 400°F. The reactor is under pressures of 250 to 300 psig, and holds the sludge under these conditions for 20 to 30 minutes. Heat treatment makes solids coagulate, breaks down the gel-like structure, and reduces the water in the sludge solids. As a result, the sludge is sterilized and readily dewatered, without adding chemicals, to a solids content of 30 to 45 percent. Heat conditioning is much less common than chemical conditioning due to its high energy usage.

3.2.4 DEWATERING

Dewatering converts sludge from a flowing mixture of liquid and solids to a cake-like substance more readily handled as a solid. Mechanical and heat drying techniques may be used. In addition to significantly reducing the moisture content, dewatering reduces sludge volume, increases the fuel value of a sludge, and decreases transportation costs for final disposal. Dewatering also prepares sludges for such forms of ultimate disposal as combustion, landfilling, or land application. For a more detailed description of municipal sludge dewatering, see Dewatering Municipal Wastewater Sludges (EPA 1987).

Mechanical Dewatering Methods

Mechanical devices for dewatering include vacuum filters, filter presses, centrifuges and belt filter presses. Sludge cakes discharged from these units will generally be 12 to 45 percent solids, depending on the sludge being dewatered, the type of conditioning employed, and the dewatering device. In general, belt presses and centrifuges are preceded by polymer conditioning; filter presses are preceded by inorganic chemical, heat, or ash conditioning; and vacuum filters by any of the above methods. Many wastewater treatment plants employ mechanical methods for dewatering sludge.

Heat Drying

Heat drying is the process of evaporating water from sludge by thermal means. The units most commonly used evaporate the water by direct drying, that is, hot air directly contacts the sludge to be dried, as in a rotary kiln. The heat-dried products generally contain 10 percent moisture or less. Heat drying is employed at a few treatment plants (e.g., Milwaukee, WI and Houston, TX), and is usually used to produce products such as Milorganite and Huactonite.

Multiple-Effect Evaporation

The Carver-Greenfield Light Oil Process (oil-medium dehydration) is a patented technique for the evaporation of water from sludge. It produces either a sterile fertilizer or a dry (approximately 95 percent solids content) product capable of being utilized as an energy source. At the present time, the Carver-Greenfield Light Oil Process is an innovative technology. Units are under construction or starting up at four POTWs in the U.S.

Air Drying

A variety of natural solar evaporation techniques including sand drying beds, vacuum assisted beds, paved beds, and lagoons are used by a large number of POTWs. Liquid sludge is naturally dewatered by drainage and by evaporation to the air. Sludges are placed in drying beds or lagoons, allowed to dry and then removed. However, the use of drying beds is generally limited to areas with available land and suitable climates (i.e., annual evaporation rate exceeds annual rainfall unless covered drying beds are used). Despite the limitations of natural solar evaporation techniques, drying beds and lagoons are common at small POTWs throughout the country. Some large POTWs, such as Chicago and San Diego, have used drying beds, lagoons and paved beds for sludge dewatering.

3.2.5 COMPOSTING

Composting is a sludge stabilization process normally performed after dewatering. In composting, the organic constituents of the sludge are aerobically decomposed. The decomposition of organic matter as a result of heat produced by biological activity during composting of the sludge reduces pathogens as well as volatile materials that cause odors. The final compost product is a humus-like material suitable for use as a soil conditioner and low nutrient fertilizer.

In general, the composting process consists of mixing dewatered sludge, either raw or digested, with a bulking agent such as woodchips, sawdust or finished compost to increase the porosity and to reduce the moisture content. The mixture is then aerated for some time (11 to 15+ days) to raise the temperature and further decrease moisture content through evaporation. The high temperature (about 55°C) ensures pathogen destruction and aids in reducing the moisture content. The compost is then usually cured by storage at lower temperatures for extended periods. The compost product is often screened to recover and reuse coarse bulking agents such as woodchips.

Composting methods include windrow, static-pile, and a variety of in-vessel composting techniques.

Three example sludge treatment trains are shown in Figure 3-1. Many other configurations are also commonly in use. While some preliminary sludge treatment processes are designed for specific final disposal methods, most preliminary processes can be used with a number of final disposal methods. Permit writers should be familiar with the treatment processes being used at a particular facility.

3.3 PATHOGEN REDUCTION

3.3.1 PROCESSES TO SIGNIFICANTLY REDUCE PATHOGENS (PSRP)

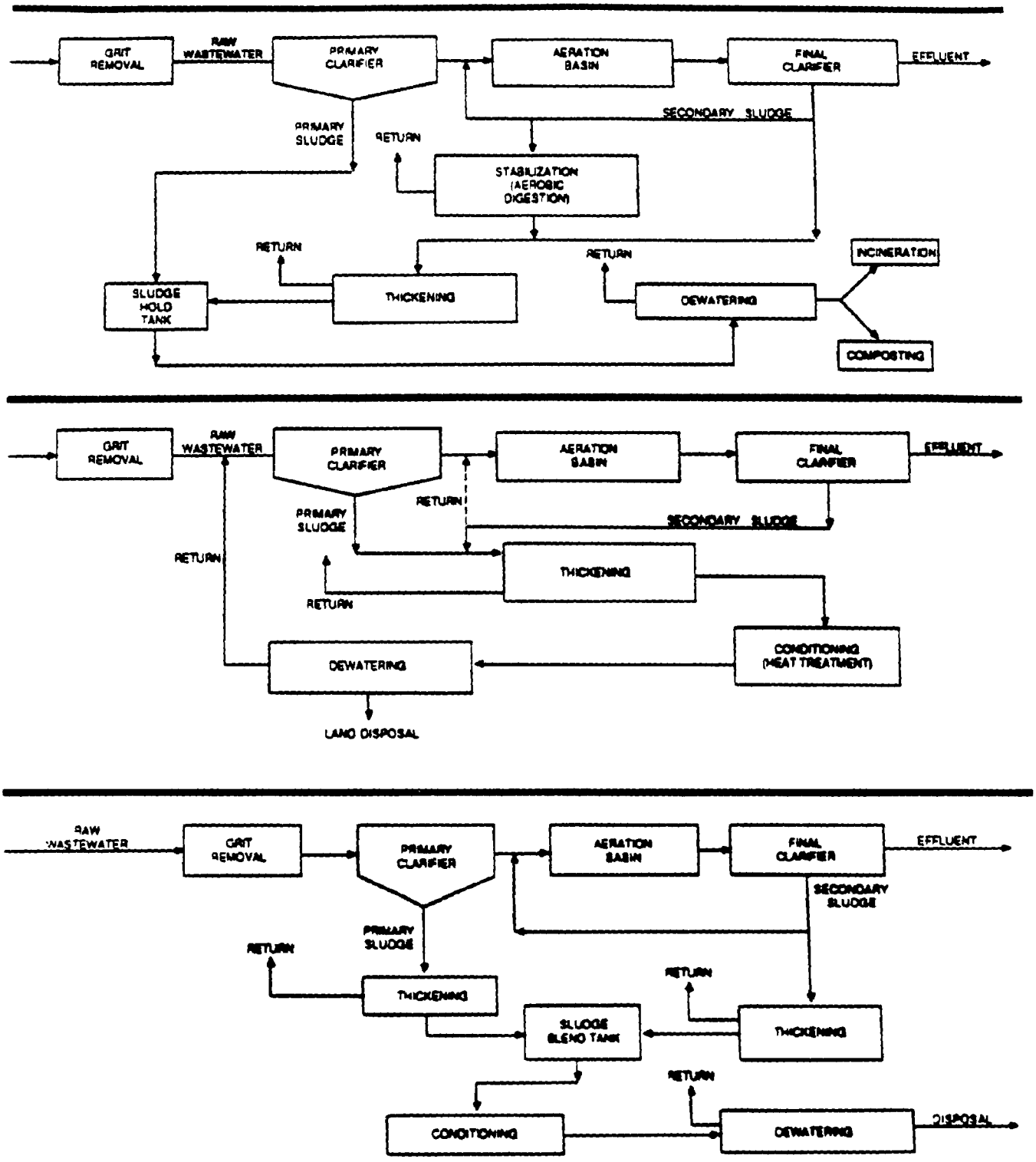
40 CFR Part 257, promulgated under the joint authority of the Clean Water Act and Subtitle D of RCRA, requires that sewage sludge applied to land (either applied to the land surface or incorporated into the soil) be treated by a process to significantly reduce pathogens (PSRP). In addition, three site restrictions must be met: 1) public access to the land must be prevented for 12 months; 2) grazing by animals whose products are consumed by humans must be prevented for one month; 3) no crops directly consumed by humans where the edible portion of the crop comes into contact with the sludge amended soil may be grown for 18 months. (These restrictions do not apply to sewage sludge that is disposed of by trenching or burial operations.)

Of the sludge treatment processes discussed above, aerobic digestion, air drying, anaerobic digestion, composting, and lime stabilization are accepted as PSRPs in 40 CFR Part 257. In addition to the processes discussed above, other sludge treatment methods may be acceptable under 40 CFR Part 257 if pathogens and vector attraction of the waste are reduced to an extent equivalent to the reduction achieved by the listed PSRPs. (See discussion on PSRP and PFRP equivalency below.)

3.3.2 PROCESSES TO FURTHER REDUCE PATHOGENS (PFRP)

Under certain circumstances, sludge that is applied to land (on the surface or incorporated into the soil) must be treated by a process to further reduce pathogens (PFRP), which is more stringent than PSRP. 40 CFR Part 257.3-6 requires that sludge applied to land where crops for direct human consumption are grown within 18 months of the sludge application, and the crops will come in contact with the sludge-amended soil, must be treated by a PFRP. Where sludge is

Figure 3-1. Example Sludge Treatment Trains



treated by a PFRP, no public access or grazing restrictions apply.

Processes to Further Reduce Pathogens (PFRPs) destroy a greater number of pathogens than PSRPs do. PFRPs include more extensive composting, heat drying, heat treatment, and thermophilic aerobic digestion. PFRPs generally operate at higher temperatures than PSRPs. Other methods or operating conditions may also be acceptable PFRPs if pathogens and vector attraction of the waste are reduced to an extent equivalent to the reduction achieved by any of the above PFRP methods. (See discussion of PSRP and PFRP equivalency below.) In addition, any PSRP may be considered to be a PFRP if augmented by beta ray irradiation, gamma ray irradiation, pasteurization, or other methods that result in an equivalent reduction to these add-on methods.

3.3.3 PSRP AND PFRP EQUIVALENCY

As stated above, 40 CFR Part 257 acknowledges that other treatment methods or other operating conditions may be acceptable if they reduce pathogen and vector attraction to an extent equivalent to that achieved by the processes specified in the regulations. Equivalent methods may be modifications to a named PSRP or PFRP, a new process, or a combination of processes.

The equivalency of these "other" processes are based on documenting equivalent treatment. For PSRP the process must consistently reduce pathogenic viruses and bacteria densities by 1 log (base 10), and for PFRP the operating conditions must ensure pathogenic reduction to below detection limits. In addition, PSRPs and PFRPs must reduce vector attraction to the same extent as the reduction achieved by a good anaerobic digester.

A Pathogen Equivalency Committee (PEC) was formed by EPA in 1985. The committee reviews and makes recommendations to EPA management on applications for PSRP and PFRP equivalency. The Committee does not formally approve or disapprove methods or operational conditions but rather provides guidance to the applicants on providing the necessary data to determine equivalency.

Equivalency determinations in the past have shown most processes submitted to be equivalent on a site-specific basis only. Generally, equivalency has applied only to a particular operation run at a particular location under specified conditions. However, one process has demonstrated national

equivalency because of its ability to consistently achieve the desired reductions in pathogens and vector attraction under the variable conditions that could be encountered around the country.[1]

An EPA document entitled Environmental Regulations and Technology: Control of Pathogens in Municipal Wastewater Sludge (September 1989) describes the PSRP and PFRP processes listed under current regulation, how equivalency is determined and the process and data needed when submitting a method or operating condition for an equivalency determination.

3.4 EFFECT ON SLUDGE PROPERTIES

Some sludge processes have little effect on the concentration of pollutants in the sludge while others increase or decrease the concentration of pollutants. Simply removing water (as with gravity thickening or dewatering) does not change the concentration (mass of pollutants/mass of solid) of pollutants in the sludge solids. But digestion and other stabilization processes that decrease the volatile fraction of the sludge increase the concentration of non-biodegradable pollutants. Table 3-1 shows how processes that reduce the volatile fraction of sludge increase the concentration of metals in the remaining sludge solids. Conversely, the addition of materials such as bulking agents for composting or chemicals for stabilization decreases the overall concentration of metals in the sludge or sludge product.

Some toxins can be biodegraded by stabilization processes or can be removed from the sludge by volatilization. However, data on these mechanisms for loss of organic pollutants is very limited.

Changes in sludge pollutant concentrations are important since many sludge reuse or disposal requirements are limited by contaminant concentrations and/or loading rates.

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[1] Advanced Alkaline Stabilization with Subsequent Accelerated Drying (AASSAD)

TABLE 3-1

INCREASED METALS CONCENTRATION DURING PROCESSING (mg/kg dry weight)

Element	Raw Primary Sludge (79% volatile)	Lagooned Sludge (56% volatile)
Chromium	110	220
Copper	200	450
Nickel	46	65
Zinc	820	1,400
No. Samples	5	30

NOTE. 1977 data, Sacramento County Central treatment plant, California.
Source: EPA 1979.

REFERENCES

EPA 1979. Process Design Manual for Sludge Treatment and Disposal, U.S. Environmental Protection Agency, EPA 625/1-79-011, September 1979.

EPA 1987. Design Manual: Dewatering Municipal Wastewater Sludges, U.S. Environmental Protection Agency, EPA 625/1-87/014.

EPA 1989. Environmental Regulations and Technology: Control of Pathogens in Municipal Wastewater Sludge, U.S. Environmental Protection Agency, EPA 625/10-89-006, September 1989.

CHAPTER 4
SUMMARY OF PERMITTING PROCEDURES AND REQUIREMENTS

This section gives the permit writer some basic guidance for developing permit requirements for sludge. It addresses what application data are needed, the priority of permits to consider for case-by-case development of sludge requirements, standard permit conditions for all POTW permits, and recommended monitoring requirements.

4.1 GATHERING INFORMATION

At present, the Federal permit application forms for POTWs (Standard Form A and Short Form A) ask for some information that may be useful in evaluating and developing permit limits for sludge. These forms request information concerning basic influent and effluent characteristics and use of wastewater treatment lagoons. However, they do not ask for specific information on sludge quality, treatment, use, or disposal. The recently promulgated State sludge management program rules and revisions to the NPDES regulations (54 FR 18716, May 2, 1989) require the following application information when the POTW applies for issuance or reissuance of its NPDES permit: annual sludge volume, other permits held or requested, a topographical map extending one mile beyond the POTW's boundaries, a narrative description of POTW's use and/or disposal practices, any sludge monitoring data the applicant may have and any other information requested by the permit writer. [40 CFR Part 122.21(d)(3)(ii); 501.15(a)(2)]

Whether any additional information is necessary to write the permit will depend on such factors as whether the POTW has been identified as a Class I facility, and on the type of sludge use or disposal option(s) the POTW uses. Table 4-1 describes how information may be used by the permit writer when establishing sludge requirements. To evalutate whether additional specific information is needed, either to determine if the POTW should be treated as a Class I facility or to develop case-by-case permit conditions, the permit writer will need to refer to the permit requirements and recommendations under the applicable use or disposal option in Chapters 5 through 9. Permit writers should use this preliminary evaluation as a basis for developing a "sludge fact sheet" for the POTW that can be used in permit development and preparation of the permit fact sheet (for Class I permits).

The tables in Appendix E can serve as a tool for permit writers by identifying State requirements and recommendations. The permit writer will need to ascertain whether the practice cited in Appendix E is a requirement or a recommendation because this distinction is not made in

TABLE 4-1

INFORMATION GATHERING FOR WRITING SLUDGE CONDITIONS

Data	Use
State or local bans or prohibitions	Determine which options are not available to POTW.
Disposal/use options currently used by POTW	Determine applicable requirements and recommendations for POTW's current sludge practices.
Planned (major) changes for disposal/use options	Develop permit conditions for all planned options during permit term and thereby avoid need for reopener provision for future changes.
Annual sludge volume to each disposal/use option	Determine if there are capacity problems; track sludge volume to each use/option.
Current federal or State permits issued to POTW applicable to sludge use/ disposal options; approved sludge management plans; current management practices	Consider adopting by reference if protective of public health and the environment.
If sludge disposed off-site current federal or State permits issued to site operators	Determine compliance by disposal site and possible remedial action needed; need for POTW to find alternative disposal option.
Type of wastewater treatment used at POTW generating the sludge, e.g.: - primary - advanced primary - secondary - AWT (chemical addition)	Will determine type and quantity of sludge produced.
For new facilities, engineering reports, facilities plans, manufacturer's plans, when facilities go on-line, etc.	Estimate expected quality and quantity produced.
Sludge treatment processes used by POTW, e.g.: - digestion (aerobic, anaerobic) - composting - heat treatment - lime - etc.	Determine compliance with pathogen reduction requirements (land application; distribution and marketing). Determine need for POTW-site management practices (e.g., run-off controls for composting facilities). May affect procedures for analyzing organic compounds in sludge. See POTW Sludge Sampling and Analysis Guidance.

TABLE 4-1 (continued)

INFORMATION GATHERING FOR WRITING SLUDGE CONDITIONS

Data	Use
Chemicals used in dewatering process	Potential toxic contamination in sludge.
On-site sludge storage practices	Determine need for conditions for long-term storage
When was sludge held on-site generated (e.g., in wastewater lagoons or sludge stockpiles)?	Age of sludge may affect quality Develop disposal plan for wastewater lagoon sludge if scheduled for emptying.
Sludge quality	Determine compliance with use/disposal option requirements. See Sections 4.4 & 4.5 for recommended monitoring requirements.
Characteristic hazardous waste determination (e.g, EP toxicity test)	If sludge is a hazardous waste, defer to RCRA regulation (see Chapter 5).
Influent quality - Influent flows/loadings (BOD,TSS, priority pollutants) - Percentage of flow and loadings from industrial sources - Types of industrial contributions - Pretreatment used by industrial contributors	Help estimate sludge quality and quantity. Help identify potential sludge contamination problems and sources. Pretreatment information can help permit writer and POTW determine if needed improvements in sludge quality are feasible through additional pretreatment.
Historical sludge management problems in the generator/transporter/ applicator/owner relationship?	May indicate need to develop more comprehensive solution than POTW permit conditions alone..
Compliance history - significant noncompliance or citizen complaints due to sludge use/disposal problems	Determine need to classify as a priority or develop conditions to address problem.
Unusual circumstances at POTW or disposal site (e.g., disposal near sensitive areas such as estuaries)	Determine need to classify as a priority or develop conditions to address problem.
If sludge is landfilled, disposal in monofill or co-disposal facility	For co-disposal will need to consult with solid waste officials (see Chapter 5).
If sludge is land applied, use of land (e.g., crops grown)	Additional requirements apply to food-chain cropland.
Topographic map	Identifies location of any sludge management facilities and potential siting problems.

Appendix E. For example, California pollutant concentration limits for land application and distribution and marketing are only recommended, not required.

Sampling and analysis data that may be needed for application purposes is discussed in Sections 4.4 and 4.5.

4.2 SECONDARY INFORMATION SOURCES

Although the POTW has the burden of supplying the information needed to write the permit, the permit writer can also use secondary sources of information to gain background data on sludge practices and their potential impacts on public health and the environment. Use of these other sources may be helpful to supplement or confirm information received from the POTW. Listed below are potentially helpful information sources.

- EPA's National Sewage Sludge Survey (FY90). 400+ POTWs were surveyed for information on sludge use and disposal practices and 200 were sampled for actual sludge quality data.

- State solid waste disposal program plans. POTW solid waste/sludge management plans; State application forms.

- EPA Construction Grants program information. This includes the NEEDS data base that describes all treatment processes used at the POTW and other basic information about the facility's design and operation. Construction grants staff may also be helpful in estimating expected sludge quality and quantity from particular plants and in evaluating whether sludge use or disposal practices are designed and operated in an environmentally sound manner.

- Pretreatment program information. Information such as types and amount of industrial loadings to the POTW and past or present sludge quality problems can be found in the POTW's pretreatment program application, annual reports, and audit reports.

- NPDES compliance inspections or diagnostic evaluations. Reports of these activities may indicate problems that may adversely affect sludge processes or quality (e.g., problems with settling may indicate the presence of sludge with too high a moisture content to be used for practices requiring a relatively high percentage of solids).

- Local or State health agencies, extension agencies, and university agricultural research departments. These sources may be particularly useful to consult about particular site characteristics or problems.

- Basin Plans and Water Quality Management Plans. These sources may help identify sensitive disposal sites, e.g., wetlands, drinking water aquifers, etc.

4.3 SETTING PRIORITIES

Before developing permit conditions, a permit writer must determine whether the POTW should be considered as a Class I priority facility for sludge permitting. The process for identifying priority POTWs is explained in EPA's Interim Permitting Strategy (see Appendix A). Briefly, Class I sludge management facilities are those POTWs with approved pretreatment programs and any POTW designated as Class I due to the greater potential for their sludge or their sludge use or disposal practices to adversely affect public health or the environment (e.g., incinerators). In ascertaining whether a POTW, not subject to pretreatment regulations, should be considered a Class I or priority facility, permit writers will need to take reasonable steps to collect and evaluate available evidence to determine if problems or potential problems exist. Evidence consists of information received from primary and secondary sources during the application process, together with information in this and other guidance on potential environmental problems associated with POTW sludge use or disposal practices. See Section III of the Interim Permitting Strategy for examples of potential Class I sludge management facilities beyond the pretreatment cities.

4.4 STANDARD PERMIT REQUIREMENTS

4.4.1 GENERAL

All reissued or new permits must include some general requirements for sludge use and disposal, whether or not the facility needs additional case-by-case conditions. Most of the provisions are required by the recently promulgated State sludge management program and permitting regulations (54 FR 18716). The four primary areas each permit must address are: compliance with existing requirements and with 40 CFR Part 503 regulations when promulgated; reopening the permit when the 40 CFR Part 503 regulations are promulgated; notification of change in sludge practices; and sludge quality monitoring.

The first standard permit condition is that the permit must require the POTW to comply with all existing requirements for sludge use and disposal. For example, those POTWs who land apply sludge must comply with all applicable requirements under 40 CFR Part 257. The permit writer should also ascertain if there are any existing permits which govern the facility's sludge use and disposal practices. If these are adequate to satisfy the requirements of Section 405(d), the NPDES need only reference the other permit, and add any additional requirements necessary to protect public health and the environment. This compliance provision should also notify the permittee that compliance with the final 40 CFR Part 503 sludge technical standards by the deadlines established in the rule will be required regardless of whether or not the permit is reopened.

The reopener clause is another standard condition which must be included in the NPDES permit. It authorizes reopening of the permit to include technical standards if the technical standards are more stringent or more comprehensive than the conditions in the permit. The reopener provision notifies the permittee of future legal obligations under the CWA, and of the potential need to modify the permit to incorporate 40 CFR Part 503 requirements once they are promulgated. Note that the POTW is required to comply with applicable Part 503 requirements whether or not such requirements have been incorporated in its permit.

The notification provision requires the permittee to give notice to the permitting authority when a significant change in the sludge use or disposal practice is planned that could require modifications to the permit. Notice of new use or disposal sites that were not previously identified is also required.

In addition to the standard sludge boilerplate conditions described above, many of the standard permit conditions that apply to effluent discharge activities will also apply to sludge use and disposal activities (e.g., duty to mitigate, duty of proper operation and maintenance, and entry and inspection requirements). Other conditions have been modified to specifically address sludge use and disposal (e.g., record keeping for 5 years). Conversely, a few of the 40 CFR Part 122 regulations have been revised to limit their applicability only to effluent discharge activities (e.g., anti-backsliding). Further discussion of these standard requirements can be found in Appendix A.

4.4.2 MONITORING REQUIREMENTS

Current regulations require sludge monitoring and reporting at a frequency dependent on the nature and effect of the permittee's sludge use or disposal activities, but at least once a year [40

CFR Part 122.44(c)(2) as revised May 2, 1989]. This means that if the permit contains a permit limit for a certain parameter, the permit must also require the permittee to sample and analyze that pollutant at least once a year. Monitoring results should be reported on the discharge monitoring report (DMR) or standard form identified in the permit.

Given the fact that few permits are likely to contain pollutant limits, compliance monitoring will not yield enough information to fully characterize the sludge quality. The Interim Permitting Strategy (Appendix A) has put forth a sewage sludge monitoring policy in order to ensure that permit writers have enough information on sludge quality to evaluate the impact of the permittee's sludge use or disposal practices. The Interim Permitting Strategy recommends the following monitoring:

- For Class I POTWs, an annual scan of the 126 priority pollutants, and more frequent monitoring of the pollutants for which numeric limits have been proposed in the proposed 40 CFR Part 503 regulations for the POTW's particular use or disposal practice.

- For non-Class I POTWs with industrial users, a priority pollutant scan at the time of permit application, and annual monitoring of the pollutant for which 40 CFR Part 503 technical standards have been proposed.

- For non-Class I POTWs with no industrial users, annual monitoring of six metals: cadmium, copper, chromium, lead, nickel, and zinc.

A list of the pollutants for which technical standards have been proposed is contained in the monitoring discussion for each disposal option, in subsequent chapters. Permit writers may relax these monitoring requirements after the absence of particular priority pollutants (or detection at low levels clearly show no cause for concern) has been established through repeated testing. Future testing for those pollutants need not be required unless a change occurs in the POTW.

Permit writers need not require annual monitoring for POTWs that use wastewater stabilization lagoons as their sole treatment process if the sludge will not be removed for disposal during the permit term, unless the permit writer determines monitoring is needed. If such permit does not require monitoring, it should contain a requirement that the permittee notify the permit authority if it happens that the sludge is pumped out of the lagoon within a one year period. The permit writer will then need to modify the permit to require monitoring and impose sludge use or disposal conditions.

Permit writers will also need to specify monitoring methodologies in the POTW's permit. The NPDES regulations specify that permittees be required to monitor sludge according to test procedures approved under 40 CFR Part 136 unless otherwise specified in 40 CFR Part 503, when final, or unless test procedures are specified in the permit. Permit writers should refer to the POTW Sludge Sampling and Analysis Guidance Document (EPA, August 1989) for additional information on appropriate sludge sampling and analytical procedures.

4.5 ADDITIONAL PERMIT REQUIREMENTS FOR CLASS I POTWs

4.5.1 CASE-BY-CASE SLUDGE CONDITIONS

In addition to the standard permit conditions described above, permits for Class I POTWs must include any requirements (management practices and/or sludge concentration limits) developed on a case-by-case basis that the permit writer determines may be necessary to protect public health and the environment. The basis for these limits should be explained in a fact sheet modeled after the NPDES fact sheet developed for majors. Chapters 5 through 9 discuss additional conditions the permit writer may want to include on a case-by-case basis.

4.5.2 CASE-BY-CASE MONITORING REQUIREMENTS

As stated earlier, the Interim Permitting Strategy recommends that Class I POTWs be required to perform an annual priority pollutant scan and more frequent monitoring of the pollutants proposed in 40 CFR Part 503. This monitoring would be in addition to the current NPDES requirement for annual compliance monitoring for those pollutants limited in the permit. There are several circumstances for which permit writers should determine additional monitoring frequencies and parameters on a case-by-case basis. More frequent monitoring might be appropriate, for example, where the POTW's influent varies considerably and safe use or disposal depends on careful limiting of particular pollutants. In particular, permit writers should consider requiring more frequent monitoring for commonly occurring metals (e.g., Cd, Cu, Cr, Pb, Ni, Zn) since the harm posed by metals is well documented, there are more limits and guidance on regulating metals, and analysis for metals is relatively inexpensive. Other types of monitoring (e.g., ground water monitoring, soil sampling) may also be appropriate depending on the specific conditions surrounding the use or disposal practice. Specific recommendations for monitoring requirements are discussed in Chapters 5 through 9 for each disposal practice.

CHAPTER 5
LANDFILLING

5.1 INTRODUCTION

According to current EPA estimates, 42 percent of municipal sewage sludge generated in the United States is disposed of in landfills. This figure includes the 1 percent of sewage sludge generated that is disposed of in sludge-only landfills (54 FR 5756). The two types of sludge landfilling practices are (EPA 1978):

- Sludge-only disposal (or "monofilling") - sludge is buried alone, usually in trenches; and,

- Co-disposal - sludge is buried in a municipal solid waste (refuse) landfill

Non-hazardous municipal sludge is considered a solid waste residual generated during wastewater treatment. It is regulated at the Federal level by the Clean Water Act and Subtitle D of the Resource Conservation and Recovery Act (RCRA). Subtitle D established a cooperative framework for Federal, State, and local governments to control the management of non-hazardous solid waste. As part of this framework, EPA promulgated criteria in 1979 that set minimum performance standards for all solid waste disposal facilities. These "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (40 Part CFR Part 257) consist of location, design, and operational performance standards that must be met by solid waste management facilities. The landfill criteria pertain to endangered species, surface water, ground-water, disease, air quality, public safety, and proximity to floodplains (EPA 1986b).

Currently, sludge-only monofills and co-disposal landfills are regulated at the Federal level under the Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257). In the future sludge-only monofills will be regulated under the new Standards for the Disposal of Sewage Sludge regulations (40 CFR Part 503), while co-disposal landfills will be regulated under the Criteria for Municipal Solid Waste Landfills (40 CFR Part 258) that are being developed by the Office of Solid Waste. The Criteria for Municipal Solid Waste Landfills were proposed on August 30, 1988 (53 FR 33314) and are expected to be promulgated in March 1990. 40 CFR Part 258 requires that the POTW sending its sludge to a landfill ensure that the sludge is nonhazardous, that the sludge passes the paint filter liquids test, and that it goes to a State permitted landfill. Until these new rules are promulgated, however, only the existing requirements of 40 CFR Part 257 have the force of regulation.

5.1.1 PERMITTING RESPONSIBILITIES

Permits issued to POTWs that dispose of their sludge in sludge-only monofills or co-disposal landfills must require that the POTWs use facilities that comply with existing Federal regulations for solid waste disposal facilities (40 CFR Part 257). By including such a requirement, permit writers can ensure that the POTW's sludge will be disposed of in accordance with existing regulations, even if the POTW does not own or operate the landfill receiving its sludge. Where the POTW owns and operates the sludge-only monofill or co-disposal landfill receiving its sludge, the permit writer should request certification that the landfill is in compliance with 40 CFR Part 257. When the sludge is being sent offsite to a monofill or co-disposal landfill that is not owned and operated by the POTW, the permit writer should contact State, local and EPA solid waste officials to ascertain whether the facility is in compliance with 40 CFR Part 257 requirements. The 40 CFR Part 257 regulations which apply to sludge-only monofills and co-disposal landfills are summarized in Table 5-1. A copy of the rule appears in Appendix D.

The criteria promulgated in 1979 (40 CFR Part 257) represent the minimum regulatory standards that a State program must apply to solid waste management facilities. Many States have incorporated these criteria into State solid waste management plans. Although EPA has approved 25 State solid waste management plans and partially approved six others (EPA 1986b), it has not actively reviewed these State plans since 1981. There are a number of States without approved programs which have comprehensive, well-staffed programs that may meet the minimum criteria for EPA approval. In fact, a number of States have established regulatory requirements for their Subtitle D facilities that are, in many instances, more stringent than the existing Subtitle D criteria. States which have approved solid waste management programs must meet the permitting requirements as prescribed by RCRA. In States without approved programs, coordination may be complicated by the presence of multiple permitting authorities that permit the landfill or situations where control is divided between monofills and co-disposal landfills. State and local regulatory agencies which may regulate landfills include: solid waste management agencies, water quality control agencies, health departments, building departments, planning and zoning commissions and board of county commissioners. Information on State sludge management requirements is summarized in several tables presented in Appendix E. Since State regulatory programs may change from time to time, the permit writer should not assume that the information in Appendix E is definitive. Rather, the permit writer should consult with the appropriate State agency to determine current requirements and recommendations.

TABLE 5-1

40 CFR PART 257 REQUIRED MANAGEMENT PRACTICES FOR SLUDGE-ONLY AND CO-DISPOSAL LANDFILLS, LAND APPLICATION SITES AND SLUDGE LAGOONS AND STOCKPILES

Environmental Concern	Management Practice
Floodplains	Facilities in floodplains shall not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources. (As a matter of policy, EPA expects that if sludge is land-applied to the surface and incorporated into the soil and if vegetation is grown, the criteria should be satisfied. See p. 40, *A Guide to Regulations and Guidance for the Utilization and Disposal of Municipal Sludge*, EPA 1980.)
Endangered Species	Facilities shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife, and shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species. Questions about the potential for adversely affecting endangered or threatened species at a particular site should be directed to the nearest Regional office of the U.S. Fish and Wildlife Service. (Note: Notices of draft NPDES permits also are routinely sent to the U.S. Fish and Wildlife Services. See 40 CFR 124.10(c).)
Surface Water	Facilities shall not cause a discharge of pollutants into waters of the United States in violation of Section 402 of the Clean Water Act, shall not cause a discharge of dredged or fill material in violation of Section 404 of the Act, and shall not cause non-point source pollution that violates an approved Section 208 water quality management plan.
Ground Water	Facilities shall not contaminate an underground drinking water source beyond the solid waste boundary, or beyond an alternative boundary. Consult the regulation for procedures necessary to set alternative boundaries (see Appendix D). To determine contamination, Appendix I of 40 CFR Part 257 provides a list of contaminant concentrations. Release of a contaminant to groundwater which would cause the concentrations of that substance to exceed the level listed in Appendix I constitutes contamination.
Disease	Disease vectors shall be minimized through the periodic application of cover material or other techniques as appropriate to protect public health.
Air	Facilities shall not engage in open burning of residential, commercial, institutional, or industrial solid waste. Infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land-clearing debris, diseased trees, debris from emergency clean-up operations and ordinance is allowed.
Safety	1. Explosive gases generated by the facility shall not exceed 25 percent of the lower explosive limit for the gases in facility structures and 100 percent of the lower explosive limit at the property line. 2. Facilities shall not pose a hazard to the safety of persons or property from fires. 3. Facilities within 10,000 feet of any airport runway used by turbojet aircraft, or within 5,000 feet of any airport runway used by piston-type aircraft shall not pose a bird hazard to aircraft. 4. Facilities shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site.

When permitting POTWs that dispose of their sludge in monofills, the permit writer should consult State, local and EPA solid waste officials for information regarding the monofills used by the POTW. These authorities may also have permit and inspection/enforcement files that permit writers should review. If the sludge-only monofill that a POTW uses is not in compliance with existing Federal regulations, the permit writer, in conjunction with enforcement personnel, should take action that will bring the POTW's sludge disposal into compliance. An example of such action would be to develop and attach to the permit a compliance schedule that sets a date within the term of the permit by which the POTW will dispose of its sludge in a sludge-only monofill (or any other method) that complies with Federal requirements. While the appropriate term for compliance depends on a number of factors, the potential for harm to public health or the environment should be the primary consideration.

When permitting POTWs that use co-disposal landfills, permit writers should consult with State, local, and EPA solid waste officials to determine if the co-disposal landfills that the POTW uses are in compliance with existing Federal requirements. Approximately 80 percent of the nation's municipal solid waste landfills are inspected at least once a year and 25 percent of these landfills have ground-water monitoring systems in operation (EPA 1986b). Thus, facility performance data may be available for many of these landfills. If a co-disposal facility is violating 40 CFR Part 257 requirements, the permit writer should pursue one of the following courses of action depending upon the sludge/solid waste ratio of the landfill:

- If sludge comprises a small proportion of the fill sent to the co-disposal facility (e.g., less than 30 percent of total received mass), the permit writer should defer to solid waste regulatory officials in determining an appropriate response.

- If sludge comprises a substantial proportion of the fill disposed of in a co-disposal facility (e.g., more than 30 percent), the permit writer should work with solid waste regulatory officials in determining an appropriate response. An appropriate response will depend on the availability of more protective use or disposal alternatives and, most importantly, the potential for adverse effect on public health and the environment.

The recommendation that a proportion of 30 percent sludge to refuse in a co-disposal landfill serve as a dividing line between deferring to and consulting with solid waste officials is just a rule of thumb. There is no scientific basis to this division. It is the permit writers responsibility to determine whether sludge volumes in any amount are increasing the potential for environmental degradation in each particular case.

5.2 TECHNOLOGY GUIDELINES

Sludge-Only Monofills

Most sludge-only landfills consist of a series of trenches where dewatered sludge is deposited below ground surface and covered with soil. Other sludge-only designs include area fill mounds, area fill layers, and diked containment; each of these methods involves sludge deposition above the ground surface. These above-ground methods are rarely used and will not be discussed further. Additional information on all sludge-only disposal methods can be found in EPA's Process Design Manual of Municipal Sludge Landfills (EPA 1978).

Both narrow trench and wide trench techniques are used for the burial of sludge. Narrow trenches are defined as having widths less than 10 feet; wide trenches are defined as having widths greater than 10 feet. The depth and length of both narrow and wide trenches are variable and dependent upon a number of factors. Trench depth is a function of (1) depth to ground-water and bedrock, (2) sidewall stability, and (3) equipment limitations. Trench length is virtually unlimited, but inevitably dependent upon property boundaries and other site conditions. In addition, trench length may be limited by the need to discontinue the trench for a short distance or place a dike within the trench to contain a low-solids sludge and prevent it from flowing throughout the trench (EPA 1978).

A soil cover is normally applied over sludge the same day that it is received, although cover application may be less frequent in some cases. The frequency of cover application optimizes odor control; therefore, trenches are more appropriate for unstabilized or partially stabilized sludges than other landfilling methods. The soil excavated during trench construction provides the material that is required for daily cover. Accordingly, soil importation is seldom required in trench applications (EPA 1978).

Narrow Trench Method

As stated previously, a narrow trench has a width of less than 10 feet. Sludge is usually deposited in a single application and a single layer of cover soil is applied atop this sludge. Relevant sludge and site conditions as well as design criteria for this form of disposal include (EPA 1978):

Sludge and Site Conditions for Narrow Trenches	
Sludge solids content	- 15-20% for 2-3 ft widths
	- 20-28% for 3-10 ft widths
Sludge characteristics	- unstabilized or stabilized
Hydrogeology	- deep ground-water and bedrock
Ground slopes	- <20%

Design Criteria for Narrow Trenches	
Trench width	- 2-10 ft
Bulking required	- no
Cover soil required	- yes
Cover soil thickness	- 2-4 ft
Imported soil required	- no
Sludge application	- 1,200-5,600 yd^3/acre
Equipment	- backhoe with loader, excavator, trenching machine

The main advantage of a narrow trench is its ability to handle sludge with a relatively low solids content. As shown above, a 2- to 3-ft width is required for sludge with a solids content between 15 and 20 percent. Normally, soil applied as cover over sludge of such low solids would sink to the bottom of the sludge. However, because of the narrowness of the trench, the soil cover receives support from the solid ground on either side of the trench and bridges over the sludge. Cover is usually applied in a 2- to 3-ft thickness (EPA 1978).

Sludge with a solids content of 20 to 28 percent is more appropriate for a 3- to 10-ft trench width. Cover is usually applied in a 3- to 4-ft thickness and dropped from a minimum height to minimize the amount of soil that sinks into sludge deposits (EPA 1978).

The main disadvantage of a narrow trench operation is that it is relatively land-intensive. As shown above, typical sludge application rates in actual fill areas (including inter-trench areas) range from 1,200 to 5,600 yd^3/acre. Generally, application rates for narrow trenches are less than for other methods. Another drawback with narrow trench operations is that the installation of liners is impractical (EPA 1978).

Wide Trench Method

A wide trench has a width of ten feet or greater. Relevant sludge and site conditions as well as design criteria are:

Sludge and Site Conditions for Wide Trenches

Sludge solids content	- 20-28% for land-based equipment
	- ≥28% for sludge-based equipment
Sludge characteristics	- unstabilized or stabilized
Hydrogeology	- deep ground-water and bedrock
Ground slopes	- <10%

Design Criteria for Wide Trenches

Trench width	- >10 ft
Bulking required	- no
Cover soil required	- yes
Cover soil thickness	- 3-4 ft for land-based equipment
	- 4-5 ft for sludge based equipment
Imported soil required	- no
Sludge application	- 3,200-14,500 yd^3/acre
Equipment	- track loader, dragline, scraper, track dozer

As with narrow trenches, wide trenches should be oriented parallel to one another to minimize inter-trench areas. Distances between trenches should be large enough to provide sidewall stability and adequate space for soil stockpiles, operating equipment, and haul vehicles (EPA 1978).

One advantage of a wide trench is that it is less land-intensive than narrow trenches. Typical sludge application rates range from 3,200 to 14,500 yd^3/acre. Another advantage of a wide trench is that liners can be installed to contain sludge moisture and protect the ground-water. When liners are to be used, excavation may proceed closer to bedrock or ground-water than when narrow trenches without such protection are used.

One disadvantage of a wide trench is that a sludge solids content of 20 percent or above is needed. A sludge solids content of 28 percent or greater is required to support equipment that may be operated on the sludge itself. It should be noted that sludge with a solids content of 32 percent or more will not spread out evenly in a trench when dropped from vehicles working outside of the trench. Another disadvantage of a wide trench is the need for flatter terrain than that required for narrow trench techniques.

Co-Disposal Landfills

At co-disposal landfills, wastewater sludge is deposited in a landfill together with municipal solid waste. In this way, the absorption characteristics of the solid waste and soil conditioning characteristics of the sludge can complement each other. The solid waste absorbs excess moisture from the sludge and reduces leachate migration. Sludge mixed with soil can also aid in revegetation of the completed landfill.

Sludge/Refuse Mixture

In a sludge/refuse mixture operation, sludge is deposited at the working face of the landfill and applied on top of the refuse. The sludge and refuse are then mixed as thoroughly as possible. This mixture is then spread, compacted, and covered in the usual manner at a refuse landfill. Relevant sludge and site conditions as well as design criteria are presented in the following table (EPA 1978):

Sludge and Site Conditions	
Sludge solids content	- ≥3%
Sludge characteristics	- unstabilized or stabilized
Hydrogeology	- deep or shallow ground-water or bedrock
Ground slopes	- <30%
Design Criteria	
Bulking required	- yes
Bulking agent	- refuse
Bulking ratio	- 4-7 tons refuse/wet ton sludge

Cover soil required	- yes
Cover soil thickness	- 0.5-1 ft of interim
	- 2 ft of final
Imported soil required	- no
Sludge application	- 500-4,200 yd^3/acre
Equipment	- track loader, track dozer

As shown above, sludges with solids content as low as 3 percent may be received in such operations. Usually, such sludge is spray applied from a tank truck to a layer of refuse at the working face. The bulking ratio for a 3 percent solids sludge should be at least 7 tons of refuse to 1 wet ton of sludge. Usually, only sludges with solids contents of 20 percent or more are mixed with refuse in such operations and fewer operational and environmental problems may be expected than when a 3 percent solids sludge is received. Also, less bulking agent is required with the higher solids content sludge and ratios as low as 4 tons of refuse to 1 wet ton of sludge are successfully practiced (EPA 1978). Some POTWs use sludge as a top dressing on landfills. For example, in Chicago the sludge (65% solids) is layered into a total depth of 9 feet. On at least one level, the landfill is then sealed with a 2 feet clay layer.

Also as shown above, sludge application rates for sludge/refuse mixtures compare favorably with other methods despite the fact that sludge is not the only waste being disposed on the land. Application rates generally range from 500 to 4,200 yd^3 of sludge per acre (EPA 1978).

State Requirements - Sludge/Refuse Mixture

Three States specify loading limits for sludge at refuse landfills. New Hampshire recommends a 4:1 volume ratio of refuse to sludge, and mandates that the ratio be no less than 3:1. In addition, sludge must be dewatered to a minimum 20 percent solids. Washington requires that the refuse to sludge ratio be between 4:1 and 5:1 such that the resulting mixture contain less than 40 percent moisture. Hawaii requires that the sludge/refuse mixture be spread and compacted in layers not exceeding 2 feet.

Sludge/Soil Mixture

In a sludge/soil mixture operation, sludge is mixed with soil and applied as interim or final cover over completed areas of the refuse landfill. This is not strictly a sludge landfilling method since the

sludge is not buried. However, it is a viable option for disposal of sludge at refuse landfills that could be used in many cases. Relevant sludge and site conditions as well as design criteria are presented in the following tabulation (EPA 1978).

Sludge and Site Conditions	
Sludge solids content	- ≥20%
Sludge characteristics	- stabilized
Hydrogeology	- deep or shallow ground-water or bedrock
Ground slopes	- <5%
Design Criteria	
Bulking required	- yes
Bulking agent	- soil
Bulking ratio	- 1 soil:1 sludge
Cover soil required	- no
Imported soil required	- no
Sludge application	- 1,600 yd^3/acre
Equipment	- tractor with disc

One advantage to a sludge/soil mixture operation is that it removes sludge from the working face of the landfill where it may cause operational problems. Other advantages are that the mixture can be used to support the growth of vegetation over completed fill areas, a savings in fertilizer can be realized, and siltation and erosion problems can be minimized (EPA 1978).

A disadvantage to a sludge/soil mixture operation is that it generally has greater manpower and equipment requirements than would be incurred by landfilling the same sludge quantity at the working face. Another disadvantage is that since the sludge is not completely buried, odors may be more severe than for sludge/refuse mixtures. For this reason, only well stabilized sludges are recommended for use in sludge/soil mixture operations (EPA 1978).

5.3 CHARACTERISTICS OF SLUDGES SUITABLE FOR LANDFILLING

5.3.1 SLUDGE POLLUTANT CONCENTRATION LIMITS

Federal Regulations

There are no Federal pollutant concentration limitations for sewage sludge that is disposed of in landfills. The only Federal requirement regarding sludge quality is that hazardous sludges must be disposed of according to the requirements of RCRA Subtitle C. Any municipal sewage sludge that is not a RCRA Subtitle C hazardous waste may be disposed of at an approved Subtitle D solid waste facility, provided the practice is allowed by State law.

Case-by-Case Recommendations

A review of Federal guidance documents and State requirements for the disposal of sewage sludge in landfills revealed no recommended or required sludge contaminant limits. Therefore, no contaminant limit recommendations are presented. Permit writers should set contaminant concentration limits if they determine such limits are necessary to protect public health or the environment (e.g. drinking water supply). The permit writer will have to document this decision in the permit fact sheet. The management practices and site characteristics of landfills receiving sludges containing high concentrations of contaminants should be closely examined.

5.3.2 SLUDGE PHYSICAL PROPERTIES

This section will cover recommended sludge dewatering and stabilization requirements for sludge-only and co-disposal landfills.

Federal Regulations

Neither stabilization or dewatering of sewage sludge are specifically required by 40 CFR Part 257 prior to landfilling.

Federal Guidance

Not all municipal sewage sludges are suitable for landfilling due to odors from insufficiently stabilized sludge or operational problems arising from low solids content. An assessment of the

suitability of various sludge types for disposal in sludge-only monofills and co-disposal landfills was discussed in Section 5.2 which provide information on landfill technologies.

As implied in Section 5.2, sludge with a solids content less than 15 percent are not suited for disposal in sludge-only monofills. Sludges having solids contents less than 15 percent usually will not support cover material. Obviously, the addition of soil to a low-solids sludge may act as a bulking agent and produce a sludge suitable for disposal at sludge-only monofills. However, soil bulking operations are generally not cost-effective on sludges with solids less than 15 percent. Further dewatering should be performed at the treatment plant if sludge-only monofilling is the disposal option selected.

If suitably designed and operated, co-disposal landfills can accept sludges with solids contents as low as 3 percent. However, sludge moisture should not exceed the absorptive capacity of refuse at a co-disposal landfill. Accordingly, low-solids sludge should be received at such sites only if it constitutes a small percentage of the total waste landfilled (EPA 1978).

Generally, only stabilized sludges are recommended for landfilling and some degree of stabilization should occur if landfilling is the selected disposal option. Stabilization of sewage sludge reduces odors and reduces vector attraction. Stabilization, however, is not required by all States. Suggested procedures for landfilling unstabilized sludges can be found in EPA's Process Design Manual for Municipal Sludge Landfills (EPA 1978).

State Requirements

State sludge dewatering regulations vary greatly. A total of thirty-two States and Puerto Rico require some degree of dewatering. Six States do not allow landfilling of sludges containing free liquids. One State (Oklahoma) will allow free liquids if the site has a leachate collection system. Thirteen States specify minimum percent solids allowed: Alaska requires 10 percent, Idaho and South Carolina require 15 percent, Massachusetts requires 18 percent, six States require 20 percent, two States require 30 percent, and Iowa requires 75 percent solids. Four States require dewatering but do not specify to what degree, while Connecticut evaluates the need for dewatering on a case-by-case basis.

Several States have dewatering requirements for specific types of sludge or landfilling options. California requires a minimum of 20 percent solids for primary sludge and 15 percent for secondary sludge or a mixture of the two. Texas requires a minimum of 15 percent solids in

sludge-only trench and fill landfills. For filling above the ground surface, Washington requires 15 to 20 percent solids. The sludge dewatering requirements for each State are listed in Appendix E, Table E5-1.

Twenty States require sludge to be stabilized prior to landfilling. Only Kentucky mandates a stabilization process or operational criteria (e.g., a certain temperature for a certain length of time). Oklahoma requires that raw-sludge must be disposed of in remote locations. Individual State requirements regarding stabilization can also be found in Table E5-1.

Case-by-Case Recommendations

In general, permit writers should require sludge solids content be consistent with the design standards of the monofill or landfill. If the permit writer finds there is a potential for liquids to leach into and contaminate ground-water, specifying a sludge solids content in the permit is appropriate.

For co-disposal landfills, the proposed 40 CFR PART 258 regulation would prohibit the disposal of bulk or non-containerized liquid wastes. Liquid waste has been defined as any waste that is determined to contain "free liquids" as defined by the Paint Filter Liquids Test (as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods," EPA Pub. No. SW-846). Permit writers may want to consider requiring POTWs to perform the Paint Filter Liquids Test on sludges with less than 20 percent solids.

5.3.3 LANDFILLING OF SLUDGES CONTAINING RADIONUCLIDES

POTWs that have hospitals or industries discharging wastes that contain radionuclides into their system or those located in areas of the country where there are naturally occurring radionuclides in their drinking and industrial waters can expect to see radionuclides concentrating in their sludges. Specific radionuclides that are common in POTWs are I^{131}, Ra^{226}, U^{238}, and Cs^{137}. A more comprehensive list is provided in Table 6-2 and a more indepth discussion is provided in Section 6.2. Two States, Illinois and Wisconsin, have specific requirements for sewage sludges containing radium and landfilling. These requirements have been included in Table E5-6.

5.4 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

This section contains Federal regulations and guidance, State requirements, and case-by-case recommendations for the permit writer to use in developing permit conditions to regulate the disposal of sewage sludge. This information can be applied to both sludge-only monofills and co-disposal landfills.

Required Permit Conditions

At a minimum, the permit writer should include the Federal regulations in the NPDES permit, unless they are already contained in another permit held by the POTW. The Interim Strategy requires permit writers to evaluate Class I POTWs for the potential need to incorporate additional case-by-case permit conditions. The permit writer should be aware that several of these requirements and recommendations are restrictions that apply to the location of new landfills rather than the operation and management of existing landfills. If the permit writer finds that the POTW is disposing of its sludge in a landfill that is in violation of the Federal regulations for location, the permit writer is limited to requiring the POTW to develop alternate sludge use or disposal options.

5.4.1 ENDANGERED SPECIES PROTECTION

Federal Regulations

Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. The facility or practice shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17 (40 CFR Part 257).

Federal Guidance

In general, sludge landfills should not be located in environmentally sensitive areas when feasible alternatives exist. EPA has identified five environmentally sensitive areas where landfilling should be avoided (EPA 1978). These include: wetlands, floodplains, permafrost areas, critical habitats of endangered species, and recharge zones of sole source aquifers.

State Requirements

No State has specific regulations governing the protection of endangered species in their sludge or solid waste regulations. Of course, all States that have adopted 40 CFR Part 257 into their State solid waste management plans will have incorporated regulations covering endangered species.

Case-by-Case Recommendations

If the POTW is sending its sludge to an existing landfill that is violating the endangered species provision (40 CFR Part 257. 3-2), the permit writer should require the POTW to develop an alternate sludge use or disposal option. If the POTW is in the process of siting and constructing a new landfill, the permit writer should prohibit placement in an environmentally sensitive area.

5.4.2 FLOODPLAIN RESTRICTIONS

Federal Regulations

Facilities or practices in floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources (40 CFR Part 257).

State Requirements

Thirty-three States, the Virgin Islands and Puerto Rico have regulations governing the siting of a sludge landfill in a floodplain. Seven of those States have adopted the intent of 40 CFR Part 257, allowing sludge landfills in floodplains only if they are protected from flooding by levees or other devices, and do not restrict the base flood. Fifteen States prohibit siting a sludge landfill in a floodplain; ten of these specifically refer to the 100-year floodplain. Four other States require official approval for a sludge landfill to be sited in a floodplain. State regulations regarding sludge-only and co-disposal landfills located in floodplains are summarized in Table E5-2.

5.4.3 GROUND-WATER PROTECTION

Federal Regulations

40 CFR Part 257 protects ground-water by requiring that sludge-only and co-disposal landfills shall not contaminate an underground drinking water source beyond the solid waste boundary or beyond an alternative boundary determined in accordance with provisions in the regulation. Ground-water contamination is defined an exceedance in the maximum contaminant levels in Appendix I of the rule, an increase in the concentration of that substance in the ground-water where the existing concentration of that substance exceeds the maximum contaminant levels specified in Appendix I. Maximum ground-water contaminant levels are specified in Appendix I of 40 CFR Part 257 which is presented as Appendix F of this document.

It is well known that metals are more mobile in low pH soils than in high pH soils and that a soil pH of 6.5 is generally sufficient to prevent the movement of metals. Soil pH may be a moot question in connection with landfills with lines and leachate collection systems. In reviewing permits for unlined landfills, however, the permit writer should be fully aware of the possible link between low pH soils, low pH refuse mixtures and adverse effects on ground-water quality due to metal migration.

There are presently no existing Federal regulations specifically requiring liners and leachate collection, a minimum depth to ground-water from the bottom of waste disposal areas, or a minimum distance to nearby drinking water wells. However, the proposed regulations under 40 CFR Part 258 will require some design requirements such as a flexible membrane layer, compacted earth, and leachate collection systems.

Federal Guidance

One of the primary environmental concerns about landfilling sewage sludge is the potential for ground-water contamination. The overall EPA program for the protection of ground-water is presented in the 1984 EPA Ground-Water Protection Strategy, and includes elements from other Federal legislation. The elements that are most germane to the question of sludge disposal are found in RCRA and in the Safe Drinking Water Act (SDWA).

Ground-Water Protection Strategy

The Ground-Water Protection Strategy (EPA 1984) provides for three ground-water classification categories:

Class I - Special Ground Waters are those that are highly vulnerable to contamination because of the hydrological characteristics of the areas in which they occur and are characterized by one of the following two factors: (a) Irreplaceable, in that no practical, sufficient alternative source of drinking water is available to substantial populations; or (b) Ecologically vital, in that the ground-water contributes to maintaining the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat.

Class II - Current or Potential Sources of Drinking Water and Waters Having Other Beneficial Uses are all other ground waters currently used or potentially available for drinking water or other beneficial use.

Class III - Ground Waters Not Current or Potential Sources of Drinking Water and of Limited Beneficial Use are those (1) with a total dissolved solids (TDS) level over 10,000 mg/l or (2) so contaminated by naturally occurring contaminants or human activity (not associated with a particular waste disposal or other site) that it cannot be cleaned up using methods reasonably employed in public water system treatment, or (3) those where yields are insufficient to meet the minimum needs of an average household.

The Agency released draft Guidelines for performing ground-water classification in December 1986.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) established the Wellhead Protection (WHP) program for the protection of ground-water. Under this program, States are to determine the extent of wellhead protection areas necessary to provide protection from contaminants that may have an adverse effect on human health. The SDWA required States to submit an adequate program to EPA by June 1989.

Some of the major requirements of a wellhead protection program are to:

- o Determine the extent of the well head protection area based on hydrologic and other information,

- o Describe a program to protect the water supply within the WHP area from anthropogenic sources of contaminants,

- o Develop contingency plans for the provision of alternative drinking water supplies in the event of well or wellfield contamination, and

- o Require that all potential sources of contamination in a potential WHP area be taken into consideration before the construction of new wells.

Guidance is available from the Office of Ground-Water Protection on the WHP program (EPA 1987b).

Except to the extent that monitoring may be incorporated into a wellhead protection program, neither the SDWA or the Ground-Water Protection Strategy require ground-water monitoring in the vicinity of solid waste disposal facilities.

Subtitle D of RCRA requires that the designers of a solid waste disposal facility take the proximity to ground-water into consideration during facility design, and in the placement of observation wells and sampling stations that may be installed. Monitoring requirements are not specified under Subtitle D of RCRA, although they may be specified by State agencies that administer Subtitle D. However, the proposed 40 CFR Part 258 regulation will require ground-water monitoring when promulgated.

Under Subtitle C of RCRA, generators of hazardous waste must meet stringent disposal requirements including stringent ground-water monitoring requirements. The general requirements are described in 40 CFR Part 264.90 through Part 264.100.

Assuming that the land application or landfilling of municipal sludge does not entail the disposal of hazardous materials, ground-water monitoring requirements should be evaluated on a case-by-case basis after reference to State regulation and in consultation with State Subtitle D program officials.

Liners and Leachate Collection

Leachate enters the ground-water system by both vertical and lateral movement through the soil. Careful site selection and attention to design considerations can prevent or minimize leachate contamination of ground-water. The control of leachate may be accomplished through (EPA 1978):

- o Natural conditions and attenuation by the soil
- o Imported soils or soil amendments used as liners and/or cover
- o Membrane liners

If a site design includes provisions for leachate containment (e.g., a liner) a leachate collection system must be installed. The collection system may consist of a sump into which leachate collects and is subsequently drained or pumped to a holding tank or pond. Leachate may also be collected by a series of drain pipes or tiles that intercept and channel the leachate to the surface or to a sump (EPA 1978).

Collected leachate may be handled or disposed of by one of the following methods (EPA 1978):

- o Discharge to a wastewater collection system or haul directly to a treatment plant.
- o Recycle through the landfill.
- o Evaporation of leachate in collection ponds.
- o On-site treatment and discharge to a receiving stream.
- o Transport to chemical waste disposal site.

Depending on the leachate characteristics, volume, and local regulations, it may be possible to discharge collected leachate to an existing wastewater system for subsequent treatment with municipal wastewater. Local wastewater treatment plant personnel should be consulted for leachate acceptability to determine special requirements for discharge to the treatment plant (e.g., large slugs of highly contaminated leachate may have to be mixed with municipal wastewater to prevent plant upset) (EPA 1978). In some cases leachate may have to be pretreated to reduce high organic and heavy metal concentrations. An additional source of guidance is the Guidance Manual on the Development and Implementation of Local Discharge Limitations under the Pretreatment Program (EPA, December 1987). To obtain a copy of this manual contact the Office of Water Enforcement and Permits (EN-336), Washington, D.C. 20460.

If discharge to the wastewater system is impractical or if the leachate is potentially disruptive to treatment plant operations, on-site treatment or transportation to a chemical waste disposal site will have to be utilized (EPA 1978).

On-site treatment may consist of recycling the leachate through the landfill, placing the leachate in a shallow basin to allow it to evaporate, or installing a small (specially designed) treatment plant on site. The latter alternative should be avoided if at all possible due to its high cost and the unproven reliability of such small plants (EPA 1978).

Leachate recycling has been shown to be useful because it:

- o Promotes rapid development of anaerobic decomposition in the wastes.
- o Increases the rate and predictability of biological stabilization.
- o Reduces the volume of leachate to be handled by evaporation of the water during dry periods.

However, leachate recycling systems are not feasible at some sites; in particular, areas with high rainfall and high application rates are not suitable. Its primary application should probably be restricted to co-disposal sites in climates where the evaporation rate exceeds rainfall to a significant extent (EPA 1978). Some States are presently considering a ban on leachate recycling.

A detailed discussion of natural attenuation and liner systems (soil and synthetic) and leachate collection and treatment can be found in EPA's Process Design Manual for Municipal Sludge Landfills (EPA 1978).

Depth to Ground-water

The technical literature recommends, and some States require, that a minimum thickness of soil be maintained between the bottom of the waste disposal site and the seasonal high ground-water table. This separation prevents ground-water from passing through waste cells and takes advantage of attenuating properties of the underlying soil. Recommended minimum separation generally varies from 2 to 5 feet. Greater separations may be required for higher than normal soil permeabilities or sludge loading rates.

State Requirements

Liners and Leachate Collection

Twenty-eight States and Puerto Rico specify some requirement for liners at sludge landfills. "State-of-the-Art" design criteria and requirements for liner systems have been adopted by some States, in particular New Jersey and Massachusetts, in their solid waste regulations. Five States and Puerto Rico impose liner requirements based upon case-by-case site evaluations. The remaining State regulations vary widely and are not very specific. California requires liners with a permeability of no greater than 1×10^{-6} cm/sec, or a 2-ft thick clay layer. Louisiana and Illinois mandate a material of certain permeability and require a thickness of that material of 3 and 10 feet, respectively. These, or equivalent, regulations should be consulted prior to design or review of any liner system. State liner requirements are summarized in Table E5-3.

Twenty-seven States have some requirements regarding leachate collection. Massachusetts requires leachate collection only at sludge-only landfills. Two States, Massachusetts and New Jersey, have incorporated "state-of-the-art" leachate collection system design standards into their landfill regulations. New York requires leachate collection if wet sludge comprises greater than 25 percent of materials disposed of at the facility each day. Eleven States require leachate collection but do not specify any treatment or management criteria. Alabama, Georgia, and Illinois require leachate collection on a case-by-case basis. Table E5-3 contains a State-by-State listing of leachate collection requirements. Five States specify that leachate should be treated. In Washington, leachate treatment is required in areas receiving greater than 25 inches of rainfall per year. These standards, or their equivalent, should be consulted before design or review of leachate collection systems.

Depth to Ground-water

Twenty-three States presently have regulations requiring minimum separations between the bottom of disposal facilities and the seasonal high ground-water table. The required separations and the number of States mandating that separation are listed below:

Depth to Seasonal High Water Table (ft)	Number of States
>1.7	1
>4	7
>5	9
>6	2
>10	4

The individual State requirements are listed in Table E5-2.

Distance to Wells

Sixteen States require a minimum distance between nearby drinking water wells and a sludge-only or co-disposal landfill. Distances range from 200 to 1,200 feet, with most States requiring a 1,000 foot separation. Oklahoma requires disposal facilities to be 250 feet from private wells and 660 feet from public water supply wells. New Hampshire requires a distance of 500 feet for community wells and 1,000 feet for municipal wells. A complete list of each State's requirements is provided in Table E5-2.

Soil Type

Twenty-two States require some type of soil analysis in conjunction with landfilling of sludge. Michigan requires that the landfill soil have clay characteristics. Montana requires that the percolation rate not exceed 1.5 in/hr.

Case-by-Case Recommendations

The permit writer should evaluate site-specific conditions in determining whether it is appropriate for sludges to be disposed of in sludge-only or co-disposal landfills that do not have liners and leachate collection systems or adequate buffers between ground-water and drinking water wells. Among the important factors to consider are sludge quality, the value of the ground-water resource, the proximity of ground-water uses, ground-water flow direction and velocity, and evidence of migration of contaminants from the landfill. Solid waste and ground-water program officials should be consulted in determining the appropriateness of using a particular landfill for sludge disposal.

Depth to Ground-water

Generally, a minimum soil buffer (or overburden) of 4 feet is recommended between the bottom of both types of landfills and the seasonal (annual) high ground-water table at the site. Typically, disposal facilities that are designed well and perform well would require less depth to ground-water than poorly designed, poorly managed facilities.

Distance to Wells

While the appropriate distance to drinking water wells is a site-specific determination, generally, a minimum distance of 500 feet between waste disposal areas at both types of landfills and drinking water wells is recommended. Some of the more important factors to consider in determining an appropriate setback from drinking water wells are sludge quality, direction of ground-water flow, ground-water velocity and any evidence of migration of contaminants from the landfill into ground-water. If no data are available for those factors, a conservative setback may be appropriate.

Additional Permit Conditions

In addition to site specific conditions, other recommendations for permit conditions that can help minimize ground-water contamination include:

- o Sludge pollutant concentration limits
- o Sludge solids content requirements
- o Compliance schedule for the POTW to identify alternate sludge use or disposal option.

5.4.4 SURFACE WATER PROTECTION

Federal Regulations

40 CFR Part 257.3-3 states that a facility or practice shall not cause a discharge of pollutants that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act. In addition, the regulation states that the facility or practice shall not cause non-point source pollution of the waters of the U.S. No minimum distances to surface waters are established.

Federal Guidance

Buffer Zones

While the appropriate distance to surface water is a site-specific determination, a minimum distance of 100 feet between waste disposal areas at both types of landfills and surface water is generally recommended. In determining an appropriate setback from surface waters the permit writer should consider the adequacy of systems to control precipitation run-on and run-off, the potential for leachate migration through the underlying soil or ground-water into the surface water of concern, and the slope and vegetative cover of the buffer zone.

Run-on/Run-off Controls

The technical literature generally recommends that all upland drainage be collected and directed around the landfill to prevent run-off from contacting the sludge and/or solid waste and thereby prevent surface water pollution or leachate generation. The drainage channels may be constructed of earth, corrugated metal pipe, gunite-lined earthen ditches, or stone-lined (rip rap) ditches. If the access or on-site roads of the landfill are paved, they may be used to channel drainage across the landfill (EPA 1978). The dimensions for drainage structures should be based upon accepted storm run-off calculation methods such as those developed by the U.S. Soil Conservation Service. Systems to control and divert the 24-hour, 25-year storm around active disposal areas are recommended.

On the landfill itself, all active and completed site working areas should be properly graded. The surface grade should be greater than 2 percent to promote run-off and inhibit ponding of precipitation, but less than 5 percent to reduce flow velocities and minimize soil erosion. If necessary, siltation ponds should be constructed to settle the solids contained in the run-off from the site. Straw bales, berms, and vegetation may be used in conjunction with ponds to control run-off and siltation on the site (EPA 1978). In addition, leachate collection systems at the landfill help mitigate the effects of run-on from storm events.

State Requirements

Buffer Zones

Twenty-two States have limits on the distance between sludge disposal facilities and surface water. The minimum distances and the number of States mandating the distance are listed below:

Distance Surface Water (ft)	Number of States
50	1
100	7
200	3
300	1
500	2

Wisconsin requires a distance of 300 feet to a river and 1,000 feet to a lake. The distance required by Kentucky varies from 250 feet to 1,000 feet. Rhode Island does not allow facilities to be located in a water supply watershed. Connecticut sets the distance to surface water on a case-by-case basis. The State requirements for the distance from sludge-only and co-disposal landfills to surface water are listed in Table E5-2.

Run-on/Run-off Controls

Thirty-six States, Puerto Rico and the Virgin Islands require some form of run-off control at sludge landfills; however, few States are very specific about their requirements. Alabama and Delaware require a minimum 2 percent slope on the completed fill. Connecticut and Oklahoma require slopes to be less than 4 percent, while Vermont and Mississippi require slopes to be less than 5 percent and 8 percent, respectively. Alaska and Louisiana recommend the construction of dikes, levees, or other diversion devices to control run-off. Finally, Montana, New Hampshire and New Mexico require that controls be maintained to divert run-off away from active disposal areas. State requirements for run-on/run-off controls are summarized in Table E5-3.

Case-by-case Recommendations

Complying with the Federal requirement for surface water protection normally requires the installation of proper run-on/run-off protection at landfills. In developing permit conditions to protect surface water, the permit writer should evaluate the existence and adequacy of run-on/run

off control structures, the type and size of buffer zones and management practices used at the landfill. For instance, the daily cover application at a narrow trench type monofill may be sufficient to protect surface water from contamination by sewage sludge because the cover material forms a bridge over the sludge. However, daily cover at other types of landfills does not offer the same degree of protection.

5.4.5 SAFETY

Federal Regulations

Existing Federal regulations (40 CFR Part 257) pertaining to safety at sludge landfills cover explosive gases (methane), fires, bird hazards to aircraft, and access control. Methane gas migration and control will be addressed separately; fires, bird hazards and access control are discussed below.

Existing Federal regulations pertaining to fires, access control, and bird hazards to aircraft state:

- Fires - a facility or practice shall not pose a fire hazard to the safety of persons or property. This may be accomplished through compliance with 40 CFR Part 257.3-7 (prohibition of open burning) through the periodic application of cover material or other techniques as appropriate, and control of generation of explosive gases.

- Bird hazards to aircraft - a facility or practice disposing of putrescible wastes that may attract birds and which occurs within 10,000 feet of any airport runway used by turbojet aircraft or within 5,000 feet of any airport runway used by only piston-type aircraft shall not pose a bird hazard to aircraft.

- Access - a facility or practice shall not allow uncontrolled public access as to expose the public to potential health and safety hazards at the disposal site.

Federal Guidance

The technical literature suggests that water on-site for fire protection is a factor that should be considered in the design and operation of a landfill. Insuring that solid waste and sludge are covered at the end of each day is also a protective measure against fire.

Access to landfills should be limited to one or two entrances with gates that can be locked when the site is unattended. Depending on the topography and vegetation of the site and adjoining areas as well as nearby population density, entrance gates may suffice to prevent unauthorized vehicular access. At some sites it is desirable to construct peripheral fences to keep out any trespassers and animals. Keeping trespassers and animals off sludge landfills is more important than for refuse landfills because the sludge may not be sufficiently stable to support their weight (EPA 1978).

Fencing requirements will be greatly influenced by the relative isolation of the site. Sites close to housing developments may require fencing to keep out children and to provide a visual screen for the landfill. Establishing a buffer zone between the landfill and nearest dwelling also helps limit public exposure to the landfill. EPA recommends at least a 250 foot buffer. Landfills that are in relatively isolated rural areas may require a less sophisticated type of fencing or only fencing at the entrance and other places to keep out unauthorized vehicles (EPA 1978).

State Requirements

Buffer Zones

Only six States require a buffer zone between sludge-only and co-disposal landfills and airports. Two States have adopted the Part 257 standard of 5,000 feet from piston-type only airports and 10,000 feet from turbojet aircraft airports. Two States require 10,000 feet of separation between landfills and all airports. A list of the State regulations regarding distances to airports is provided in Table E5-2 under Buffer Zones.

Thirty-two States, Puerto Rico and the Virgin Islands require some form of access control at sludge landfills. Seventeen States require either or both perimeter fencing and locked entrance gates. One State mandates access by roadway only. A list of access control requirements for each State is provided in Table E5-3.

Twenty-one States and the Virgin Islands require either a separation of landfilling operations from the facility property line or a separation from the nearest dwelling, or both. Four States require property line setbacks of 50 feet. Three States require 100 foot property line setbacks. Texas requires a 200 foot setback from the property line and Vermont requires a 300 foot setback. Idaho will allow a separation ranging from 100 to 300 feet depending on vegetative screen.

Separation requirements from the nearest dwelling range from 200 feet to 3/4 mile; 500 feet being the most common (See Table E5-2). Nevada requires a separation from one-quarter to three-quarters of a mile depending on the class of landfill.

Other requirements include a 100-foot separation from roads, and a 100-foot separation from highways and parks. Table E5-2 contains each State's requirements for buffer zones.

Fire Protection

Only one State, Wyoming, mentions fire protection in its regulations. The State requires fire lanes and other forms of fire protection at all sites.

5.4.6 AIR QUALITY CONTROL

Federal Regulations

A facility or practice shall not engage in open burning of residential, commercial, institutional, or industrial solid waste (40 CFR Part 257). The facility also shall not violate applicable requirements developed under a State Implementation Program approved under the Clean Air Act.

Federal Guidance

The technical literature suggests that odors at sludge landfills can be a serious problem unless preventive measures are taken. The sludge should be covered as frequently as necessary to minimize odor. Sludge stabilization reduces odor. Lime or chemical masking agents can be applied to reduce odors. An effective means of reducing odors is to limit storage of sludge at the landfill. Ideally, sludge should be stored at the wastewater treatment plant (EPA 1978).

In areas where odor is of concern, sludge disposed of at both types of landfills should be stabilized. Sludge stabilization processes are discussed in Chapter 3. Permit writers should consider requiring sludge treatment processes that reduce volatile solids and vector attraction for sludges that may be disposed of near airport runways.

State Requirements

Only two States have regulations covering air quality or odors. Louisiana requires daily checks for odor and monthly checks for amines and chlorinated hydrocarbons. Maryland requires that odors not be excessive or persistent.

5.4.7 GAS CONTROL

Federal Regulations

Federal regulations (40 CFR Part 257.3-8) pertaining to the monitoring and control of methane gas migration at sludge-only and co-disposal landfills specify that the concentration of explosive gases generated by the facility or practice shall not exceed:

- Twenty-five percent of the lower explosive limit for the gases in facility structures (excluding gas control or recovery system components) and

- The lower explosive limit for the gases at the property boundary.

Federal Guidance

Gas is produced by the decomposition of organic matter in sludge and refuse. The primary gases of decomposition are methane and carbon dioxide. Some nitrogen and oxygen are found. Traces of ammonia, hydrogen sulfide, hydrogen, and volatile organic species are sometimes found in landfills. The amount and composition of gases produced depends on the quantity and characteristics of sludge deposited, the amount of moisture present, and other factors (EPA 1978). Accumulation of particular gases in enclosed areas can result in explosions.

Methane, like carbon dioxide, is odorless; unlike carbon dioxide, methane is relatively insoluble in water. However, when methane is present in air at between 5 and 15 percent concentrations, and is confined in an enclosed area, it is explosive. The lower explosive limit is defined as the lowest percent by volume of a mixture of explosive gases that will propagate a flame in air at 25°C and atmospheric pressure. Thus, for methane, 25 percent of the lower explosive limit is 1.25 percent methane in air, and 100 percent of the lower explosive limit is 5 percent in air. Methane can move by diffusion through the sludge into the atmosphere where it is harmlessly dissipated. The gas can also move laterally from the landfill into surrounding soils, especially if the cover material is

relatively impermeable. Through lateral movement, methane could seep into nearby buildings or utilities. A build-up of methane to a concentration exceeding the lower explosive limit is hazardous. Migrating gas can also damage vegetation surrounding a sludge landfill by excluding oxygen from the root zone (EPA 1978).

Installation of gas control facilities is not necessary if the site is isolated and will remain isolated from inhabited structures. However, when inhabited structures are near the landfill and monitoring wells indicate that a structure is threatened, gas migration controls are required. Migration can be controlled by installing barriers to gas flow and/or by collection and venting the gas. Gas control techniques can generally be classified into permeable and impermeable methods (EPA 1978).

Permeable Methods

Permeable methods of gas venting usually entail the installation of a gravel-filled trench outside the filled area. The trench, which generally extends below the bottom of the fill area, intercepts migrating gas and vents it to the atmosphere.

Gravel-packed well vents are often used in conjunction with lateral-surface vents buried below the final cover in a gravel trench. Wall vents should penetrate into the upper waste cell. Waste gas burners are also often installed above the well vents (Tchobanoglous 1977).

Impermeable Methods

Placing a barrier of very low permeability material around the perimeter of the landfill minimizes lateral gas migration. The movement of gas through soils can be controlled by using materials that are more impermeable than the surrounding soil (EPA 1978).

The most common material used for construction of gas barriers is compacted clay. A clay layer approximately 2 ft thick is probably adequate. Often a thicker layer is required in order to ensure an adequate seal if the side slope exceeds 50 percent. To be effective, the clay layer must be continuous. The clay liner should be constructed as the fill progresses because prolonged exposure to air will dry the clay and cause it to crack. Synthetic membranes may be considered for the control of migrating gas but their effectiveness has not been established. PVC is thought to be the most effective (EPA 1978).

Gas Extraction and Recovery Systems

An effective method of gas control in refuse landfills involves the placement of an impermeable barrier combined with a gas extraction and recovery system via strategically located forced exhaust vents. However, such systems are only feasible at larger landfills and may not be suitable for sludge landfills because the high moisture content typically found in sludge does not permit gas movement, and sludge can enter and clog the evacuation pipes.

State Requirements

Thirty-eight States require some sort of gas monitoring or control program. Three States have set concentration limits for methane. Refer to table E5-3 in Appendix E for more information on State gas control management practices.

5.4.8 PATHOGEN AND DISEASE CONTROL

Federal Regulations

No facility or practice shall exist or occur unless the on-site population of disease vectors is minimized through the periodic application of cover material or other techniques as appropriate so as to protect public health (40 CFR Part 257).

Federal Guidance

Cover recommendations for sludge-only and co-disposal landfills were discussed previously in Sections 5.1.2. These recommendations are summarized below:

Method	Recommended Cover Thickness
Narrow Trench	2-4 ft
Wide Trench	3-4 ft (for equipment working outside the trench)
	4-5 ft (for equipment working inside the trench)
Sludge/Refuse Mixture	0.5-1 ft interim
	2 ft final
Sludge/Soil Mixture	None

Daily and final cover applications of 6 inches and 24 inches, respectively, are recommended at both sludge-only and co-disposal landfills. Stablilization of sewage sludge prior to disposal is another technique used to minimize vector attraction.

State Requirements

Twenty-nine States, Puerto Rico and the Virgin Islands have some requirement for daily, intermediate, or final cover at landfills accepting municipal sewage sludge. Fourteen States require 6 inches of daily cover and one State (Iowa) requires 12 inches. Texas requires 6 inches of daily cover over stabilized sludges and 2 feet over unstabilized sludges. Four other States require only that solid waste and sludge be covered at the end of each day.

Intermediate cover is specified by three States. Mississippi requires 24 inches of intermediate cover, while New York and Ohio require 12 inches.

Fourteen States specify a depth of final cover: eleven States require 2 feet, Kentucky requires 2.5 feet, two States (Oklahoma and Texas) require 3 feet, and New York requires 4 feet. The State requirements for cover are listed in Table E5-3.

Twenty-three States indicate that they have regulations covering pathogen control at sludge landfills. However, only six States dictate specific means by which pathogens are to be controlled. Montana, Virginia, Wyoming, Pennsylvania and Rhode Island require that, prior to landfilling, sludge be treated by one of the "Processes to Significantly Reduce Pathogens" (PSRP) which are described in 40 CFR Part 257, Appendix II, Section A. These processes include: aerobic digestion, air drying, anaerobic digestion, composting, lime stabilization, or any other equivalent method. The required operating parameters of each of these processes are described in Appendix II of 40 CFR Part 257.

Illinois requires sludge to be digested at sites when used as or with a cover. West Virginia requires that the sludge be demonstrated non-infectious. Alaska requires that sludge generated in permafrost areas be disinfected prior to landfilling. The individual State regulations for pathogen and disease control are listed in Table E5-3.

5.4.9 OTHER STATE MANAGEMENT PRACTICES

A list of additional State management practices that were not listed in Tables E5-1 through E5-4 is provided in Table E5-5.

5.5 MONITORING, REPORTING, AND RECORD KEEPING

5.5.1 SLUDGE MONITORING

Federal Regulations

The current NPDES regulations require sludge monitoring and reporting at a frequency dependent upon the nature and effect of the permittee's sludge use or disposal activities, but at least once a year for every pollutant limited in the permit. This means that if the permit contains a limit for cadmium, the permittee must be required to monitor its sludge at least annually for this pollutant.

Currently, there are no Federal regulations which require sewage sludge quality be monitored for specific constituents or characteristics prior to disposal in a monofill or landfill. The existing Federal regulations stipulate that sewage sludge disposed of in a landfill shall not be hazardous or cause the contamination of ground-water.

Federal Guidance

In addition to require compliance monitoring, the Sewage Sludge Interim Strategy recommends annual monitoring of the 126 priority pollutants as well as more frequent monitoring of the pollutants for which numeric limits have been proposed in the 40 CFR Part 503 Technical Sludge Standards. For the disposal practice of monofills, these pollutants include:

Arsenic	Methyl nitrosamine
Benzene	Lead
Benzo(a)pyrene	Lindane
Bis(2-ethylhexyl)pthalate	Mercury
Cadmium	Polychlorinated biphenyls
Chlorodane	Nickel
Copper	Toxophane
DDT/DDE/DDD (total)[1]	Trichloroethylene

State Requirements

Twenty-one States have regulations that stipulate sludge quality monitoring at sludge landfills. Four States mandate that the sludge be tested to demonstrate that it is non-hazardous. Six States require monitoring for specific contaminants and characteristics including: percent solids, pH, nitrogen, ammonia, nitrates, PCBs, and metals (cadmium, copper, lead, selenium, and zinc are mentioned).

Only four States specified the frequency with which sludge sampling must occur. Maryland and Michigan require an initial testing with additional sampling required as needed based on quality or use. Texas requires semiannual sampling, while New Hampshire varies sampling frequency based upon the size of the treatment plant: plants larger than 1 mgd must be sampled 3 times per year, plants smaller than 1 mgd must be sampled annually. Individual State requirements for sludge quality monitoring can be found in Table E5-4.

If radionuclides in the sludge are a concern and need to be addressed by the permit writer, then consideration should be given to at least annual monitoring of the sludge.

If the permit writer is unsure of the quality of the sludge or concerned about potential contamination because sludge quality is poor and landfill design and operation is marginal, the permit writer should develop concentration limits and/or monitoring requirements for pollutants of concern.

5.5.2 GROUND-WATER MONITORING

Federal Regulations

While existing Federal regulations prohibit contamination of ground-water, they do not specifically require ground-water monitoring at sludge-only or co-disposal landfills.

[1]DDT-2,2-Bis(chlorophenyl)-1,1,1-trichloroethane
DDE-1,1-Bis(chlorophenyl)-2,2-dichloroethene
DDD-1,1-Bis(chlorophenyl)-2,2-dichloroethane

State Requirements

Thirty-six States presently have some policy in-place regarding ground-water monitoring at Subtitle D landfills. Twenty-eight of these States require monitoring at all sites, while seven States decide on a case-by-case basis; generally based upon individual hydrogeologic conditions.

Louisiana and Oklahoma specifically require a minimum of 1 upgradient and 2 downgradient wells. New York requires a minimum of 1 upgradient and 3 downgradient wells. Maine requires a minimum of three monitoring wells but does not specify their location. Four States require that a ground-water monitoring plan be submitted as part of a permit application. The individual State requirements are listed in Table E5-4.

Of the thirty-six States that require ground-water monitoring, only three specify the frequency of sampling. Michigan and Vermont require quarterly sampling; Louisiana requires annual sampling.

Only two States (California and Texas) list specific parameters that must be monitored. These include: ground-water table elevation, temperature, specific conductance, pH, nitrates, COD, sodium, chloride, iron, manganese, sulfates, phenol, and sulfur. One study cited in the literature indicated that State requirements in Subtitle D landfills often include monitoring of pH, specific conductance, TDS and organic carbon (EPA 1986b).

Case-by-Case Recommendations

The permit writer should evaluate site-specific conditions in determining whether a monitoring system is necessary. If monitoring is deemed necessary, the permit writer needs to write monitoring system specifications (number of wells, well configuration, etc.) into the permit.

The number of wells required to adequately monitor a sludge-only or co-disposal landfill is highly site-specific, and generally depends on the hydrogeologic conditions at the site and the goals of the ground-water monitoring program. A qualified hydrogeologist should be consulted to assist in determining the number of wells required and their location (EPA 1978). Solid waste and ground-water program officials should be consulted when making determinations regarding ground-water monitoring at landfills.

Regardless of number, monitoring wells should be placed both upgradient and downgradient of the facility. Upgradient wells indicate the natural or background ground-water quality at the site while

downgradient wells measure ground-water quality after it has passed beneath the facility to detect any contamination. It is highly desirable to install all monitoring wells and begin sampling at least 6 months to a year before the site is activated to establish background quality, including any seasonal fluctuations (EPA 1978).

Information about the ground-water flow system can be determined from monitoring wells. Ground-water elevations should be measured at scheduled frequencies and the ground-water flow gradient determined. Flow rate of ground-water can be determined using tracers in the monitoring wells. This information is very valuable in the event of contamination and should be obtained and utilized in consultation with a qualified hydrogeologist.

The frequency of ground-water sample collection is dependent upon the specific characteristics of a site; including aquifer flow rate and the resource value of the aquifer. Analyses of the initial and second samplings may suggest an adjustment of the sampling frequency. Studies indicate that leachates frequently are released in slugs, or high concentrations, at periodic intervals that are seasonably or climatically influenced. This may dictate intensified sampling efforts at certain times. Quarterly sampling is most often recommended, however, sampling frequency is site specific and should be adjusted if experience indicates that more frequent samplings are necessary (EPA 1978).

A phased approach is recommended for ground-water monitoring in sludge monofills. In Phase I, samples should be analyzed for pH, TKN-N, Nitrates, TOC, and TDS. If Phase I indicates that contamination is occurring, then more detailed Phase II monitoring should be required. Phase II analytes should consist of iron, heavy metals (especially lead), chorides, and any other drinking water parameters. Monitoring of all contaminants for which drinking water standards [aka Maximum Contaminant Levels (MCL's)] have been established (see Appendix I of 40 CFR Part 257) is recommended so that the extent and degree of ground-water contamination can be determined. Monitoring ground-water for contaminants found in an analyses of the sludge are also recommended (EPA 1978).

The EPA Process Design Manual for Municipal Sludge Landfills (EPA 1978), recommends monitoring for the following parameters as appropriate: pH, TDS, nitrate, chlorides, TOC, and heavy metals, and methylene blue-active substances.

5.5.3 GAS MONITORING

Federal Regulations

The concentration of explosive gases generated by a Subtitle D facility shall not exceed 25 percent of the lower explosive limit for gases in facility structures, and 100 percent of the lower explosive limit for gases at the property boundary (40 CFR Part 257).

Federal Guidance

The technical literature generally recommends that sludge-only and co-disposal landfills located near structures conduct periodic gas monitoring to detect gas migration and accumulation. In most cases, over 70 percent of the gas volume produced from the decomposition of solid wastes and sludge consists of methane and carbon dioxide; methane is the gas of major concern.

State Requirements

Thirty-seven States and Puerto Rico have some policy regarding gas migration and control at Subtitle D facilities. Nine other States cite the limit of less than 25 percent of the lower explosive limit in structures. A total of eight States do not have specific numerical standards, instead they simply state that gas migration and accumulation should be prevented. Four States decide upon the need for gas control on a case-by-case basis. Table E5-3 contains a summary of the gas control policy for each State.

None of the thirty-seven States that have regulations governing landfill gas specify sampling frequency.

5.5.4 SURFACE WATER MONITORING

State Requirements

Twenty States presently have some policy regarding surface water monitoring. A total of twelve States require surface water monitoring at all sludge landfills. The remaining eight States have the option of requiring surface water monitoring on a case-by-case basis.

Only Maine specifies the number of surface water sampling stations; a minimum of two. Maryland requires that a plan for surface water monitoring be proposed. The individual State requirements are listed in Table E5-4. No States presently specify either the frequency of surface water monitoring or the parameters that should be monitored in their regulations.

5.5.5 MONITORING FOR HAZARDOUS WASTES

In order to fulfill the stipulation that hazardous sludge not be disposed of in a nonhazardous material landfill, the permit writer may want to require monitoring to demonstrate that the sludge is not hazardous. An Extraction Procedure (EP) Toxicity test is generally performed to determine whether or not sludge is hazardous. The EP toxicity test, which appears at 40 CFR Part 261, Appendix II, involves the preparation of an aqueous extract of the suspected hazardous waste, which is analyzed for the constituents in Table 5.2. The sludge exhibits the characteristics of EP toxicity, and therefore is a hazardous waste, if the extract from a representative sample contains any of the contaminants listed in the table at a concentration equal to or greater than the respective tabulated value.

In it generally agreed that the EP toxicity test procedure is not sufficient for screening of potentially hazardous materials because there are many more toxic substances that may appear in a suspected hazardous waste than the 14 compounds to which the EP toxicity test applies. A new test, known as the Toxicity Characteristic Leaching Procedure (TCLP) test, has been under development for several years and is expected to be published in final form in late 1989. When finalized, the TCLP test will replace the EP toxicity test. An important difference between the two tests is that the TCLP is designed to evaluate a greater number of compounds (particularly organics) than are considered by the EP procedure. The constituents analyzed in the TCLP test are listed in Table 5-2. Tests of the draft TCLP performed on 18 municipal sludges have shown that none of the sludges contained hazardous levels of pollutants. Several of the sludges, however, had contaminant concentrations at levels close to those defined by the TCLP test as hazardous (EPA 1987).

5.5.6 REPORTING AND RECORD KEEPING

Federal Regulations

The recently promulgated revisions to the NPDES Permitting Regulation (54 FR 18716) require the POTW to report monitoring results with a frequency dependent on the nature and effect of the

TABLE 5-2

MAXIMUM CONCENTRATIONS FOR CONTAMINANTS ANALYZED UNDER EP TOXICITY AND TCLP TESTS

Contaminant	EP Tox. Max Conc. (mg/L)	TCLP (Proposed) Max Conc. (mg/L)
Acrylonitrile	-	5 0
Arsenic	5.0	5 0
Barium	100.0	100 0
Benzene	-	0 07
Bis(2-chloroethyl) ether	-	0.05
Cadmium	1 0	1 0
Carbon disulfide	-	14 4
Carbon tetrachloride	-	0.07
Chlordane	-	0.03
Chlorobenzene	-	1 4
Chloroform	-	0.07
Chromium	5.0	5.0
o-Cresol	-	10.0
m-Cresol	-	10.0
p-Cresol	-	10.0
2,4-D	10.0	1.4
1,2-Dichlorobenzene	-	4 3
1,4-Dichlorobenzene	-	10 8
1,2-Dichloroethane	-	0 40
1,1-Dichloroethylene	-	0.1
2,4-Dinitrotoluene	-	0 13
Endrin	002	0 003
Heptachlor (and its hydroxide)	-	0 001
Hexachlorobenzene	-	0.13
Hexachlorobutadiene	-	0.72
Hexachloroethane	-	4.3
Isobutanol	-	36
Lead	5.0	5.0
Lindane	0 4	0.06
Mercury	0.2	0 2
Methoxychlor	10 0	1 4
Methylene chloride	-	8 6
Methyl ethyl ketone	-	7 2
Nitrobenzene	-	0.13
Pentachlorophenol	-	3 6
Phenol	-	14.4
Pyridine	-	5 0
Selenium	-	1 0
Silver	5.0	5 0
1,1,2,2-Tetrachloroethane	-	10.0
1,1,2,2-Tetrachloroethane	-	1 3
Tetrachloroethylene	-	0.1
2,3,4,6-Tetrachlorophenol	-	1 5
Toluene	-	14 4
Toxaphene	0.5	0.07
1,1,1-Trichloroethane	-	30.0
1,1,2-Trichloroethane	-	1 2
Trichloroethylene	-	0.07
2,4,5-Trichlorophenol	-	5.8
2,4,6-Trichlorophenol	-	0.30
2,4,5-TP (Silvex)	1 0	0.14
Vinyl chloride	-	0.05

sewage sludge use or disposal practices, but in no case less than one a year [40 CFR Part 122.44(i)(2)]. The regulations also require that records of monitoring required by the permit for the permittee's sewage sludge use and disposal activities must be retained for a period of at least 5 years [40 CFR Part 122.21(p)].

State Requirements

Reporting and record keeping requirements vary widely from State to State. Thirty States require some degree of reporting and record keeping at sludge landfills. Seven States require keeping records of the source of sludge, and sludge quantity and quality. Ohio and Oklahoma require a log of daily operations at the facility.

The frequency with which reports must be submitted varies from monthly to quarterly to semi-annually. Only three States specify a reporting frequency in their regulations.

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CHAPTER 6
LAND APPLICATION

6.1 INTRODUCTION

Currently, about 18 percent of municipal sewage sludge is applied to the land (EPA 1987a). Land application options include:

- o Agricultural Utilization: Use of sludge as a source of fertilizer nutrients and/or as a soil amendment to enhance crop production.

- o Forest Utilization (Silviculture): Use of sludge on forested land to enhance forest productivity.

- o Land Reclamation Utilization: Application of sludge to strip mine lands, mine tailings, or other disturbed or marginal land for the purpose of revegetation and reclamation.

- o Dedicated Land Disposal (DLD): Application of sludge to soils, with or without vegetation, for the primary purpose of sludge disposal. This option differs from the others in that sludge is generally applied at higher rates and system management is more intensive. Crop production (if any) is of secondary importance.

This chapter describes the permit requirements and recommendations for land application sites. This section briefly describes each of the different land application practices. Section 6.2 then provides the general requirements and recommendations applicable to all forms of land application. Finally, sections 6.3, 6.4, 6.5 and 6.6 address any additional requirements and recommendations for agricultural utilization, forest utilization, land reclamation utilization and dedicated land disposal, respectively.

6.1.1 AGRICULTURAL UTILIZATION

Hundreds of communities, both large and small, have developed successful agricultural utilization programs. Agricultural utilization is especially common in New Jersey, Pennsylvania, Ohio, Illinois, Michigan, Missouri, Wisconsin, and Minnesota. These programs benefit the municipality generating the sludge by providing an ongoing, environmentally acceptable means of sludge

disposal, and provide the participating farmer with a substitute or supplement for conventional fertilizers.

Agricultural utilization assumes that the sludge is applied at "agronomic rates," defined as the annual sludge application rate at which the nitrogen (N) and/or phosphorus (P) supplied by the sludge and available to the crop does not exceed the annual N and/or P growth requirements of the crop. Therefore, assuming contaminant concentrations are low, the amount of sludge applied to the site is determined by the available N or P requirement of the crop to be grown.

Sludge application rates for agricultural utilization (dry unit weight of sludge applied per unit of land area) are usually low relative to other land application practices. Thus, large land areas may be needed, which may require the cooperation of many individual land owners. In addition, because of planting, harvesting and delays caused by adverse climatic conditions, scheduling sludge transport and application requires careful management.

6.1.2 FOREST UTILIZATION (SILVICULTURE)

Except for certain areas in the Great Plains and the Southwest, forested lands are abundant and well distributed throughout most of the United States. Many major municipalities are located near forests; in fact, it is estimated that close to one-third of the land within the standard metropolitan areas is forested. Furthermore, approximately two-thirds of all forest land in the United States is commercial timberland. Thus, the application of sludge to forest soils has the potential to be a major sludge utilization/disposal practice.

Studies have shown that sludge application can greatly improve forest productivity (EPA 1984). Forest soils have perennial root systems (which allow year-round application in mild climates), large amounts of organic material (which immobilize metals in the sludge) and high infiltration rates (which reduce run-off and ponding). Another advantage is that forest products such as wild edible berries, mushrooms, game and nuts make up a very small part of the average human diet (EPA 1984). Studies in forests where sludge has been applied have suggested that there is no accumulation of trace metals in the muscle tissue of wild animals (Haufler, Hest, 1985). Data have also shown no statistical difference in metal accumulations (Zabowoski and Zasoski, 1986) in wild berries grown on sludge amended soil. The primary environmental and public health concern associated with forest application is pollution of water supplies (EPA 1984).

Although silviculture is not yet a common practice, approximately 12 States have silviculture sites. Silvicultural sludge application may be particularly beneficial to recently cleared land and newly established (i.e., 3 to 10 years) forest plantations, as well as established forests. Municipalities in Washington have particularly well developed programs, and the State of Washington has a guidance document for forest land application (WDOE 1982).

6.1.3 LAND RECLAMATION

Surface mining, mineral exploration, and deposition of spoils and tailings from mining operations have created over 1.5 million hectares (3.7 million acres) of drastically disturbed land. The properties of these and other drastically disturbed and marginal lands vary considerably from site to site. Their inability to support vegetation is the result of several factors:

- Lack of nutrients - The soils have low N, P, K, and/or micro-nutrient levels.
- Physical properties - Stony or sandy materials have poor water-holding capacity and low cation exchange capacity (CEC). Clay soils have poor infiltration, permeability, and drainage.
- Chemical properties - The pH of mine soils, tailings, and some drastically disturbed soils range from very acidic to alkaline. Potentially phytotoxic levels of Cu, Zn, Fe, and salts may be present.
- Organic matter - Little, if any, organic matter is present.
- Biological properties - Soil biological activity is generally reduced.
- Topography - Many of these lands are characterized by steep slopes that are subject to excessive erosion.

Historically, reclamation of these lands is accomplished by grading the surface to slopes that minimize erosion and facilitate revegetation. In some cases, topsoil is added. Soil amendments such as lime and fertilizer are added, and grass, legumes, and/or trees are planted. Although these methods are sometimes successful, numerous failures have occurred primarily because of the very poor physical, chemical, or biological properties of these disturbed lands.

There have been a number of successful land reclamation projects involving the use of sludge or sludge compost. Most have been conducted on strip-mined land or mine tailings in the Eastern coal States of Pennsylvania, Illinois, Virginia, West Virginia, and Alabama. No significant ground-water degradation problems associated with sludge application have been documented at any of these sites. Philadelphia has a program which regularly uses sludge in reclamation projects.

Typically, sludge is applied only once to land reclamation project sites. Therefore, an ongoing program of sludge application to disturbed lands requires that a planned sequence of additional sites be available for the life of the program. This objective may be achieved through arrangements with land owners and mining firms active in the area, or through the planned sequential rehabilitation of existing disturbed land areas. In some cases, reclaimed areas may be used for agriculture production using agronomic rates of sludge application.

6.1.4 DEDICATED LAND DISPOSAL

Generally, a project utilizing land dedicated to sludge disposal has the following characteristics:

- The primary purpose is long-term sludge application. Any additional site activities or benefits such as the production of agricultural crops or improvement of soil characteristics are secondary to the sludge disposal activity.

- Normally, sludge application rates are substantially higher than for other options, e.g., agriculture, forest, etc. Obviously, higher application rates reduce the area of land required.

- Usually, the municipality owns or has a long-term lease on the land, which gives the municipality substantial latitude in use of the land for sludge disposal.

- The site should be more carefully designed, managed, and monitored than sites where sludge is applied at agronomic rates as a fertilizer amendment to cropland, forest land, etc. Access restrictions should be in place at all times.

- Site design and operations are focused upon containing any environmentally detrimental sludge constituents within the dedicated disposal site. Surface run-off, ground-water leachate, and harvested crops (if any) are carefully monitored. Strict controls are almost always required, both during operation and site closure. Some States require a notation on the land deed that the site has been used for land application.

A special case occurs when animal feeds are grown on land dedicated to sludge disposal. Regulations generally require operators of these projects to implement an extensive facility management plan to prevent adverse environmental impacts or human health.

6.2 GENERAL REQUIREMENTS AND GUIDANCE FOR ALL FORMS OF LAND APPLICATION

6.2.1 PERMITTING RESPONSIBILITIES

Permits must state that sludge be applied to lands in accordance with the general 40 CFR Part 257 requirements for solid waste disposal facilities and practices. (See Table 5-1 in the Landfill Chapter.) These requirements address floodplains, endangered species, surface water, ground-water, disease, air, and safety.

To ensure that sludge of an appropriate quality is applied to lands in a manner that protects public health and the environment, three types of permit conditions are needed:

- Sludge quality. The permit should contain conditions to ensure that the quality of the sludge is suited to the particular form of land application practice. It is particularly important that the permit writer consider the metals content of sludges that will be applied to soils with a pH of 6.5 or less because metals tend to be more mobile in low pH soils than in high pH soils and may have an adverse impact on ground-water quality.

- Selection of appropriate application sites. The permit should contain conditions ensuring that only sites that are suited to sludge application are used. For example, it is generally not appropriate to apply sludge within 200 feet of a drinking water well. As another example, sludge should generally not be applied to agricultural sites where the slope exceeds more than 15 percent; and

- Management of application sites. The permit should require that application sites be properly managed. For example, to protect surface waters, buffer strips should be maintained between the sludge application site and surface water. To protect ground and surface waters, sludge should not be applied during periods when the soil is saturated.

As the sludge generator, the POTW is always responsible for sludge quality. However, ensuring that sludge application sites are selected and managed properly is not always within the control of the POTW. Many POTWs employ a contractor to select and manage sludge application sites. Some POTWs provide sludge to a farmer who applies the sludge and manages the site.

To ensure that sludge application sites are selected and managed properly, permit writers should consider requiring a POTW either:

- To select and manage application sites itself, following the conditions set forth in the permit and the guidelines in the POTW's general land application plan (discussed in the next paragraph), EPA's Process Design Manual for Land Application of Municipal Sludge (EPA 1983), or State or local guidelines that the permit writer determines are appropriate; or

- To establish contracts with any parties who assume responsibility for site selection and site management. Contracts should specify how sites will be selected or managed (for example, by reference to the sources described just above). Contracts should also address issues such as when the sludge may be applied (for example, application by heavy vehicles when the soil is wet may damage soil structure), how much sludge can be applied and under what conditions sludge application can be terminated by one of the parties to the contract (EPA 1984). An example contract, drawn from the 1984 EPA Intra-Agency Sludge Task Force Report (EPA 1984) is presented in Figure 6-1.

A permit that does not require a POTW to select and manage land application sites itself, and that does not require the POTW to have contracts with other parties who select and manage land application sites, should be based on the recommendations for distribution and marketing of sludge in Chapter 7.

During the life of the permit, a POTW may apply sludge to many individual sites. Thus, at the time that it applies for a permit, the POTW may not be able to answer important questions such as: where will the sludge be applied; how does the site compare to a good set of evaluation criteria; what management practices should be employed? Permit writers should consider requiring POTWs to develop an approvable plan, similar to a Best Management Practices (BMP) plan, that sets guidelines for how sludge application sites will be selected and managed. These plans should not only address the recommended permit conditions in this Chapter, they should also address a number of other considerations such as those discussed in the Process Design Manual for Land Application of Municipal Sludge (EPA 1983)

Figure 6.1. EXAMPLE LAND APPLICATION PROGRAM CONTRACT

CONTRACT

THIS CONTRACT, made this ____ day of _____, 19____, by and between _____, hereinafter referred to as Owner, and _____, hereinafter referred to as City, witnesseth that,

WHEREAS, Owner is the owner of a parcel of agricultural real property located in (PARCEL NO), (TOWNSHIP), (COUNTY), Ohio, which can be reached as follows _____, and

WHEREAS, City operates a waste treatment or disposal plant which after processing produces a product known as sewage sludge, and

WHEREAS, Owner will allow sewage sludge from City to be placed on the above-mentioned real property only on the terms set out below,

NOW THEREFORE, Owner and City mutually agree as follows

1 The "Ohio Guide for Land Application of Sewage Sludge," Bulletin 598 of the Cooperative Extension Service of the Ohio State University, as revised in May, 1976, shall be used as a guideline for responsible management practices Hereinafter Bulletin 598 will be referred to as "The 1976 Guide "

2 The City will deliver sewage sludge to the above-mentioned property of Owner and will properly spread or otherwise deposit said sewage sludge on said property without charge to the Owner City shall be responsible for all equipment used to deliver and spread such sewage sludge

3 The Owner and the City will mutually agree on the specific portion of said property which is to receive sludge In the absence of unusual factors, they will abide by the site election criteria of the 1976 Guide

4 The Owner or his representative may decline to receive sludge on said property when, in Owners's or his representative's judgement, the sludge application equipment would damage the soil structure because of excessive soil moisture at the disposal site When possible, the Owner will give the City notice of poor field conditions 24 hours prior to the appointed application time However, the City does realize that this is not always possible and that there will be some days when untimely excessive rainfall will require termination of spreading activities at a moment's notice on a given field

5 The Owner will notify City in writing of the dates between which City may deliver and spread sewage sludge The City may deliver said sewage sludge only during the period thus described The Owner will make himself or his representative available to City or its employees during such period to ensure said sewage sludge is deposited on the proper location on said property

6 Owner shall specify the access to be used by the City when sewage sludge is applied to a specific portion of said property The Owner shall provide and maintain an access for use by the City without charge to the City, and the City shall not be liable for any damages thereto, except damage caused by City's negligence

7 Using the criteria of the 1976 guide, the Owner and the City have mutually agreed on the rates and amounts per acre said sewage sludge is to be applied during the Contract period For the term of this Contract, the City will adhere to mutually agreed upon application rates listed in Attachment A which is included as a part of this Contract

8 The City shall properly analyze its sewage sludge on a monthly basis for the total nitrogen, ammonia and nitrate nitrogen, phosphate, potassium, lead, zinc, nickel, copper, and cadmium content. The results of such analysis will be provided to the Owner or his representative upon request without charge before sludge is applied to said property

9. City shall keep and maintain records of the following items, and shall make such records available to Owner or his representative upon request·

(a) All analyses of the composition of sewage sludge produced by the City.
(b) All reports concerning the operation or production of sewage sludge by the City
(c) All applications to agricultural land of sewage sludge produced by City including dates of application, amounts applied, specified rates of application, specific parcels of land upon which sewage sludge has been applied.
(d) All required governmental permits or approvals for the application of sewage sludge on agricultural land.

10. City will deliver and apply sludge which is well stabilized and which does not present a severe odor nuisance to Owner or other rural residents who live in the vicinity of the sludge disposal site The Owner may refuse to accept any sludge which is exceptionally odorous.

11. The Contract shall continue in effect for a period of three years following the date first above written. The Parties hereto may renew this Contract in writing Either party may cancel this Contract by giving written notice to the other party of the intention to do so. Cancellation will be effective five days after receipt of such notice. Such notices shall be delivered personally or by certified mail to the address(es) listed at the end of this Contract.

OWNER

_____

_____

Address· _____

_____

_____

_____

CITY

_____

By _____

Title _____

By _____

Title _____

Address. _____

_____

Source: EPA 1984(MODIFIED)

that are not listed in this Section as recommended permit conditions. In general, these considerations are very site-specific in nature and are not easily summarized as a permit condition. For example, site soil texture and parent geologic material should be evaluated because these factors influence permeability, infiltration and drainage. However, while highly permeable soil (e.g., sand) and highly impermeable soil (e.g., clay) may present design and operational problems, sludge can be successfully applied to virtually any soil (EPA 1983).

Permit writers should require the POTW to develop the plan within a reasonable period of time (e.g., four months) and submit it to the permit writer for approval. Permit writers should compare the plan to this guidance, the Process Design Manual and any State or local guidelines. If necessary, the permit writer should request that the POTW make changes to the plan to ensure that sludge application sites are selected and managed properly. In Regions that have separate permits and construction grants sludge coordinators, the construction grants coordinator may be able to provide assistance in reviewing land application plans.

A land application plan may not be needed if: 1) the POTW provides with its application a list of the sites it will use during the life of the permit, 2) demonstrates that the sites are appropriate, and 3) specifies the management practices that it (or a contractor) will follow. Also, a plan may not be needed if a State or local agency evaluates land application sites using criteria that the permit writer determines will adequately protect public health and the environment, and has an effective program for monitoring compliance with appropriate site management practices.

Permit writers should require POTWs to keep records identifying the location and owner of each application site, who applied the sludge, and what use is made of the site. For example, if a site is used for agriculture, are fruits and vegetables grown, other types of food-chain crops, or non-food chain crops only (e.g., turf or ornamental plants)? With each subsequent permit application, permit writers should require POTWs to submit a site-by-site summary of cumulative loadings of heavy metals limited in the permit. Also, unless records are available from a State or local agency showing site suitability, the POTW should keep records that show, for each site, what evaluation criteria were used to select the site, how the site compared to the criteria, and any site management practices that were determined to be necessary.

When drafting permit conditions for land application, the permit writer should first ensure that existing Federaland State requirements will be met. Next, the permit writer should consider whether further conditions may be appropriate to protect public health and the environment. Then, within this framework, he or she should encourage beneficial use/recycling (the ultimate selection

of sludge use/disposal practices is up to the municipality). In many cases using sludge provides environmental benefits, particularly when compared to current practices or site conditions. For example, if the sludge contains high levels of heavy metals, which may result in loadings of metals that exceed the recommendations for agriculture, it may be appropriate to use it if it will clearly improve the quality of ground-water or surface water run-off at a site that has been strip-mined and is now barren (particularly if the site is clearly not suitable for agriculture, or the POTW can assure that the site will not be used for food-chain crops during the life of the permit and the metals guidance would only be exceeded by a small amount).

Section 6.2.2 addresses the specific requirements and guidance concerning sludge quality and Section 6.2.3 addresses the specific requirements and guidance concerning operation conditions and management practices. Each topic discussion addresses applicable Federal regulations, Federal guidance, and State regulations. Appendix E presents additional information on State management practices. Table E6-5 summarizes State management practices for land application. Additional land application management practices specified by only one or two States are presented in Table E6-6. State requirements for site-specific considerations are summarized in Table E6-3. State prohibitions for land application are presented in Table E6-7. Land reclamation management practices are summarized in Table E6-8. Ohio, Arizona and Washington reported management practices for forest application (see Table E6-9). Texas reported management practices for land treatment (i.e. dedicated lands) (see Table E6-10).

6.2.2 CHARACTERISTICS OF SLUDGES SUITABLE FOR LAND APPLICATION

Sludge Pollutant Concentration Limits

Federal Regulations

Pathogens

Permits must state that sludge applied to land will be treated by a pathogen reduction process that meets the requirements of 40 CFR Part 257 (See Table 6-1). Briefly, pathogen reduction is required whether or not food-chain crops (as defined in 40 CFR Part 257) are grown. Among other conditions, if public access to the sludge application site is controlled for twelve months, the sludge must only be treated by a "Process to Significantly Reduce Pathogens" (PSRP) (e.g., anaerobic digestion, air drying for three months, composting which includes a minimum 4-hour period during which the temperature exceeds 55 degrees Centigrade, and lime stabilization). If the

TABLE 6-1

40 CFR PART 257 PATHOGEN REDUCTION REQUIREMENTS FOR LAND APPLICATION AND DISTRIBUTION AND MARKETING OF SLUDGES

- Sewage sludge or septic tank pumpings that are applied to the land surface or incorporated into the soil must be treated by a Process to Significantly Reduce Pathogens (PSRP) These process include
  - *aerobic digestion* at residence times ranging from 60 days at 15°C to 40 days at 20°C with a volatile solids reduction of at least 38%,
  - *air drying* on underdrained sand beds or paved or unpaved basins in which the sludge is at a depth of nine inches for at least three months The average daily temperature must exceed 0°C for two of these months;
  - *anaerobic digestion* at residence times ranging from 60 days at 20°C to 15 days at 35-55°C with a volatile solids reduction of at least 38%,
  - *composting* at a minimum operating temperature of 40°C for five days. For four hours during this period the temperature must exceed 55°C, and
  - *lime stabilization* in which sufficient lime is added to produce a pH of 12 after two hours of contact. Other processes may be acceptable if pathogens and volatile solids are reduced to an equivalent level
- When sludge is treated by a PSRP, public access to the site must be restricted for at least twelve months and grazing by animals whose products are consumed by humans must be prevented for at least one month.
- If crops for direct human consumption are grown within 18 months after sludge or septic tank pumpings are applied to a site and the edible portion of the crop will contact the waste, the sludge or pumpings must be treated by a Process to Further Reduce Pathogens (PFRP) PFRPs include·
  - *composting* at a temperature of at least 55°C for three days if the in-vessel or static aerated pile methods are used Using the windrow method, a temperature of at least 55°C must be maintained for 15 days and the pile must be turned five times during this high temperature period;
  - *heat drying* dewatered sludge cake until the moisture content is reduced to no more than 10%. Sludge particles must be heated to at least 80°C or the wet bulb temperature of the gas stream in contact with the sludge must exceed 80°C at the point where it leaves the dryer;
  - *heat treating* liquid sludge to temperatures of 180°C for 30 minutes;

(Continued)

TABLE 6-1 (Continued)

- *thermophilic aerobic digestion* at residence times of ten days at 55-60°C with a volatile solids reduction of at least 38%, and
- *a PSRP followed by* either *beta or gamma ray irradiation* at a dosage of at least 1 0 megarad at room temperature (ca. 20°C) or pasteurization for at least 30 minutes at a minimum temperature of 70°C Other processes may be acceptable if pathogens and volatile solids are reduced to an equivalent level

- The Waste Water Solids Criteria Branch of the Office of Water Regulations and Standards leads a Pathogen Equivalency Committee which evaluates and makes recommendations on the equivalency of proposed sludge treatment processes to the processes identified in 40 CFR Part 257 The Committee also provides technical assistance to persons preparing proposals for Committee review. For further guidance please consult "Environmental Regulations and Technology Control of Pathogens in Municipal Wastewater Sludge " (EPA September 1989)

public will have access to the site within a year of sludge application, or if the edible portion of a crop that is grown for human consumption within eighteen months of application will contact the sludge (e.g., root crops such as beets and potatoes or low-growing crops such as bush beans and strawberries), a "Process to Further Reduce Pathogens" (PFRP) is required (e.g., heat drying or composting which includes a period during which temperature exceeds 55°C for at least three days). 40 CFR Part 257 also states that a practice shall not occur unless disease vectors are minimized through the periodic application of cover material "or other techniques as appropriate so as to protect public health." Treatment of sewage sludge or septic tank pumpings by one of the pathogen reduction processes described above (which substantially reduce the vector attraction of sludge) should satisfy this requirement.

Polychorinated Biphenyls (PCBs)

Sludge containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight), but less than 50 mg/kg, must be incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation of the sludge into the soil is not required if it is assured that the PCB content is less than 0.2 mg/kg (actual weight) in animal feed or less than 1.5 mg/kg (fat basis) in milk (40 CFR Part 257).

Sludges containing greater than 50 mg/kg of PCBs must be treated under the requirements of 40 CFR Part 761.60 which allow only incineration, disposal in a chemical waste landfill, or alternate disposal method if approved by the Regional Administrator.

Other than the pathogen and PCB restrictions discussed above and a cadmium limit for food-chain crops discussed further in the chapter, there are no Federalregulations on contaminant levels in sewage sludge.

State Requirements

Multi-Grade Pollutant Concentration Limits

At least six States define and regulate more than one grade of sludge. States with multiple sludge grades define those grades according to contaminant levels. In Massachusetts, sludge grading depends on contaminant levels, stabilization, and content of putrescible materials. Allowable uses are specified for each grade along with the degree of State review required. New Jersey's grades are based on metal concentration and the length of time a given concentration could be applied at

agricultural rates before reaching cumulative loading limits. Colorado sets numerical limits for each grade and specifies the types of use allowed for each grade. The contaminants and the multiple grades of sludge quality regulated by these States are shown in Table E6-1.

Generally, the States allow certain uses such as land application only for better quality sludge, Grades 1 and 2 in most cases. New Jersey, taking a resource-use approach, prohibits landfilling of high-quality sludge. Allowed uses, application rates, and safeguards all may vary with sludge quality. Grade 3 & 4 sludge cannot be used on food-chain crops, but usually is allowed for land reclamation or other uses.

No States have specific contaminant limits for silviculture or dedicated lands. Some States allow higher concentrations for land reclamation. See Table E6-2 for State sludge concentration limits for use in land reclamation.

Pathogens

In addition to the contaminant concentration limitations listed in Table E6-1, thirty-four States have regulations or guidelines addressing pathogen control. Twenty-one of these States have requirements similar to the current Federalregulations. Eleven States did not detail their requirements other than to acknowledge that pathogen control is required. Note that only the listed processes in 40 CFR Part 257 Appendix II are acceptable methods of pathogen control to meet PSRP and PFRP standards.

Physical Properties

The improvement of the characteristics of the sludge facilitates ultimate use or disposal. For land application, the degree of sludge stabilization is a very important characteristic. Stabilization refers to a number of processes that reduce the potential for odor. Stabilization processes also reduce pathogen levels and usually help to reduce the volatile solids content. The most common methods of stabilization include anaerobic digestion, aerobic digestion, lime stabilization, and composting. Anaerobic digestion is the most common method of sludge stabilization and generally biodegrades about 50 percent of the volatile solids in a sludge. Because much of the organic matter has already been eliminated, stabilized sludges tend not to cause odor problems. Low odor potential is desirable and is sometimes required by States for land application.

Another sludge characteristic of importance for land application is water content. Sludge water content affects the design of a land application program because:

- The higher the sludge solids content, the lower the volume of sludge that will have to be transported, stored, etc., because less water must be handled.

- The type of transport that can be utilized, e.g., type of truck, feasibility of pipeline transport, etc. depends in part on sludge water content.

- The removal of water reduces the nitrogen content because much of the nitrogen appears as ammonia (NH_3+) and exists in the aqueous phase.

- The method of sludge application and sludge application equipment needed (e.g., type of sludge application vehicle, need for incorporating the sludge into the soil, etc.), and the methods available to transfer and store sludge depend in part on sludge water content.

Treatment processes such as thickening, conditioning, dewatering, composting, and drying can lower sludge water content and raise the percent solids.

Federal Regulations

There are no specific Federalregulations for sludge dewatering. The requirements for pathogen control discussed previously dictate the degree of stabilization that is required.

State Requirements

Thirty one States require sludge stabilization prior to land application (see Table E6-5). Sixteen States currently have regulations addressing sludge dewatering requirements for sludge that is to be land applied. Alaska and Colorado have established minimum solids content percentages. These are 10 and 16 percent, respectively.

Land Application of Sludges Containing Radionuclides

Case-by-Case Recommendations

In some areas of the country radionuclides in wastewater sludges has become an issue. Where there is a significant level of radioactivity in POTW sludges, some simple requirements applied to POTW wastes can reduce potential risks to public health and the environment.

Any POTW that has a hospital or industry discharging wastes which contain radionuclides to its system or is located in an area of the country that has naturally occurring radionuclides in drinking or industrial source waters can expect to find radionuclides concentrating in wastewater sludges. Fortunately most of the radionuclides used in hospitals have a short half-life, but this is not the case with many naturally occurring radionuclides found in drinking water. The naturally occurring radionuclides of concern are typically radium, uranium and radon. The half-life of some radionuclides that have been identified in POTW sludges are shown in Table 6-2.

Because the sludges containing radionuclides are of concern in both landfilling and land application, background soil information helps put the issues into perspective. The nationwide average concentration of naturally occurring radionuclides radium-226, thorium-232 and uranium-238 in soils are each about 1 pCi/g soil and virtually all State averages are less than 1.5 pCi/g soil (EPA 1989b). Because the half-life of radium-226 is 1,620 years and the half life of thorium and uranium isotopes are tens of thousands to billions of years, one cannot dismiss the importance of these radionuclides where they are found in POTW sludges.

One way to obtain information regarding naturally occurring radionuclides is to check with the States' water supply staff or obtain local community water supply information. If the water supply has significantly less than the 5 pCi/L which is the maximum contaminant level (MCL) for radium (combined), then the permit may not need to address the contaminant. If, on the other hand, the radium level in water is a significant percentage of the MCL, then the permit writer should consider putting specific conditions in the permit. Another consideration is the concentration of radionuclides received by the POTW from medical or industrial wastes which may also necessitate specific permit conditions. For land application of sewage sludge containing radionuclides it is recommended that the soil concentration of a particular radionuclide not be increased to a significant amount above the background level of that radionuclide in the soil. A sample calculation using radium has been provided in Table 6-3.

TABLE 6-2

HALF-LIFE OF RADIONUCLIDES
IDENTIFIED IN POTW SLUDGES

Isotope	Source	Half-Life
^{241}Am	Smoke Alarm Manufacturers	432 y
^{131}I	Nuclear Medicine	8 04 d
^{51}Cr	Nuclear Medicine	27 8 d
^{75}Se	Nuclear Medicine	120 d
^{99m}Tc	Nuclear Medicine	6 02 h
^{137}Cs	Nuclear Fallout	
^{226}Ra	Natural	1620 y
^{228}Ra	Natural	6 7 y
^{238}U	Natural	$4\ 5 \times 10^{9}$ y

SOURCE: EPA 1988b

TABLE 6-3

SAMPLE CALCULATION
FOR SLUDGES THAT CONTAIN RADIUM

1	^{226}Ra and ^{228}Ra Concentration	
	Average Sludge Concentration	12 pCi/g
2	Sludge Application.	
	Typical Example Sludge Application Rate (Nitrogen limited)	30,000 gal/acre
	Typical Example % Solids	4.0%
	Application Method	incorporation, 1 ft
3.	Yearly Application Rate of Radium:	
	= Application Rate × % Solids × Sludge Ra Concentration	
	= (30,000 gal/acre) × (1 ft^3/7.48 gal) × 62.4 lb/1 ft^3) × (1 kg/2.2 lb) × (1000 g/1 kg) × (0.04) × (12 pCi/g)	
	= 5.4 × 10^7 pCi/yr	
4	Weight of Soil:	
	1 acre-ft of soil weighs 1.639 X 10^9 g	
5	Maximum Increase Allowed in Soil:	
	The maximum concentration of radionuclides allowed in the soil should be decided on a case-by-case basis. Limits are set either as a maximum concentration or as a maximum increase. Guidance exists in Wisconsin, Illinois, and EPA Office of Drinking Water. For purposes of this example only, the maximum increase allowed shall be set at 0.1 pCi/g soil	
6.	Annual Increase to Soil Radium:	
	= Radium Yearly Application Rate / Weight of Soil	
	= (5.4 × 10^7 pCi/yr) / (1.639 × 10^9 g)	
	= 0.033 pCi/g/yr increase	
7	Number of Years Sludge Can be Applied at Rate:	
	= Max. increase of RA allowed in soil / Annual increase to Soil Ra	
	= (0.1 pCi/g) / (0.033 pCi/g/yr)	
	= 3.0 years	

EPA's Office of Drinking Water has developed draft guidance (September 1980) which is directed towards the land application of drinking water sludges. Although this information was not developed for wastewater sludge disposal or use, it may be useful in some instances. Permit writers identifying a problem with radionuclides may want to consult this guidance.

State Requirements

Two States, Illinois and Wisconsin, have specific requirements for sewage sludges containing radium. These requirements have been included in Table E7-11.

6.2.3 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

This section addresses the operation conditions and management practices that are required and recommended of those facilities that land apply their sludge. The conditions and practices are categorized into the following eight groups: floodplains, surface water protection, ground-water protection, endangered species protection, safety/access control, sludge application method and storage.

Floodplains

Federal Regulations

Federalregulations (40 CFR Part 257.3-1) allow the location of land application sites in a floodplain. However, these sites must not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources. The base flood is defined as the 100-year flood.

40 Part 257 requires that facilities or practices within the 100 year floodplain not "result in washout of solid waste, so as to pose a hazard" to public health and the environment. EPA has determined that this requirement should be satisfied if sludge applied to lands within the 100 year floodplain is incorporated into the soil and vegetation is grown promptly (EPA 1980).

State Requirements

Twenty-seven States have regulations addressing land application of sludge in floodplains (see Table E6-3). Nine States restrict application within the 100-year floodplain. Three of those States indicate that application within the 100-year floodplain may be allowed if protective measures such as diversion dikes are constructed. Eight States use the 10-year floodplain as the boundary within which land application is prohibited. Two States allow application within the 10-year floodplain if the sludge is injected or incorporated.

Surface Water Protection

Federal Regulations

Federalregulations do not specifically address run-off controls for surface water protection. However, 40 CFR Part 257.3-3 does state that a facility or practice shall not cause non-point source pollution of waters of the United States that violate applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

Federal Guidance

The EPA Technology Transfer publication Use and Disposal of Municipal Wastewater Sludge (EPA 1984) recommends the use of good soil conservation practices and discourages application to saturated, snow-covered, or frozen ground.

State Requirements

Thirty States have regulations or guidelines for run-off control (see Table E6-3). The types of control measures include a minimum vegetative cover requirement or a requirement that the sludge be incorporated, avoidance of application during rain or when soil moisture is high, limitation of the quantity of sludge applied, and good soil conservation practices.

Two States relate run-off controls to particular storm events. Arizona references the 25-year, 24-hour storm and Texas references the 10-year, 1-hour storm.

Thirty-three States reported minimum allowable distances to surface waters (see Table E6-3). The reported minimum setbacks from surface waters range from 25 to 3,000 feet and vary with the type of surface water body and its use. For surface water bodies used for water supply, the required setback is typically greater than 300 feet.

Case-by-Case Recommendations

Each facility should be designed to handle a defined storm event so as to minimize stormwater run-off related problems. The permit writer should determine the design storm for a particular State. If there is no State designated design storm, the 25-year, 24-hour storm is recommended.

Ground-Water Protection

Federal Regulations

Federal Regulations (40 CFR part 257.3-4) require that land application facilities or practices not contaminate an underground drinking water source or potential underground drinking water source (any aquifer with less than 10,000 mg/l dissolved solids) beyond the outermost perimeter of the solid waste boundary (projected in the horizontal plane) as it would exist at the end of disposal activity. States may establish an alternate boundary if such a change would not contaminate drinking water resources. Contamination of an underground drinking water source is defined in 40 CFR Part 257 as introducing a substance that would cause the maximum contaminant concentration level specified in Appendix I of 40 CFR Part 257 to be exceeded, or that would cause an increase in concentration of a contaminant that already exceeds the limit listed in Appendix I of 40 CFR Part 257. 40 CFR Part 257 is presented in Appendix D of this document.

State Requirements

Thirty-three States have rules addressing groundwater monitoring (see Table E6-4). Twenty of these States indicate groundwater monitoring may be required in some cases. The criteria under which monitoring would be required are generally not specified. However, some examples include high seasonal groundwater levels, repeated applications at a single site, and application rates in excess of the rate based on nitrogen uptake by crops. Thirteen States require groundwater monitoring. Parameters measured include depth to water table, nitrates, metals, organics, pH, and fecal coliform levels. Minnesota requires semiannual analyses.

Thirty-four States reported minimum allowable distances to wells (see Table E6-3). The distance required varies with the use of the well. Land application sites must generally be 500 feet or more from public water supply wells. The required setback from private water supply wells ranges from 100 to 500 feet.

Thirty-five States reported minimum allowable depths to groundwater (see Table E6-3). The minimum depths range typically from 1 to 10 feet, although Arizona requires that the mean annual groundwater elevation be at least 40 feet below the surface. The lower end of the range in several cases refers to the seasonal high water level. Illinois specifies a minimum depth of 10 feet for the application of liquid sludge and 5 feet for the application of solid sludge and notes that permeability is also a factor, and Texas allows a decrease in required depth from 4 to 3 feet if the soil has "slow permeability."

Nine States reported minimum allowable depths to bedrock (see Table E6-3). The allowable depths range from 20 inches to six feet.

Endangered Species

Federal Regulations

Land application facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. In addition, the facilities or practices must not result in the destruction or adverse modification of the critical habitat of a Federally-listed endangered or threatened species (40 CFR Part 257.3-2).

State Requirements

No States were identified as having specific regulations or guidelines addressing endangered species.

Safety/Access Control

Federal Regulations

Owners and operators of land application sites are required by 40 CFR Part 257.3-8 to limit exposure of the public to any potential health and safety hazards. For sites where sludge has been

treated by a process to significantly reduce pathogens, public access must be controlled for at least 12 months after sludge application, and grazing by animals whose products are consumed by humans must be prevented for at least one month (40 CFR Part 257.3-6).

If crops for direct human consumption are to be grown within 18 months subsequent to sludge application or incorporation, the sludge must be treated with a process to further reduce pathogens (PFRP). These processes are listed in 40 CFR Part 257 Appendix II and Section 2.0 of this document. If the sludge will not contact the edible portions of the crop, pathogen reduction to PSRP levels is acceptable (40 CFR Part 257). 40 CFR Part 257.3-8 requires that a facility or practice within 10,000 feet and 5,000 feet of airport runways for turbojet and piston-type aircraft, respectively, shall not pose a bird hazard to aircraft.

Federal Guidance

The extent of access control needed to limit exposure to a land application site should be based on these site-specific considerations: 1) the degree to which the sludge has been treated to reduce pathogens, (2) the procedures used to apply and incorporate the sludge into the soil, (3) the remoteness of the sludge application site from public use areas, and (4) the ownership of the site area, whether private or public. In general, if there is potential for exposure of the public to health or safety hazards, some sort of positive access control must be implemented, the exact means dependent on those considerations listed above (EPA 1983).

State Requirements

Thirty-five States have requirements for access control and/or grazing restrictions (see Table E6-5). The most common practice is the same as the Federalrequirement to control public access for at least 12 months after sludge application. Twenty-one States have buffer zone requirements (see Table E6-3). Six States reported minimum allowable distances to roads, ranging from 15 to 300 feet. Twelve States reported minimum allowable distances to property lines, ranging from 25 to 500 feet. The required distance is typically less for subsurface sludge application than for sludges applied to the surface. The most frequently cited setback from property lines was 50 feet.

The setbacks that States require from dwellings varies with the type of application and the density or perceived sensitivity of nearby developments. The most commonly recommended setbacks range from 250 to 500 feet. If the sludge is injected or incorporated, the required setback is typically between 50 and 250 feet. Setback requirements are generally greater near schools,

institutions, recreational areas, or residential subdivisions. These setbacks range from 600 to 1,000 feet.

Air Quality Control

State Requirements

Only three States have regulations or guidelines addressing maintenance of air quality and odor control. Rhode Island, Washington, and Wisconsin reported rules requiring odor controls, but methods for odor control were not specified.

Soil Characteristics

Soil characteristics can have a direct affect on both surface and ground-water. Soil characteristics of concern for a land application site include soil permeability, soil pH, and soil cation exchange capacity. Soil cation exchange capacity is an indirect measure of the soil's ability to capture positive ions, the form in which most metals are found in the soil. High soil pH immobilizes most metals and reduces their absorption by plants. However, it has not been demonstrated that pH control is necessary on forested sites where soils are naturally acid (EPA, 1986a). Permeability refers to the ease with which water is transmitted through soil. Soils with very low permeability are poor candidates for land application due to ponding, potential for run-off problems, and subsequent limitations in allowable loading rate. Soils with very high permeability are also ill-suited to land application where leaching to the groundwater aquifers is a concern.

Federal Regulations

The only Federal regulation with regard to soil characteristics is the allowance of cumulative cadmium application rates over 5 kg/ha on food-chain croplands in cases where the background soil pH is greater than 6.5 and the soil cation exchange capacity is 5 meq/100 g or greater. If the background soil pH is less than 6.5, the maximum allowable cumulative cadmium application rate can still be greater than 5 kg/ha provided that the pH of the soil and sludge mixture is adjusted and maintained at 6.5 or greater, or if the only food-chain crop produced is used solely for animal feed and other requirements are met (See Appendix D).

Federal Guidance

The Process Design Manual for Land Application (EPA 1983) contains the following guidelines for the permeability of the most restricting soil layer above a 1-meter depth and its associated degree of limitation for agricultural sludge application:

Permeability	Degree of Limitation
<0.08	Severe
0.08 - 0.24	Moderate
0.24 - 0.8	Slight
0.8 - 2.4	Moderate
>2.4	Severe

Soil permiability characteristics alone do not limit sludge utilization feasibility. This is important in combination with other site conditions including slope, depth to groundwater, and rainfall patterns.

State Requirements

Only four States have specific numerical criteria for soil permeability (see Table E6-3). Minnesota does not allow land application at sites where the permeability is less than 0.2 inches/hr (0.5 cm/hr) or greater than 6 inches/hr (15 cm/hr) throughout the top five feet of soil. Kentucky does not allow land application where the permeability is less than 0.2 inches/hr (0.5 cm/hr) or greater than 20 inches/hr (51 cm/hr). Vermont and Wisconsin do not allow land application where the soil permeability is greater than 6 inches/hr (15 cm/hr). Several States have requirements for a minimum depth of permeable soil or the texture of the soils present at the site. In general, these States require 2 feet of permeable soil. Texture requirements range from sandy loam to silty clay.

Twenty-five States have pH regulations (see Table E6-5). The most common requirement is that the pH of the soil or sludge/soil mixture be at least 6.5. Four States specify that the pH must be maintained at 6.5 or greater for a period of time after application (typically two years).

Topography

Topography influences surface and subsurface water movement, which in turn affect the soil erosion and potential run-off of applied sludge. Topography can indicate the kinds of soil to be

found on a site. Soils on ridge tops and steep slopes are typically well drained, well aerated, and usually shallow. Steep slopes increase the possibility of surface run-off of sludge unless very permeable soils are present. Soils on broad flat lands frequently are poorly drained, and may be waterlogged during part of the year. The soils between these two extremes will usually have intermediate properties with respect to drainage and run-off.

Federal Guidance

To protect surface waters, permit writers should require that the recommended slope limitations in EPA's Land Application Manual, or similarly protective State or local guidelines, be followed. Table 6-4 presents those recommendations.

State Requirements

A review of State regulations indicates the same general slope limitations as presented in Table 6-4 (see Table E6-3). Thirty-six States have regulations/guidelines regarding the slopes allowable for sludge application sites. The typical requirement is a maximum allowable slope ranging from 5 to 15 percent. The maximum allowable slope typically is higher if the sludge is incorporated into the soil or if "solid" or "cake" sludge is used rather than liquid sludge.

Sludge Application Methods and Seasonal Restrictions

State Requirements

A few States have specific provisions for sludge application methods. Michigan requires sound agricultural practices (e.g. avoid soil compaction). New Jersey requires uniform applications for land application. South Dakota specifies that the sludge application vehicles should have deflection plates. West Virginia requires the equipment to have high flotation tires for land application.

Twenty-one States have requirements addressing incorporation of the applied sludge (see Table E6-5). Four States specify incorporation if the PCB content of the sludge is greater than 10 ppm. Five States require incorporation within 48 hours. Oklahoma requires incorporation at the time of application.

TABLE 6-4
RECOMMENDED SLOPE LIMITATIONS FOR LAND APPLICATION SLUDGE

Slope	Comment
0-3%	Ideal; no concern for run-off or erosion of liquid sludge or dewatered sludge
3-6%	Acceptable; slight risk of erosion; surface application of liquid sludge or dewatered sludge okay.
6-12%	Injection of liquid sludge required for general cases, except it closed drainage basin and/or extensive run-off control. Surface application of dewatered sludge is usually acceptable
12-15%	No liquid sludge application without effective run-off control; surface application of dewatered sludge acceptable, but immediate incorporation recommended
>15%	Slopes greater than 15% are only suitable for sites with good permeability where the slope length is short and is a minor part of the total application area.

Source: EPA 1983

Twenty-eight States have seasonal limits on land application of sludge (see Table E6-5). In general, these regulations prohibit application during rainfall, on saturated ground, or on ice/snow-covered ground. Application to frozen or snow-covered ground is allowed in some States at sites meeting certain slope restrictions. These restrictions usually require slopes less than 2 to 6 percent.

Case-by-Case Recommendations

Sludge should not be applied during periods of inclement weather. In some States, sludge should not be applied to soils that are frozen or covered with snow (see Table E6-5). Soil moisture is a major consideration which impacts the timing of sludge application. Traffic on wet soils during or immediately following heavy rainfalls may result in compaction and, in the case of agriculture, reduced crop yields. Muddy soils also make vehicle operation difficult. Application to frozen or snow-covered ground with greater than 3 percent slope may result in excessive run-off into adjacent streams.

Storage

Storage facilities are needed to hold sludge during periods of inclement weather, equipment breakdown, frozen or snow-covered ground, or when access would damage the field or crop.

Federal Guidance

The volume of storage required may range from the equivalent of 15 days production in climates where weather rarely prevents sludge application to 160 days in cold, damp climates where sludge application may be impossible over much of the year (EPA 1984). A very conservative design for storage capacity is for 1 year's production (EPA 1983).

State Requirements

Three States have regulations regarding sludge storage needs. Indiana and Missouri require a minimum 90-day and 30-day storage capacity respectively. Michigan limits field storage to less than 7-days unless the sludge is covered and a seepage barrier provided.

6.2.4 MONITORING, REPORTING, AND RECORD KEEPING

This section discusses compliance and environmental monitoring requirements, reporting and recordkeeping for land application sites. Elements of the land application system that may require monitoring through the life of the project include the quality of the applied sludge, the soil, the crop, groundwater, and surface water.

Sludge Monitoring

Federal Regulations

The current regulations require sludge monitoring and reporting at a frequency dependent upon the nature and effect of the permittee's sludge use or disposal activities, but at least once a year for every pollutant limited in the permit. This means that if the permit contains a limit for PCB's for example, the permittee must monitor its sludge at least annually for this pollutant. (40 CFR Part 122.44(c)(2)). Also a minimum of annual monitoring is obviously necessary to demonstrate compliance with the 40 CFR Part 257 contaminant regulations for cadmium, PCBs, and pathogens.

Federal Guidance

Regular sludge quality analyses are necessary to ensure that unacceptable quantities of sludge constituents are not applied to the site. The frequency of sludge sampling will be a function of:

- System size - A larger system should sample more frequently.

- Historical variations in sludge characteristics - The greater the variability that has been found in sludge physical and/or chemical characteristics, the more often the sludge should be analyzed. Where no historical data exist, monitoring should be more frequent to build a database.

- Land application option being used - Dedicated land disposal sites may require the same frequency of monitoring as landfills. Land reclamation, forest application, and agricultural application sites generally require intermittent monitoring (EPA 1983). The quality of sludges applied to food-chain croplands should be frequently monitored.

- The industries discharging to the POTW.

- Problems and/or compliance history of the POTW.

Sludge should be analyzed periodically for pH, percent solids, nitrogen, phosphorus, potassium, heavy metals, and any other contaminants listed in the facility permit. If the system used is

sensitive to pathogens and/or priority organics, these parameters should also be measured (EPA 1983).

The Sewage Sludge Interim Strategyrecommends annual monitoring of the 126 priority pollutants as well as more frequent monitoring of the pollutants for which numeric limits have been proposed in the 40 CFR Part 503 Technical Sludge Standards. For the disposal practice of land application these pollutants include:

Aldrin/dieldrin	Lead
Benzo (a) pyrene	Lindane
Cadmium	Mercury
Chlordane	Nickel
Copper	Polychlorinated biphenyls
DDT/DDE/DDD (total)	Selenium
Heptachlorobenzene	Toxaphene
Hexachlorobutadiene	Zinc

State Requirements

Thirty-six States have regulations addressing sludge monitoring. These regulations are summarized in Table E6-4 (summary of State monitoring and reporting requirements). The parameters typically monitored include:

- Percent solids
- pH
- Nutrients - nitrogen, phosphorus, potassium
- Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc
- PCBs.

Other parameters monitored by some States are conductivity, benzene, and EP toxicity. The frequency of sludge sampling is often related to the size of the treatment facility. In Kentucky, for example, facilities less than 1 mgd in size are only required to sample annually. Facilities between 1 and 2 mgd must sample semi-annually. Facilities between 2 and 10 mgd are required to sample

[1]DDT-2,2-Bis(chlorophenyl)-1,1,1-trichloroethane
DDE-1,1-Bis(chlorophenyl)-2,2-dichloroethene
DDD-1,1-Bis(chlorophenyl)-2,2-dichloroethane

quarterly. Facilities greater than 10 mgd are required to sample monthly. Three States require sampling and analysis prior to each application of sludge. The testing and monitoring program for sludges applied to land as part of Madison, Wisconsin's METROGRO operation and Salem, Oregon's BIOGRO operation are summarized in Table 6-5. In both of these programs, digested sludge is applied to privately-owned farmland.

Case-by-Case Recommendations

If a particular pollutant, such as radionuclides, is a concern, consideration should be given to more frequent monitoring of the sludge for that pollutant. Sludges applied to lands used for producing food-chain crops should be monitored more frequently than is generally recommended in other land application processes. The pH of the sludge-soil mixture should be measured each time sludge is applied to food-chain croplands and whenever food-chain crops are grown. Once, during the first year of the permit, the soil cation exchange capacity of food-chain croplands where sludge is applied should be measured.

Soil Monitoring

Federal Regulations

There are no Federalregulations addressing soil monitoring at land application sites.

Federal Guidance

The need for soil monitoring depends on the site characteristics and the particular land application option being used. In general, monitoring requirements for dedicated land disposal sites are more extensive than for other land application options.

The major parameters of concern for agricultural land application are pH maintenance at 6.5 standard units or greater to reduce potential metal migration; cation exchange capacity (CEC), and soil nitrogen, phosphorus and potassium if optimum crop yields are a project goal. If sludge is applied at or below agronomic rates, EPA recommends analyses of the soil for pH every year sludge is applied and for cation exchange capacity once during the life of the permit and every 2 years for other parameters (EPA 1983).

TABLE 6-5
SLUDGE MONITORING PROGRAMS FOR TWO
AGRICULTURAL LAND APPLICATIONS

Constituent Measured	Frequency	
	Madison, WI	Salem, OR
Total Solids	Daily	Monthly
Dissolved Solids	---	Quarterly
Conductivity	Monthly	---
Total Nitrogen	Daily	Monthly
Ammonia Nitrogen	Daily	Monthly
Total Phosphorus	Bi-monthly	Monthly
Total Potassium	Bi-monthly	Monthly
pH	Bi-monthly	Quarterly
Total Sulfur	Semiannual	---
PCB	Bi-monthly	---
Aluminum	Semiannual	---
Arsenic	Bi-monthly	Quarterly
Boron	Semiannual	Quarterly
Cadmium	Bi-monthly	Monthly
Calcium	Semiannual	---
Copper	Bi-monthly	Monthly
Cobalt	Semiannual	---
Chromium	Bi-monthly	Quarterly
Iron	Semiannual	Quarterly
Lead	Bi-monthly	Quarterly
Lithium	Semiannual	---
Manganese	Semiannual	Quarterly
Magnesium	Semiannual	Quarterly
Mercury	Bi-monthly	Quarterly
Molybdenum	Bi-monthly	Quarterly
Nickel	Bi-monthly	Monthly
Selenium	Bi-monthly	Quarterly
Strontium	Semiannual	---
Zinc	Bi-monthly	Monthly
Priority Pollutant Scan	Annual	Monthly
Aldrin/Dieldrin	Bi-monthly	---
Benzene	Bi-monthly	---
Benzidine	Bi-monthly	---
Benzo(a)pyrene	Bi-monthly	---
Benzo(a)anthrecene	Bi-monthly	---
Bis(2-ethylhexyl)pthalate	Bi-monthly	---
Carbon Tetrachloride	Bi-monthly	---
Chlordate	Bi-monthly	---
Chloroform	Bi-monthly	---
Cyanide	Bi-monthly	---
3,3-Dichlorobenzidine	Bi-monthly	---
Dichloromethane	Bi-monthly	---
2,4-Dichlorophenoxy Acetic Acid	Bi-monthly	---

Constituent Measured	Frequency	
	Madison, WI	Salem, OR
Dimethyl Nitrosamine	Bi-monthly	---
Endrin	Bi-monthly	---
Heptachlor	Bi-monthly	---
Hexachlorobenzene	Bi-monthly	---
Hexachlorobutadiene	Bi-monthly	---
Lindane	Bi-monthly	---
Malathion	Bi-monthly	---
Pentachlorophenol	Bi-monthly	---
Phenanthrene	Bi-monthly	---
Phenol	Bi-monthly	---
Tetrachloroethylene	Bi-monthly	---
Trichloroethylene	Bi-monthly	---
Toxaphene	Bi-monthly	---
2,4,6-Trichlorophenol	Bi-monthly	---
Vinyl Chloride	Bi-monthly	---
VSS Reduction	Bi-monthly	---
Fecal Coliform	Bi-monthly	---
Salmonella	Bi-monthly	---

Source: EPA 1983, METROGRO 1989

Soil constituents of interest in forest application systems include pH, metals, and nutrients. Forest soils are typically more acidic than agricultural sites; soil pH values of 5.5 and lower are common. Experience with sludge applications to forest soils in established forests indicates that the increased metals available due to lower soil pH do not cause phytotoxicity in most forest plant species. In addition, because forest products are not food chain crops, increased metal content of the plants themselves is not a concern for public health. For these reasons, lower pH limits can be allowed with forest application, if there is no danger of trace metal migration to useful aquifers (EPA 1983).

The Process Design Manual for Land Application of Municipal Sludge (EPA 1983) contains a suggested minimal monitoring program for land reclamation sites. Elements of this program for soils include:

- Collection of samples prior to sludge application. Samples of topsoil should be collected throughout the site and analyzed for buffer pH to determine lime requirements to raise the soil pH to 6.5 and to determine the CEC. Samples from the complete soil profile should be collected at depths from 0 to 6 inches, 6 to 12 inches, 12 to 24 inches, and 24 to 36 inches.

- Samples should be collected again one year following sludge application. These samples should be taken at depths of 0 to 6 inches, 6 to 12 inches, and 12 to 24 inches.

Samples collected prior to application and 1 year following application should be analyzed for pH, phosphorus, calcium, magnesium, potassium, sodium, iron, aluminum, manganese, copper, zinc, chromium, cobalt, lead, cadmium, nickel, and Kjeldahl nitrogen. At the end of the second year after sludge application, surface soil samples should be collected and analyzed for pH to determine if it is still at 6.5.

State Requirements

Twenty-three States have soil sampling/monitoring requirements for land application (see Table E6-4). Generally, the States require pre-application soil sampling and follow-up sampling after application. The frequency of follow-up sampling varies. Three States require annual monitoring. The parameters measured include pH, CEC, nutrients, metals, conductivity, PCBs, and organic matter content. Table 6-6 summarizes the soil analyses and sampling frequency for agricultural land application operations in Madison, Wisconsin and Salem, Oregon.

TABLE 6-6

SOIL MONITORING PROGRAMS FOR TWO AGRICULTURAL LAND APPLICATION OPERATIONS

	Monitoring Frequency			
	Soil-Plow Layer		Soil-Subsoil Layer	
Constituent	Salem, OR	Madison, WI	Salem, OR	Madison, WI
Aluminum	Prior to application	-	Prior to application	-
Boron	Prior to application	-	Prior to application	-
Cadmium	Prior to application	-	Prior to application	Every three years
Calcium	Prior to application	-	Prior to application	-
CEC	Prior to application	One time	Prior to application	-
Chromium	-	-	-	Every three years
Conductivity	Prior to application	-	Prior to application	-
Copper	Prior to application	-	Prior to application	Every three years
Iron	Prior to application	-	Prior to application	-
Lead	Prior to application	-	-	Every three years
Magnesium	-	-	Prior to application	-
Manganese	Prior to application	-	Prior to application	-
Mercury	Prior to application	-	Prior to application	-
Molybdenum	Prior to application	-	Prior to application	-
Nickel	Prior to application	-	Prior to application	Every three years
Organic Matter	Annually during application	Every three years	-	-
pH	Annually during application	Every three years	-	-
Phosphorous: Available	Annually during application	-	-	-
Phosphorous: Total	-	Every three years	-	-
Potassium: Available	Annually during application	-	-	-
Potassium: Total	-	Every three years	-	-
Sodium	Prior to application	-	-	-
Zinc	Prior to application	-	Prior to application	Every three years

Three States have separate requirements for soil monitoring at land reclamation sites. Arkansas requires monitoring prior to application and then annually following application. In Illinois, the monitoring program is proposed by the applicant at the time he seeks a permit for sludge disposal at a land reclamation site. New Jersey requires soil monitoring.

Vegetation Monitoring

Vegetation monitoring is usually only necessary if heavy sludge application rates are used, as with a dedicated disposal site, and there is concern that food chain vegetation being grown on the site may be accumulating potentially harmful quantities of heavy metals, particularly cadmium, from the sludge amended soil.

Federal Regulations

There are no Federalregulations addressing vegetation monitoring at land application sites.

Federal Guidance

Generally, if sludge is applied at low agronomic rates there is little need to sample and analyze the vegetation. Table 6-7 contains a list of potential crop monitoring parameters for agricultural crops (EPA 1983). Actual parameters monitored may vary from this list, depending on the sludge constituents of concern.

State Requirements

Ten States have regulations addressing crop monitoring and plant tissue sampling and analysis (see Table E6-4). Illinois and Maine indicate analyses may be required for some sites. Idaho requires biennial analyses for metals.

TABLE 6-7
POTENTIAL CROP MONITORING PARAMETERS

A. Heavy Metals	
	Cadmium
	Copper
	Molybdenum
	Nickel
B. Macronutrients (optional)	Zinc
	Nitrogen
	Phosphorus
C. Other elements or Constituents*	Potassium
	Antimony
	Arsenic
	Chromium
	Iron
	Manganese
	Mercury
	Selenium
	PCB's

* The other constituents listed under C are analyzed only if there are significant quantities of those contained in the sludge being applied, and the crop may enter the food chain.
Source: EPA 1983

Ground-Water Monitoring

Ground-water monitoring may be required to ensure that an application site is not contaminating ground-water aquifers in the sludge application or sludge storage area. The constituents monitored in a ground-water monitoring program depend on the goals of the program. Ground-water monitoring is often required for dedicated land disposal sites. It may be required for forest application or land reclamation sites over vulnerable aquifers. Ground-water vulnerability is dependent on geologic and hydrologic factors including precipitation, depth to ground-water,

physical and other characteristics of geologic material soils, etc. The permit writer may want to consult a qualified geologist or hydrogeologist to evaluate ground-water vulnerability. Ground-water monitoring is generally not required for agricultural projects if the sludge application rate is limited by crop nutrient requirements. Ground-water monitoring programs to prevent contamination of water supplies should include monitoring of indicator parameters (See Federal Guidance below, and Appendix C of The Land Application Manual (EPA 1983), and The Procedures Manual for Ground-Water Monitoring at Solid Waste Disposal Facilities (EPA 1977b)). If high concentrations of certain heavy metals, toxic chemicals, or fecal bacteria are present in the sludge, they should be included in the ground-water monitoring program.

Federal Regulations

40 CFR Part 257 requires that sludge application not contaminate underground drinking water sources (any aquifer with less than 10,000 mg/l dissolved solids) with contaminants in concentrations equal to or greater than the levels specified in Appendix I (40 CFR Part 257). Contamination is measured at the boundary of the application area as it would exist when the solid waste disposal activity (sludge application) ceases, however, an alternate boundary can be set which considers, among other factors, the natural attenuation and dilution characteristics of the aquifer and the proximity and withdrawal rates of ground-water users (See Appendix D).

Federal Guidance

The following is a list of parameters generally included in a ground-water monitoring program (EPA 1983):

- pH
- Electrical conductivity and/or TDS
- Total hardness
- Alkalinity
- Chlorides
- Sulfates
- Total organic carbons
- Nitrate-nitrogen
- Total phosphorus
- Methylene blue active substances (surfactants)

- o Selected metals or toxic organic substances
- o Indicator microorganisms

State Requirements

Thirty-four States have rules addressing ground-water monitoring (see Table E6-4). Thirty-three States require ground-water monitoring in some cases. Parameters measured include depth to water table, nitrates, metals, organics, pH, and fecal coliform bacteria. Sampling frequency is variable, with one State requiring semiannual analyses and another quarterly analyses. Twelve States set ground-water monitoring requirements on a case-by-case basis. High seasonal ground-water levels, repeated sludge applications at a single site, and application rates in excess of the rate based on nitrogen uptake by crops are considered grounds for requiring ground-water monitoring. The Madison, Wisconsin and Salem, Oregon land application programs require ground-water monitoring prior to application and at three and five year intervals after application. The parameters measured prior to application at Madison include dissolved solids, nitrates, total coliform, chloride, and zinc. Follow-up analyses were conducted for dissolved solids and nitrates. At Salem, the parameters measured prior to application and at 3 and 5 year intervals after application include dissolved solids, nitrates, total coliforms, arsenic, and mercury.

Case-by-Case Recommendations

When a ground-water monitoring condition is written, permit writers should require the use of Appendix C of the Process Design Manual for Land Application of Municipal Wastewater Sludge (EPA 1983) and the Procedures Manual for Ground-Water Monitoring at Solid Waste Disposal Facilities (EPA 1977b), or similarly protective guidelines, to design and operate ground-water monitoring systems. Using lysimeters to detect leachate in the unsaturated zone above an aquifer can provide early warning of potential future ground-water contamination.

Surface Water Monitoring

Federal Regulations

Federal regulations do not specifically address surface water monitoring. However, 40 CFR Part 257.3-3 does state that a facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide

water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

Federal Guidance

Properly designed land application sites should be located, constructed, and operated to minimize the chance of surface water run-off containing sludge constituents. For agricultural sites where sludge is applied at agronomic rates, surface water monitoring is typically not required. Generally, surface water monitoring should be considered in the following situations (EPA 1983):

- Surface water run-off from the site is collected, stored, and discharged to surface waters outside the application area under an NPDES permit.

- The sludge application site is in close proximity to surface waters that are sensitive (e.g., drinking water supplies, swimming areas, etc.), and monitoring is required to ensure that migration of sludge constituents to these surface waters does not occur.

- It is desirable to alleviate community concern about surface water quality impacts.

Generally, the parameters of concern in a surface water monitoring program are those that may affect public health, or those that may contribute to eutrophication, e.g., nitrogen and phosphorus. An illustration of parameters that are often analyzed in surface water samples taken in connection with sludge application site(s) monitoring is shown in the following list (EPA 1983):

- Fecal coliforms
- Total P
- Total N (Kjeldahl)
- Dissolved oxygen
- BOD or TOC
- Temperature
- pH
- Suspended solids

State Requirements

Twenty States have regulations addressing surface water monitoring (see Table E6-4). Six States require monitoring on a case-by-case basis. Idaho requires baseline monitoring and follow-up monitoring during the life of the project for nitrogen, metals, organics, pH, and fecal coliform bacteria.

Reporting and Record Keeping

Federal Regulations

The recently promulgated revisions to the NPDES Permitting regulations (54 FR 18716) require that the permit contain a requirement that the permittee report monitoring results with a frequency dependent upon the nature and effect of the sewage sludge use or disposal practice but in no case less than once a year (40 CFR Part 122.44(i)(2). The regulations also require that records pertaining to the POTWs sludge use and disposal activities (as set forth in 40 CFR Part 501.15 (2)(2)) be retained for 5 years (40 CFR Part 122.21(p)).

Federal Guidance

Operational and monitoring data may be required by local, State, or Federal Agencies Consequently, any municipality implementing a sludge application system should develop an adequate record keeping program.

Management and reporting activities may include equipment use and maintenance records, performance records, required regulatory reports, cost records, and public relations activities (e.g., complaints). These records can also be used as the basis for scheduling future site inspections and evaluating the efficiency of operations.

Records on the sludge application portion of the program should contain at least the following:

- Sludge characteristics and amounts applied to specific locations.
- Major operational problems, complaints, or difficulties.

- Qualitative and/or quantitative data related to the selection and operation of the land application site, including monitoring data on ground and surface water, soils, and crops.

State Requirements

Thirty States have reporting/record keeping requirements (see Table E6-4). These States may require the POTW to keep records of one or more of the following: the amount and quality of sludge applied, the location at which the sludge is applied, the use of harvested crops, the amount of lime or fertilizer required, and the results of all environmental monitoring analyses. The required reporting frequency varies from monthly to quarterly, semi-annually, or annually. Three States require deed records for land application sites. Kentucky requires a deed record regarding cadmium application. Massachusetts requires a deed notice for land application sites receiving sludge/seepage classified as type II or III under the State's sludge classification system. Mississippi requires a deed record of the amount of PCBs and cadmium applied.

6.3 ADDITIONAL REQUIREMENTS AND GUIDANCE FOR AGRICULTURAL LAND APPLICATION

6.3.1 PERMITTING RESPONSIBILITIES

Unless a condition prohibits sludge application to lands used for producing food-chain crops, the permit must state that the POTW will comply with the requirements of 40 CFR Part 257.3-5 (See Table 6-8). Briefly, these regulations set annual and cumulative loading limits for cadmium and management practices (primarily, adjustment of the sludge-soil mixture as needed to attain pH 6.5 or greater at the time of sludge application and whenever food-chain crops are grown). The regulations also require that sludges containing PCBs at levels equal to or greater than 10 mg/kg (dry weight) be incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. If the POTW can assure that PCB concentrations in animal feed or milk are low, incorporation is not required.

Provided special restrictions are followed, 40 CFR Part 257.3-5 allows for cadmium applications to exceed the generally required rates. However, these restrictions include pH maintenance, the development of a facility operation plan which demonstrates how the animal feed (if grown) will be distributed to preclude ingestion by humans and a stipulation in the land record or property deed stating that food-chain crops should not be grown on the land. These kinds of restrictions

TABLE 6-8

40 CFR PART 257 3-5 CONTAMINANT LIMITS FOR SLUDGE USED ON FOOD-CHAIN CROPLANDS

Cadmium

a. The pH of the sludge and soil mixture must be greater than 6 5 at the time of sludge application unless the sludge contains less than 2 mg/kg (dry weight) cadmium.

b. The annual application of cadmium from sludge must not exceed 0.5 kg/ha for tobacco and food-chain crops.

c The cumulative application of cadmium from sludge must not exceed the following values which depend upon the cation exchange capacity (CEC) and background pH of the soil:

pH	CEC meq/100 g	Maximum Cumulative Application kg/ha
≥6 5	<5	5
	5-15	10
	>15	20
<6 5*	-	5

*The cumulative application rates for soils with a background pH equal to or greater than 6 5 may be used if the pH of the solid waste and soil mixture is adjusted to and maintained at 6 5 or greater whenever food-chain crops are grown

d If animal feed is the only food-chain crop produced, there is no limit to the cadmium application rate, as long as the pH of sludge and soil mixture is 6 5 or greater at the time of sludge application or at the time the crop is planted, whichever occurs later, and this pH level is maintained whenever food-chain crops are grown A plan must also be developed which demonstrates how the animal feed will be distributed to preclude human ingestion, and the measures to be taken to safeguard against possible health hazards from cadmium entering the food chain, which may result from alternative land uses Future property owners must also be notified by a stipulation in the land record or property deed which states that the property received sludge at high cadmium application rates and that food-chain crops, except for animal feed, should not be grown due to possible health hazards.

PCBs

Sludge containing concentrations of PCBs equal or greater than 10 mg/kg (dry weight) must be incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation is not required if it can be assured that the PCB content is less than 0 2 mg/kg (actual weight) in animal feed or less than 1 5 mg/kg (fat basis) in milk (Sludge containing more than 50 mg/kg PCBs must be disposed of in a chemical waste landfill or incinerated under special conditions (see 40 CFR 761 Subpart D for PCB disposal requirements).

* The other constituents listed under C are analyzed only if there are significant quantities of those contained in the sludge being applied and the crop may enter the food chain.

Source: EPA 1983.

generally make high rate cadmium applications appropriate only in a dedicated land disposal setting (EPA 1983).

If the permit writer incorporates conditions (discussed in the recommendations section below) requiring that sludges be applied at agronomic rates (e.g., at a rate that will supply only as much available nitrogen as the particular crop grown on an application site can assimilate), and implementing the depth to ground-water and seasonal limit recommendations, the ground-water provisions of 40 CFR Part 257.3-4 should be satisfied. When sludge is applied at agronomic rates in agricultural settings, the access control provisions of 40 CFR Part 257.3-8 should be satisfied without writing a permit condition requiring fences or signs.

6.3.2 TECHNOLOGY

Methods of sludge application on agricultural land are dependent on the physical characteristics of the sludge and soil and the crops grown. Liquid sludges can be applied by surface spreading or subsurface injection. Surface application methods include spreading by farm tractors, tank wagons, special applicator vehicles equipped with flotation tires, tank trucks, portable or fixed irrigation systems, and ridge and furrow irrigation.

Surface application of liquid sludge is normally limited to sites with less than 6 percent slopes. Surface application of liquid sludge is normally practiced when forage crops are grown. After sludge has been applied to the soil surface and allowed to partially dry, it is commonly incorporated by plowing or disking prior to planting the crop (i.e., corn, soybeans, small grains, cotton, other row crops). Ridge and furrow irrigation systems can be designed to apply sludge during the crop growing season but it is difficult to provide even distribution. Spray irrigation systems generally should not be used to apply sludge to forage or row crops during the growing season unless proper management is provided (e.g., application to recently harvested hay fields, subsequent irrigation with fresh water) since the adherence of sludge to plant vegetation can reduce photosynthesis and have a detrimental effect on crop yields. In addition, spray irrigation tends to increase the potential for odor problems. Surface application of liquid sludge by tank trucks and applicator vehicles is the most common method for agricultural croplands.

Liquid sludges can also be injected below the soil surface. Available equipment includes tractor-drawn tank wagons with injection shanks (originally developed for liquid animal wastes) and tank trucks fitted with flotation tires and injection shanks (developed for sludge application). Both types of equipment minimize any odor problems and reduce ammonia volatilization by immediate

mixing of soil and sludge. Sludge can be injected either before planting or after harvesting all crops except forage crops that are cut and baled. Because some injection shanks can either ruin the forage stand or create deep ruts in the field, specialized equipment should be used to inject sludge into forage crop fields.

Dewatered sludges are applied to cropland by handling equipment similar to that used for applying animal manures, limestone, or solid fertilizers. Typically, the dewatered sludge will be surface-applied and then incorporated by plowing or disking. Incorporation is not generally used when dewatered sludges are applied to forage crops.

6.3.3 CHARACTERISTICS OF SLUDGE SUITABLE FOR AGRICULTURAL LAND APPLICATION

The constituents of a sludge have a direct bearing on the options available for sludge use and disposal. For agricultural land application, the most important constituents are nutrients, pathogens, metals, and certain toxic organic chemicals. The form and the concentration of the nutrients nitrogen, phosphorus, and potassium in the sludge affect the fertilizer value of the sludge for agricultural land application. The amount of available nitrogen in excess of plant requirements is of concern for potential nitrate contamination of groundwater. Pathogen reduction is required prior to agricultural land application to prevent potential human health problems. High metal concentrations are of concern in agricultural land application because of their potential to damage crops, and to enter the food chain. Certain toxic organic chemicals are of concern due to their potential to enter the food chain or to infiltrate into groundwater.

This section summarizes current Federaland State regulations for the agricultural land application disposal option. These are in addition to the requirements and recommendations contained in Section 6.2.

Sludge Pollutant Concentration Limits

Federal Regulations

Current Federal regulations address cadmium, PCBs, and pathogens.

Cadmium

Annual cadmium applications to sites growing food-chain crops for human consumption, including tobacco, are limited to 0.5 kg/ha/yr (40 CFR Part 257). The cumulative application of cadmium to a site is limited based on pH and soil cation exchange capacity according to the schedule listed in Table 6-9.

TABLE 6-9
MAXIMUM PERMISSIBLE CUMULATIVE CADMIUM APPLICATION TO A LAND APPLICATION SITE USED TO PRODUCE FOOD-CHAIN CROPS

	Max. Cumulative Application (kg/ha)	
Soil Cation Exchange Capacity (meq/100 g)	Background Soil pH<6.5	Background Soil pH>6.5
<5	5	5
5-15	5	10
>15	5	20

If the only crop produced is used exclusively as animal feed, then cadmium application rates are not limited, provided that the following conditions are met:

- The pH of the sludge and soil mixture is maintained at 6.5 or greater whenever the crop is grown.

- To preclude ingestion by humans and safeguard against possible health hazards from cadmium entering the food chain, a facility operating plan is prepared that describes how the animal feed will be distributed

- The land record or property deed states that the property received sludge at high cadmium application rates and that food-chain crops, except for animal feed, should not be grown due to possible health hazards. (40 CFR Part 257)

Permit writers should use the recommendations for dedicated lands in Section 6.5 when cadmium loadings will exceed the levels set forth in Table 6-9.

There are no current Federalregulations for cadmium loadings to crops that are non food-chain crops as defined in 40 CFR Part 257.

PCBs

Sludge containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight), but less than 50 mg/kg, must be incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation of the sludge into the soil is not required if it is assured that the PCB content is less than 0.2 mg/kg (actual weight) in animal feed or less than 1.5 mg/kg (fat basis) in milk (40 CFR Part 257).

Pathogens

For agricultural land application, 40 CFR Part 257 contains some specific requirements. If crops for direct human consumption will be grown within 18 months subsequent to sludge application or incorporation, the sludge must be treated with a process to further reduce pathogens (PFRP). These processes are also listed in 40 CFR Part 257 Appendix II, Chapter 3 and Section 6.2 of this document. If the sludge will not contact the edible portions of the crop, pathogen reduction to PSRP levels is acceptable (40 CFR Part 257).

State Requirements

Some States have set cumulative loading limits for contaminants in sludge applied to cropland (see Table E6-2 in Appendix E). Where more restrictive State limits apply, permit writers should determine the basis for these limits and consider incorporating them into the permit.

Some States have set sludge contaminant concentration limits, primarily for heavy metals and PCBs (See Table E6-1). One State has set limits for a number of pesticides. However, it appears that these limits were based on analytical detection limits. At this time, EPA does not generally recommend contaminant concentration limits beyond those in the Joint EPA/FDA/USDA Guidance on Land Application of Municipal Sludges for the Production of Fruits and Vegetables (1981). Permit writers should consider incorporating State limits after determining the basis for these limits.

State contaminant concentration limits are presented in Table E6-1. In general, the State "Grade 1" sludge limits in this table allow unrestricted agricultural use. States may impose restrictions or ban use of lower grades of sludge for agriculture.

Table 6-10 summarizes existing State regulations for annual loading of sludge contaminants at agricultural sites. Table 6-11 is a similar summary for the allowable cumulative loading of sludge contaminants at agricultural sites. Table E6-2 presents all State annual and cumulative application rate limits and variances for sludge contaminants.

Case-by-Case Recommendations

Contaminant Cumulative Loading Limits

In addition to the required limits for cadmium and PCBs, EPA and USDA have issued guidance on the recommended maximum cumulative sludge metal applications for croplands (EPA 1977a, 1984; USDA 1984) (See table 6-12). For permits issued to POTWs applying sludge to lands used for producing food-chain crops, permit writers should consider requiring POTWs or their agents to not exceed these loadings of heavy metals. Permit writers also may want to set limits on cumulative sludge metal loadings to lands used to produce non-food-chain crops (e.g., nurseries, Christmas tree farms) so as to preserve future use of these lands for food-chain crops. Tables 6-13 and 6-14 show, for various sludge application rates, how many years sludges containing various concentrations of heavy metals could be applied before exceeding recommended cumulative application rates. These tables assume that sludge is applied to soils with less than 5 meq/100 g cation exchange capacity. For sites with a CEC between 5 and 15 meq/100 g, multiply the number of years that appear in the tables by a factor of two. For sites with a CEC of 15 meq/100 g or greater, multiply the number of years by a factor of four. In the table, 0 mg/kg means that the concentration does not allow for any application of sludge at that particular rate.

Contaminant Annual Loading Limits

Research has shown that crop uptake and plant toxicity are controlled by cumulative rather than annual loading of heavy metals (EPA 1987b). Provided conditions are placed in permits 1) requiring that sludge be applied at agronomic rates; and 2) limiting cumulative metals loadings, incorporating limits on annual application of heavy metals (other than the required cadmium limits) is not generally recommended. Where applicable, permit writers should consider incorporating State limits (summarized in Table E6-2).

TABLE 6-10

SUMMARY OF CURRENT STATE ANNUAL CONTAMINANT APPLICATION RATES FOR LAND APPLICATION

Constituent	No States* Regulating	Max. Annual Application Rate (kg/ha)		
		Median	Mode	Range
Arsenic	2	57	-	2-112
Cadmium	25	.5	.5	5- 6
Chromium	4	47	-	27-56
Copper	6	18	14	9-56
Lead	5	53	56	22-252
Mercury	2	10	-	8-11
Nickel	6	11	-	5-63
Zinc	6	28	28	18-112

* See Table E6-2 for variances allowed by many states based upon cation exchange capacity (CEC), or in some states, for other parameters.

TABLE 6-11

SUMMARY OF CURRENT STATE CUMULATIVE CONTAMINANT APPLICATION RATES FOR LAND APPLICATION

Constituent	No States* Regulating	Max Annual Application Rate (kg/ha)		
		Median	Mode	Range
Arsenic	1	112	112	112
Cadmium	36	5	5	5-20
Chromium	6	313	140	140-560
Copper	31	140	140	84-560
Lead	32	530	560	200-2520
Mercury	2	3	-	6-6
Molybdenum	1	9	9	9
Nickel	31	56	56	341-627
PCB	2	1	-	1-2
Selenium	2	13	-	9-18
Zinc	31	280	280	168-1120

* See Table E6-2 for variances allowed by many states based upon cation exchange capacity (CEC), or in some states, for other parameters

TABLE 6-12

MAXIMUM METAL APPLICATION[1] (kg/ha) FOR UNAMENDED SOIL AT INDICATED SOIL CATION EXCHANGE CAPACITY (CEC)

Metal	CEC[2]		
	0-5	5-15	15
Cadmium	5	10	20
Nickel	50	100	200
Copper	125	250	500
Zinc	250	500	1,000
Lead	500	1,000	2,000

[1] Cadmium limits have the force of regulation (40 CFR Part 257) Annual Cd application should not exceed 0 5 kg/ha. All recommendations apply only to soils adjusted to pH 6 5 when sludge is applied and maintained at no less than pH 6 5 thereafter.

[2] meq/100 g.

TABLE 6-13

YEARS OF APPLICATION FOR CADMIUM AND NICKEL

Years of Sludge Application at:
2 tonnes/hectare (dry weight)
0.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	4	6	12	27	41	83
Ni	41	62	125	277	416	833

Years of Sludge Application at:
11 tonnes/hectare (dry weight)
4.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	1	2	5	7	15
Ni	7	11	22	50	75	151

Years of Sludge Application at:
20 tonnes/hectare (dry weight)
8.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	1	2	4	8
Ni	4	6	12	27	41	83

Years of Sludge Application at:
44 tonnes/hectare (dry weight)
20 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	1	1	3
Ni	1	2	5	12	18	37

Years of Sludge Application at:
70 tonnes/hectare (dry weight)
31 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	1	2
Ni	1	1	3	7	11	23

Years of Sludge Application at:
112 tonnes/hectare (dry weight)
50 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	0	1
Ni	0	1	2	4	7	14

Years of Sludge Application at:
340 tonnes/hectare (dry weight)
152 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	4	6	12	27	41	83
Ni	41	62	125	277	416	833

Years of Sludge Application at:
900 tonnes/hectare (dry weight)
400 tons/acre

	Concentration of Metal in Sludge (mg/kg)					
Metal	600	400	200	90	60	30
Cd	4	6	12	27	41	83
Ni	41	62	125	277	416	833

Estimated Sludge Application in Dry Weight for Different Land Disposal Options

Disposal Option	Time Period of Application	Reported Range of application rates		Typical Rate	
		mt/ha	T/ac	mt/ha	T/ac
Agricultural Utilization	Annual	2-70	1-30	11	5
Forest Utilization	1 time or at 3-5 year intervals	10-220	4-100	44	20
Land Reclamation Utilization	1 time	7-450	3-200	112	50
Dedicated Disposal Site	Annual	220-900	100-400	340	150

Notes: The rates shown are only for the sludge application area and do not include area for buffer zone, sludge storage, or other project area requirements. This table assumes that sludge is applied to soils with less than 5 meq/100 g cation exchange capacity. For sites with a CEC between 5 and 15 meq/100 g, multiply the number of years that appear in the table by a factor of two. For sites with a CEC of 15 meq/100 g or greater, multiply the number of years by a factor of four.

TABLE 6-14

YEARS OF APPLICATION FOR COPPER, LEAD, AND ZINC

Years of Sludge Application at:
2 tonnes/hectare (dry weight)
0.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	11	17	23	34	41	62	69
Pb	46	69	92	138	166	250	277
Zn	23	34	46	69	83	125	138

Years of Sludge Application at:
11 tonnes/hectare (dry weight)
4.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	2	3	4	6	7	11	12
Pb	8	12	16	25	30	45	50
Zn	4	6	8	12	15	22	25

Years of Sludge Application at:
20 tonnes/hectare (dry weight)
8.9 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	1	1	2	3	4	6	6
Pb	4	6	9	13	16	25	27
Zn	2	3	4	6	8	12	13

Years of Sludge Application at:
44 tonnes/hectare (dry weight)
20 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	1	1	1	2	3
Pb	2	3	4	6	7	11	12
Zn	1	1	2	3	3	5	6

Years of Sludge Application at:
70 tonnes/hectare (dry weight)
31 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	1	1	1	2
Pb	1	2	2	4	4	7	7
Zn	0	1	1	2	2	3	4

Years of Sludge Application at:
112 tonnes/hectare (dry weight)
50 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	1	1
Pb	0	1	1	2	3	4	5
Zn	0	0	0	1	1	2	2

Years of Sludge Application at:
340 tonnes/hectare (dry weight)
152 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	0	0	1	1	1
Zn	0	0	0	0	0	0	0

Years of Sludge Application at:
900 tonnes/hectare (dry weight)
400 tons/acre

	Concentration of Metal in Sludge (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0

Sample Calculations

Parameters	SI Unit Tables	English Unit Tables
1 Sludge Loading Rate	2 tonne/hectare-yr	.9 tons/acre-yr
2. Parameter concentration	600 mg Cd/kg sludge	600 mg Cd/kg sludge
3. Parameter cumulative loading limit	5 kg Cd/hectare	5 kg Cd/ hectare
4 Parameter deposition Rate	2 tonnes/ha-yr x 1000 kg sludge/tonne x 0.0006 kg Cd/kg sludge = 1.2 kg Cd/hectare-yr	.9 ton/acre-yr x 910 kg/ton x 2.47 acre/hectare x 0.0006 kg Cd/kg sludge =1.2 kg Cd/hectare/yr
5. Years of use at that rate =(Site life/Annual loading)	(5 kg Cd/ha)/(1.2 kg Cd/ha/yr) = 4.1667 > 4 yr (round to nearest integer)	(5 kg/ha x ha/1.2 kg Cd/hectare-yr) = 4.119 > yr (round to nearest integer)

Sludge Pollutant Concentration Limits

The 1981 Joint EPA/FDA/USDA Guidance on Land Application of Municipal Sludges for the Production of Fruits and Vegetables recommends that only sludges with less than 25 mg/kg cadmium, 1,000 mg/kg lead and 10 mg/kg PCBs be applied to lands used to produce fruits and vegetables (EPA 1981). Research has shown that, for cadmium and lead, these recommendations are very conservative and provide a wide margin of safety (EPA 1987b). Based on the 1981 Guidance, permit writers should generally consider requiring that sludge applied to lands used for fruits and vegetable production meet these contaminant concentration levels. In this case, sludge with higher levels of cadmium and lead could still be applied to lands where grains or fodders are grown. Within the restrictions imposed by 40 CFR PART 257.3-5, sludges with higher PCB levels might also be used (See Appendix D).

In certain circumstances, it may be acceptable to allow sludges with somewhat higher amounts of cadmium and lead to be used on lands for fruit and vegetable production. For example, public health should be adequately protected if the permit writer:

- Places a sludge cadmium limit of 38 mg/kg (dry weight) in the permit, and a lead limit of 1500 mg/kg (dry weight). These limits are 50 percent greater than generally recommended;

- Writes the recommended cumulative loading limits into the permit (per 40 CFR Part 257.3-5, annual cadmium loading cannot exceed 0.5 kg/ha);

- Limits sludge application to the agronomic rate; and

- Requires that the sludge only be applied to lands where, for the life of the permit, crops with low or very low heavy metal uptake rates will be grown. Table 6-15 presents the relative cadmium uptake rates of various crops. Crop uptake rates for lead are much lower than for cadmium.

Pathogen Control

To provide additional assurance beyond the pathogen reduction requirements of 40 CFR Part 257, the 1981 Joint EPA/FDA/USDA Guidance recommends that in warm, moist climates, crops that are customarily eaten raw or only partially blanched should not be planted within 36 months of sludge application. Studies since 1981 have confirmed that certain pathogens can survive for long

TABLE 6-15

RELATIVE ACCUMULATION OF CADMIUM INTO EDIBLE PLANT PARTS BY DIFFERENT CROPS[a]

High Uptake	Moderate Uptake	Low Uptake	Very Low Uptake
Lettuce	Kale	Cabbage	Snapbean family
Spinach	Collards	Sweet corn	Pea
Chard	Beet	Broccoli	Melon family
Escarole	Turnip	Cauliflower	Tomato
Endive	Raddish globes	Brussel sprouts	Pepper
Cress	Mustard	Celery	Eggplant
Turnip greens	Potato	Berry fruits	Tree fruits
Beet greens	Onion		
Carrot			

[a] The above classification is based upon the response of crops grown on acidic soils that have received a cumulative Cd application of 5 kg/ha. It should not be implied that the above higher uptake crops cannot be grown on such a soil, or soils of higher Cd concentrations. Such crops can be safely grown if the soil pH is 6.5 or greater at the time of planting, since the tendency of the crop to accumulate heavy metals is significantly reduced as the soil pH increases above 6.5

Source: EPA 1983.

periods of times (e.g., three years) if the sludge/soil mixture is not turned over at least two or three times to expose these pathogens to air and sunlight which desiccate them.

6.3.4 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

Federal Guidance

Sludge Application Rates

Because of concerns about nitrate pollution of ground-water, permit writers should consider requiring that sludges be applied at rates that do not exceed the nitrogen requirement of the particular crop grown on the application site (the agronomic rate). When sludges are applied at greater than agronomic rates, the recommendations for dedicated lands should be considered (EPA 1983). Some States (for example, Ohio) take a more conservative approach and limit sludge application rates to plant phosphorus rather than nitrogen requirements (EPA 1984). Limiting sludge application to the plant phosphorus requirement typically lowers permissible sludge application rates by a factor of two to five (EPA 1983). EPA's Land Application Manual (EPA 1983) presents detailed information on how to calculate plant nutrient requirements and appropriate sludge application rates. Permit writers should consider requiring that POTWs or their agents use the Land Application Manual or protective State or local guidelines, where available, to calculate sludge application rates.

Distance to Surface Waters

To ensure that sludge does not run off into surface waters, permit writers should require that buffers be maintained between the sludge application area and water bodies. Buffers serve at least two purposes: 1) they provide a factor of safety against errors during sludge application; and 2) they provide treatment and filtering of sludge and/or run-off from sludge surfaces.

The condition of the ground surface of buffers is a critical factor in determining appropriate size (for example, bare soil provides virtually no filtering while a grass surface offers fair treatment). Thus, as illustrated in Table 6-16, the recommended size of buffers depends on the method of sludge application, the type of surface water being protected and the condition of the ground surface of the buffer.

TABLE 6-16
RECOMMENDED DISTANCE TO SURFACE WATERS FOR AGRICULTURAL LAND APPLICATION

Sludge Application Method/Buffer Condition	Type of Water Body		
	Continually Flowing	Intermittent	Ditches
Surface Applied:			
Continually Vegetated Buffer	200'	100'	50'
Bare Soil Buffer	200'	200'	100'
Injected/Incorporated:	100'	50'	25'

If recommended conditions for sludge application rates and slope restrictions are not included in the permit, buffers should be wider.

Seasonal Limitations

To protect surface waters and ground waters, permit writers should prohibit sludge application to saturated ground (EPA 1984). Permit writers should also require that sludge application cease during storm events when precipitation exceeds 1/4 inch per hour (EPA 1983). In general, permit writers should require that sludge not be applied to frozen or snow-covered ground because of potential run-off problems (EPA 1984). However, it has been shown that when proper precautions are used, unsaturated frozen ground or snow-covered lands may provide some level of benefit in stabilizing and dewatering sludges. If this form of treatment is a consideration, the permit writer should require the permit application to demonstrate that a combination of slope restrictions and run-off control measures will protect surface waters.

The timing of sludge applications should conform to farming operations, and is influenced by crop, climate, and soil properties. In addition, sludge applications must be scheduled around the tillage, planting, and harvesting operations for the crops grown. A general guide to allowable times for surface and subsurface applications of sludge for North Central States is shown in Table 6-17. Individual States or local USDA-SCS extension personnel can provide similar information.

Depth to Ground-water

To protect ground-water, permit writers should generally prohibit sludge application to sites where ground-water is less than three feet from the surface of the soil. Seasonal perched ground waters require less protection (EPA 1983). Fields that are normally flooded or saturated early in the spring may be suitable application sites if depth to ground-water is at least three feet at the time that sludge is applied and the field is not likely to be saturated during the growing season.

Distance to Wells Used for Drinking Water

Limiting sludge application to the agronomic rate and setting a minimum depth to ground-water make contamination of ground-water unlikely. However, to provide an additional margin of safety, permit writers should consider prohibiting sludge application within 200 feet of drinking water wells (EPA 1983). Permit writers should consult with ground-water program officials to determine if a State wellhead protection program has set other requirements.

Access Control

To lessen the possibility that humans will come into direct contact with pathogens that may be present in sludge, permit writers should consider prohibiting application of sludge that has not been treated by a Process to Further Reduce Pathogens within 300 feet of inhabited dwellings, schools or playgrounds. If the property owner (and any tenant) agrees, it may be acceptable to apply sludge closer to dwellings located on the application site.

In general, permit writers should prohibit sludge application within 30 feet of property lines. If the adjoining property is another farm field or wooded lot, it may be acceptable to apply sludge within 30 feet of the property line.

State Requirements

Sludge application rates for agriculture are calculated based on crop needs, permissible sludge constituent concentration (based on health and environmental effects), and soil characteristics.

TABLE 6-17

GENERAL GUIDE TO MONTHS AVAILABLE FOR SLUDGE APPLICATION TO DIFFERENT CROPS IN NORTH CENTRAL STATES*

Month	Corn	Soybeans	Cotton‡	Forages#	Small Grains†	
					Winter	Spring
January	S*	S*	S/I	S*	C	S*
February	S*	S*	S/I	S*	C	S*
March	S/I	S/I	S/I	S	C	S/I
April	S/I	S/I	P, S/I	C	C	P, S/I
May	P, S/I	P, S/I	C	C	C	C
June	C	P, S/I	C	H, S	C	C
July	C	C	C	H, S	H, S/I	H, S/I
August	C	C	C	H, S	S/I	S/I
September	C	H, S/I	C	S	S/I	S/I
October	H, S/I	S/I	S/I	H, S	P, S/I	S/I
November	S/I	S/I	S/I	S	C	S/I
December	S*	S*	S/I	S*	C	S*

* Application may not be allowed due to frozen or snow-covered soils in some states; S/I, surface or incorporated application, S, surface application,C, growing crop present; P, crop planted; H, after crop harvested.

† Wheat, barley, oats, or rye.

‡ Cotton, only grown south of southern Missouri.

Established forages, legumes (alfalfa, clover, trefoil, etc), grass (orchard grass, timothy, brome, reed canary grass, etc.), or legume-grass mixture.

Source: EPA 1983.

Application rates are designed so that the most limiting constituent sets the appropriate application rate for the sludge. The two constituents that are usually most important to control are nitrogen and cadmium. Nitrogen is typically the first sludge component to limit the rate of sludge application, since adding excess nitrogen to soil may potentially contaminate ground-water with nitrates.

Typical sludge application rates for agriculture range from 1 to 30 dry tons of sludge per acre per year in cases not restricted by high contaminant concentrations. (EPA, 1984). Twenty-one States have maximum loading limits in accordance with crop nutrient requirements (i.e., agronomic rate limitations). Seven States have maximum volumetric loading limits, which range generally from 10,000 to 30,000 gallons per acre per year. Eight States have maximum mass loading limits, which range generally from 2 to 20 dry tons per acre per year.

A number of States place restrictions on animal grazing. The most common restriction is to control animal grazing for at least one month after sludge application. In some States, however, access by grazing animals is restricted for as much as 6 or 12 months. Three States require that fences and signs be installed.

Forty-one States have crop use limitations (see Table E6-5). Thirty-five States reported mandatory time delays after sludge application before planting human consumption crops. The delays ranged generally from 1 to 3 years, and the most common delay was 18 months for human consumption crops (specified by 10 States; typically includes tobacco). Twenty-four States reported that some crops were not allowed. Three States (Arizona, Georgia, and Rhode Island) prohibit the application of sludge to land that will be used to grow human consumption crops. Four more States allow human consumption crops only if special conditions are met. Five States do not allow raw crops to be grown. Nine States do not allow contact with root crops, food plants, or low fruits.

6.3.5 ADDITIONAL MONITORING CONSIDERATIONS FOR AGRICULTURAL LAND APPLICATION

In addition to the monitoring requirements and recommendation discussed in 6.2.2, sludges applied to lands used for producing food-chain crops should be monitored more frequently than is generally recommended in other land application processes. The pH of the sludge-soil mixture should be measured each time sludge is applied to food-chain croplands and whenever food-chain crops are grown. Once, during the first year of the permit, the soil cation exchange capacity of food-chain croplands where sludge is applied should be measured.

6.4 ADDITIONAL REQUIREMENTS AND GUIDANCE FOR SILVICULTURAL (FOREST LAND) APPLICATION

Forest land application rates are usually limited to the nitrogen needs of the trees. This rate is typically 4 to 100 tons per acre in one single application or in a set of closely spaced applications every 3 to 5 years. A typical application rate would be 18 tons per acre every 5 years, which is equivalent to an average yearly application rate slightly less than that for agricultural application (EPA 1984). This section presents contaminant limits and management practices for silvicultural application of sewage sludge.

6.4.1 CHARACTERISTICS OF SLUDGES SUITABLE FOR SILVICULTURAL LAND APPLICATION

Federal Regulations

The only Federalsludge quality limits are the pathogen reduction requirement of 40 CFR Part 257.

State Requirements

Two States reported regulations addressing maximum loading limits for forest land application in cases not limited by high concentrations of contaminants.

Case-by-Case Recommendations

If the permit writer is concerned that a silvicultural sludge application site might be used at a later date to grow food-chain crops, the permit writer should consider requiring that the POTW or its agent comply with the contaminant cumulative loading limits recommended for food-chain croplands. If sludge application is limited to the agronomic rate (discussed below), metal toxicity to forest plants should not be a problem (EPA 1983).

6.4.2 OPERATING CONDITIONS AND MANAGEMENT PRACTICES FOR SILVICULTURE

Federal Regulations

There are no required permit conditions for sludge application to forest lands beyond the 40 CFR Part 257 requirements that apply to all forms of land application (See Tables 6-1 and 6-2). Recommended permit conditions to ensure that the surface water and ground-water provisions of 40 CFR Part 257 are met are discussed in the Case-by-Case Recommendation section.

Federal Guidance

Sludge Application Rate

Because of concerns about nitrate pollution of ground-water, permit writers should consider requiring that sludges be applied at rates that do not exceed the nitrogen requirement of the type of forest on the application site (the agronomic rate). The forested floor often includes a layer of organic matter high in carbon and low in nitrogen, which will temporarily immobilize nitrogen then slowly mineralize in later years. It is this feature of forest soils that allows heavier, multi-year applications. EPA's Process Design Manual for Land Application of Municipal Wastewater Sludge (EPA 1983) presents detailed information on how to calculate nutrient requirements and appropriate sludge application rates. Permit writers should require that POTWs or their agents use this manual or protective State or local guidelines, where available, to calculate sludge application rates. When sludges are applied at greater than agronomic rates, the recommendations for dedicated lands should be considered (EPA 1983).

To protect the structure of forest soils from damage caused by heavy application vehicles and to reduce costs, sludges are typically applied to forest lands in a single application (or closely-spaced series of applications) once every three to five years. A typical application rate would be 40 metric tons per hectare every five years, which is an average yearly rate slightly less than for agricultural application (EPA 1984). Such an application scenario is acceptable, provided measures are taken to ensure sludge does not run off into surface waters and that ground waters are protected.

Distance to Surface Waters

To ensure that sludge does not run off into surface waters, permit writers should require that buffers be maintained between the sludge application area and water bodies. Buffers serve at least two purposes: 1) they provide a factor of safety against errors during sludge application; and 2) they provide treatment and filtering of sludge and/or run-off from sludge surfaces.

The condition of the ground surface of buffers is a critical factor in determining appropriate size (for example, bare soil provides virtually no filtering while an undisturbed forest floor offers excellent treatment). Thus, the recommended size of buffers depends on the method of sludge application, the type of surface water being protected and the condition of the ground surface of the buffer as shown in Table 6-18:

TABLE 6-18
RECOMMENDED DISTANCES TO SURFACE WATER FOR SILVICULTURAL APPLICATIONS

	Type of Water Body			
Sludge Application Method/Buffer Condition	Large Continually Flowing	Small Tributary	Intermittent	Ditches
Surface Applied:				
Undisturbed Buffer	200'	100'	50'	25'
Disturbed Buffer	200'	200'	100'	50'
Injected/Incorporated:	100'	100'	50'	25'

If recommended conditions for sludge application rates and slope restrictions are not included in the permit, buffers should be wider.

Application Site Slope Limitations

Provided that the recommended buffers around surface waters are written into the permit and sludge application is limited to the agronomic rate, application to forested sites with good vegetative cover and slopes not exceeding 30 percent is acceptable. Permit writers should consider defining a wet season and generally prohibit application on slopes greater than 15% during this

period except where slope length is short, is a minor part of the total application area and is not associated with streams, or where it can be demonstrated that management techniques are effective in controlling run-off.

Seasonal Limitations

The seasonal limitations recommended for agriculture should be written into the permit.

Depth to Ground-water

High-rate sludge application once every three to five years (to maintain an agronomic rate over the period between applications) may result in excess nitrogen being available in the first year or two after application. Thus, to protect ground-water aquifers from nitrate pollution, permit writers should prohibit sludge application in this manner on sites where ground-water is less than six feet from the surface of the soil (EPA 1983). Seasonal, perched ground waters require less protection (EPA 1983).

Distance to Wells Used for Drinking Water

To provide a margin of safety, depending on the geology in the area, permit writers should consider requiring a minimum setback distance of 300 to 1,500 feet from drinking water wells. (EPA 1983). Permit writers should consult with ground-water program officials to determine if a State wellhead protection program has set other requirements and also with hydrogeologists for site-specific considerations.

Access Controls

The setback distance for areas which will be used by the public will need to be considered on site-specific basis depending on the potential exposure of the public to health and safety hazards. A setback of at least 300 ft. should be used when sludges that are treated by a PSRP are applied (EPA 1983). This distance may be lessened in remote areas and/or if appropriate signs are posted. Access should be controlled for at least 12 months in all of the above situations. Sludge that has been treated by a PFRP should not require access restriction.

State Requirements

For dedicated forest application sites, Ohio allows application at 5 to 10 times agricultural rates. Washington limits application rates to the nitrogen needs of the forest crop.

6.4.3 ADDITIONAL MONITORING CONSIDERATIONS FOR SILVICULTURE

For additional safety, if the aquifer immediately under the application site is used as a source of drinking water, permit writers should consider requiring ground-water monitoring. Nitrates will be of particular concern where application rates exceed the agronomic rates.

6.5 ADDITIONAL REQUIREMENTS AND GUIDANCE FOR LAND RECLAMATION

To ensure that sufficient nutrients and organic matter are introduced into the soil to support vegetation until a self-sustaining ecosystem is established, the amount of sludge applied at one time during land reclamation can be relatively large, ranging from seven to 450 dry metric tons per hectare (EPA 1984). Thus, the permit needs to address the potential for temporary pollution of surface and ground waters. Permit writers should ask themselves, provided the requirements of 40 CFR Part 257 are met and public health and the environment are protected, will using sludge provide environmental benefits? If so, they should encourage use of sludge in land reclamation projects.

6.5.1 CHARACTERISTICS OF SLUDGES SUITABLE FOR LAND RECLAMATION

Federal Regulations

There are no required permit conditions for sludge application for land reclamation beyond the 40 CFR Part 257 requirements that apply to all forms of land application. (See Tables 6-1 and 6-2).

Case-by-Case Recommendations

If the permit writer is concerned that a site where sludge is applied might be used at a later date to grow food-chain crops, the permit writer should consider requiring that the POTW or its agent comply with the contaminant cumulative loading limits recommended for food-chain croplands. If site conditions make it unlikely that the reclaimed land could be used to produce food-chain crops, additional metals limits are not needed, so long as soil pH is adjusted to provide the appropriate

soil acidity for revegetation (discussed below). With pH adjustment (as needed), metal toxicity to plants grown on the site should not be a problem (EPA 1983).

State Requirements

Five States specified maximum loading limits for land reclamation sites in cases not limited by specific contaminant concentrations. Florida limits applications to 30 dry tons per acre per year. Illinois notes that loading limits are based on nitrogen and metals. New Hampshire limits applications to 15 dry tons per acre per year. New Jersey bases its limit on the nutrient requirements of the proposed vegetation. Pennsylvania limits application to 60 dry tons per acre.

State sludge contaminant concentration limits for land reclamation are specified in Table 6-19. State regulations for annual and cumulative application rates and variances for land reclamation are shown in Table 6-20.

6.5.2 OPERATING CONDITIONS AND MANAGEMENT PRACTICES FOR LAND RECLAMATION

Case-by-Case Recommendations

Soil pH Adjustment

Permit writers should consider requiring that the soil pH of the site be adjusted, as necessary, to provide a suitable environment for revegetation. Most grasses and legumes along with many shrubs and deciduous trees grow best in the soil pH range from 5.5 to 7.5 (EPA 1983). If the soil pH becomes highly acid, phytotoxicity problems may be encountered from both the trace metals applied in the sludge and native toxic elements found at the site (EPA 1983).

Sludge Application Rates

The appropriate amount of sludge to apply to a land reclamation site is highly site-specific (EPA 1983). As noted above, sludge application rates vary from seven to 450 dry metric tons per hectare. A typical application rate is 112 metric tons per hectare (EPA 1983, 1984). Permit writers should ask permit applicants to specify how much sludge will be applied to a land reclamation site. This information is used along with data on site features (soil pH, slope, depth to ground-water) to

TABLE 6-19

STATE SLUDGE CONTAMINANT CONCENTRATION LIMITS FOR LAND RECLAMATION

State/Contaminant	Limitation (mg/kg)
California	
Cadmium	25
Lead	500
PCBs	5
Florida	
Cadmium	100
Copper	3,000
Lead	1,500
Nickel	500
Zinc	10,000

Source: EPA 1987c.

TABLE 6-20

STATE REGULATIONS FOR ANNUAL AND CUMULATIVE APPLICATION RATES AND VARIANCES FOR LAND RECLAMATION

State	Constituent	Limitation (kg/ha) Annual	Cumulative	Basis for Standard	Variance Allowed	Comments
PA	Cadmium	67	3 36	Farming	5 6 kg/ha	
AR	Cadmium		5	CEC < 5		
CA	Cadmium	0 5	5	Soil pH, CEC < 5	Max = 20 kg/ha when CEC > 15	
FL	Cadmium	5	5			
PA	Chromium	67 2	336	Farming	560 kg/ha strictly land reclamation	
AR	Copper		125	CEC < 5		
CA	Copper		140	CEC < 5	Max = 500 kg/ha when CEC > 15	
PA	Copper	16.8	84	Reclamation for Farm	140 kg/ha strictly land reclamation	
FL	Copper	125	125			
PA	Lead	67 2	336	Farming	560 kg/ha strictly land reclamation	
AR	Lead		500	CEC < 5		
CA	Lead		400	CEC < 5	Max = 800 kg/ha when CEC > 5	
FL	Lead	500	500			
PA	Mercury	22	1 12	Farming	1 68 kg/ha strictly land reclamation	
PA	Nickel	6.72	33 6	Farming	56 kg/ha strictly land reclamation	
CA	Nickel		50	CEC < 5	Max = 20 lb/ac when CEC > 15	
AR	Nickel		50	CEC < 5		
FL	Nickel	125	125			
CA	Zinc		250	CEC < 5		
AR	Zinc		250	CEC < 5		
PA	Zinc	33 6	168	Farming	280 kg/ha strictly land reclamation	
FL	Zinc	250	250	0 94		1 01

Source: EPA 1987c.

determine appropriate measures to protect plants from metal toxicity (e.g., liming) and to protect surface and ground waters.

Distance to Surface Waters

Permit writers should consider using the agricultural buffer recommendations for land reclamation sites. (The silvicultural recommendations assumed that a forest floor would be present to filter and treat sludge and/or run-off.) When large amounts of sludge are used, wider buffers may be appropriate. However, in some cases, sludge has been used to stabilize the banks of waterways and, while probably causing a small, temporary amount of surface water pollution, resulted in overall environmental benefits. 40 CFR Part 257 requires that sludge application not cause a discharge of pollutants into waters of the United States in violation of NPDES requirements or the requirements of a Section 208 water quality management plan.

Application Site Slope Limitations

In general, permit writers should prohibit application of sludge to slopes in excess of 15 percent (EPA 1983). When sludge use will provide clear environmental benefits and measures are taken that will control run-off from the site, it may be acceptable to use sludge on somewhat steeper slopes.

Seasonal Limitations

To protect surface and ground waters, permit writers should strongly consider using the seasonal limitations recommended for agriculture.

Depth to Ground-water

The typical, one-time, high-rate sludge applications used in land reclamation projects may result in excess nitrogen being available in the first year or two after application. Thus, to protect ground-water aquifers from nitrate pollution, permit writers should prohibit sludge application in this manner on sites where ground-water is less than three feet from the surface of the soil (EPA 1983). Seasonal, perched ground waters require less protection (EPA 1983).

Distance to Wells Used for Drinking Water

To provide a margin of safety, depending on the geology in the area, permit writers should consider requiring a minimum setback distance of 300 to 1,500 feet from wells used for drinking water. (EPA 1983). Permit writers should consult with ground-water program officials to determine if a State wellhead protection program has set other requirements. It may be appropriate to require testing for nitrates in water drawn from nearby wells.

Access Controls

Permit writers should consider prohibiting application of sludge that has not been treated by a Process to Further Reduce Pathogens within 300 feet of areas used by the public. Where permit writers are concerned that members of the public who may not know that sludge has been applied will use the site, they should consider requiring posting of signs stating that sludge has been applied to the site. Sludge that has been treated by a PFRP should not require access controls.

State Requirements

Maryland requires even spreading for sludge application on marginal land and contour plowing.

A number of States have requirements for land reclamation (See Appendix E). Permit writers should incorporate applicable State requirements where appropriate.

6.5.3 ADDITIONAL MONITORING CONSIDERATIONS FOR LAND RECLAMATION

For additional safety, if the aquifer immediately under the application site is used for drinking water nearby, permit writers should consider requiring ground-water monitoring.

6.6 ADDITIONAL REQUIREMENTS AND GUIDANCE FOR DEDICATED LAND DISPOSAL

Dedicated land disposal uses land as a sludge treatment system. Soil microorganisms, sunlight and oxidation degrade the organic matter in the sludge while the soil binds any metals that may be present. To protect surface and ground waters, precautions which may be necessary at dedicated sites may include physical barriers to control run-off and leaching and careful monitoring for contamination of ground and surface waters. Often, leachate and run-off water must be captured and treated prior to release (EPA 1983, 1984).

In most cases, the POTW or its contractor owns the dedicated land disposal site. POTWs usually take one of the following four approaches to dedicated land disposal:

1. All surface water run-off is contained within the site through use of dikes, lagoons, etc., and disposed of through evaporation. All ground-water leachate is contained due to natural impervious geological barriers (e.g., impervious clay, bedrock, etc.) between the site and any underground drinking water sources. No attempt is made to remove moisture or other sludge constituents (e.g., nitrogen, metals) from the site;

2. Same as 1 above, except crops are planted to enhance removal of moisture and sludge nutrients. In some cases, these crops are used as animal feeds;

3. Same as 1 or 2 above, except run-off is controlled and discharged in accordance with NPDES permit conditions; or

4. Same as 1, 2, or 3 above, except that ground-water leachate is intercepted, usually using subsurface drain tiles, to prevent percolation into ground-water aquifiers. Under favorable geological conditions, interceptor ditches, well point systems, deep well pumping or other interception systems may also be feasible. Intercepted leachate may be removed by evaporation, discharge to a sewage treatment plant, irrigation of site vegetation or discharge directly to surface waters in accordance with a NPDES permit (EPA 1983).

6.6.1 PERMITTING RESPONSIBILITIES

Unless the permit prohibits use of the dedicated site for food-chain crop production, permit writers should use the required permit conditions for agriculture. In this case, if the 40 CFR Part 257.3-5(a)(1) cadmium limits will be exceeded (5-20 Kg Cd/ha), only animal feeds can be grown, a stipulation must be placed in the property deed notifying future owners that the property has received high-rate cadmium applications and should not be used to grow food-chain crops, and a facility operating plan must be prepared demonstrating how the animal feed will be distributed to preclude ingestion by humans (See 40 CFR Part 257, Appendix D). If food-chain crop production is prohibited, permit writers should use the required permit conditions for silvicultural use of sludge. All sludges applied to lands must be treated by a Process to Significantly Reduce Pathogens.

A number of States have requirements for dedicated land disposal (See Appendix E). Permit writers should incorporate applicable State requirements where appropriate. There are no reported State contaminant limits specifically for dedicated land use of sludge.

6.6.2 CHARACTERISTICS OF SLUDGES SUITABLE FOR DEDICATED LAND DISPOSAL

Sludge Pollutant Concentration Limits

Provided that the requirements of 40 CFR Part 257 are met, no additional contaminant loading limits are recommended.

6.6.3 OPERATING CONDITIONS AND MANAGEMENT PRACTICES FOR DEDICATED LAND DISPOSAL

Case-by-Case Recommendations

Sludge Application Rates

To ensure that run-off control and ground-water protection measures will protect public health and the environment, permit writers should ask applicants to select a maximum annual sludge application rate and write this rate into the permit.

Sludge application rates range from 100 to 400 tons per acre (220 to 900 dry metric tons per hectare) per year, approximately 20 times those of agricultural lands. Dedicated sites where crops are grown will have application rates toward the lower end of this range (EPA 1984).

Distance to Surface Waters and Run-off Control Measures

Permit writers should consider prohibiting application of sludge to a dedicated disposal site within 300 feet of any pond or lake used for recreational or livestock purposes and any other surface waters (EPA 1983). Applying sludge to dedicated sites that are at least 200 feet from intermittent streams should be acceptable (EPA 1983). Permit writers should require permit applicants to demonstrate that run-off control measures will protect surface waters from the 24-hour, 25-year storm event.

Application Site Slope Limitations

Permit writers should consider prohibiting dedicated site disposal of sludge on slopes equal to or greater than 12 percent (EPA 1983).

Seasonal Limitations

Unless the permit writer is assured that run-off control and ground-water protection measures will adequately protect surface and ground waters, the permit writer should consider writing the seasonal limitations recommended for agriculture into the permit.

Depth to Ground Water and Leachate Control

Generally, permit writers should consider prohibiting disposal of sludge on dedicated sites where an underground drinking water source (any aquifer with less than 10,000 mg/l of dissolved solids) is less than 10 feet from the surface of the soil (EPA 1983). Seasonal, perched ground waters require less protection (EPA 1983). Permit writers should consult ground-water protection staff (Appendix B) with any questions regarding the classification of aquifers. Disposal on dedicated sites with less than 10 feet of depth to ground water may be acceptable if appropriate measures are taken to protect ground waters from leachate from the site.

To protect ground waters from contamination, permit applicants should be required to demonstrate that leachate from their dedicated disposal site will be controlled in one of the following ways:

- The local climate is arid with a high net evaporation, and underground drinking water sources are deep;

- An impervious geological barrier (e.g., bedrock or thick clay) lies between the site and the underground drinking water source effectively preventing percolation of volumes of leachate which could contaminate these sources;

- A below ground leachate interception system will be constructed (e.g., drain tiles, well points, etc.) which will collect the leachate before it can percolate into the aquifer; or

- The volume of leachate reaching the aquifer is such a small percentage of the ground-water aquifer flow volume that potential degradation is negligible (EPA 1983).

Permit writers should require that any collected leachates be disposed of in a manner that complies with all Federalrequirements, and should consider requiring any additional measures that may be necessary to protect public health and the environment.

Distance to Wells Used for Drinking Water

To provide a margin of safety, permit writers should consider requiring a minimum setback distance of 1,000 feet from wells used for drinking water (EPA 1983). Permit writers should consult with ground-water program officials to determine if a State wellhead protection program has set other requirements. It may be appropriate to require testing for nitrates in water drawn from nearby wells.

Access Controls

Permit writers should consider prohibiting application of sludge to dedicated disposal sites located within 500 feet of areas used by the public. If residential dwellings or other heavy public use areas are adjacent to the site, a 2,000 foot buffer is recommended (EPA 1983). Unless a dedicated disposal site is located in a very remote area, permit writers should consider requiring that the site be enclosed by a fence with locking gates.

6.6.4 ADDITIONAL MONITORING RECOMMENDATIONS FOR DEDICATED LAND DISPOSAL

In general, to check for possible ground-water pollution from leachate, permit writers should require ground-water monitoring. In addition, permit writers should consider requiring that any crops grown for animal feed be tested periodically to ensure that PCBs, cadmium and other metals that may be in high concentrations in the sludge do not pose a threat to the food-chain. If animal feeds are grown, the sludge should be tested for contaminants more frequently than is generally recommended.

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CHAPTER 7
DISTRIBUTION AND MARKETING

7.1 INTRODUCTION

Distribution and marketing refers to the sale or give away of sewage sludge. Distribution and marketing is similar to land application in that the sewage sludge product is generally applied to the land, but is different in that with distribution and marketing there is little or no control over the end use of the product. While land application generally has some sort of a "contract mechanism" between the POTW and the ultimate user which enables control of the end use, often distribution and marketing sludges are sold or given away for "home use" (either bagged or in bulk form). Because the POTW cannot be certain (in most cases) that users will comply with application rates and management practices and because distribution and marketing sludges have a strong likelihood of human exposure, strict contaminant concentration limits, pathogen controls and labeling requirements are appropriate.

Many of the benefits and concerns associated with land application apply to distribution and marketing (D&M) as well. The primary benefits of distribution and marketing relate to the soil conditioning and fertilizer value of sludge, while its primary concern is the possible exposure of the public to sludge contaminants either through direct exposure or introduction to the food chain.

Existing regulations allow the use of D&M sludge products for many different applications such as lawns, shrubs, ornamental plants, and vegetable gardens. Products with moderate to high levels of contaminants are not recommended for application to vegetable gardens, however, because the amount of sludge that is applied cannot be controlled as well as it is in large-scale land application programs. This lack of control raises the possibility that high levels of contaminants might be applied to a given plot of ground. Sludges with low levels of heavy metals and toxic organic compounds, therefore, are most appropriate for D&M programs because they pose less of a risk to home gardeners (EPA 1984a). Three States currently prohibit the use of composted sludge on vegetables or in home gardens. Five additional States prohibit applying sludge to food chain crops in land application programs and may similarly restrict sludge use in D&M programs.

7.1.1 PERMITTING RESPONSIBILITIES

At present, while no Federal regulations are specifically tailored to the distribution and marketing of sludge products, D&M is subject to the same regulations as land application (40 CFR Part 257).

The 40 CFR Part 257 regulations limit cadmium and PCBs in sludge applied to land used for producing food-chain crops (Appendix D, 40 CFR Part 257.3-5). Briefly, these regulations set annual and cumulative loading limits for cadmium, PCBs, and management practices (primarily pH adjustment of the sludge-soil mixture to pH 6.5 or greater to reduce cadmium mobility). Due to the practical difficulty for the POTW in controlling proper application of D&M sludges, permit writers should consider restricting D&M to sludges with very low concentrations of cadmium and PCBs, unless the permit requires the POTW operator to provide a label or handout stating that the sludge should not be used on food-chain crops. Additional permit recommendations for POTWs using D&M programs are provided below under "Case-by-Case Recommendations".

The 40 CFR Part 257 regulations also set pathogen reduction requirements for sludges that are applied to land surface or incorporated into the soil (Appendix D, 40 CFR Part 257.3-6). Briefly, pathogen reduction is required whether or not food-chain crops are grown. Among other conditions, if public access to the sludge application site is controlled for twelve months, the sludge must only be treated by a "Process to Significantly Reduce Pathogens" (PSRP) (e.g., anaerobic digestion, air drying for three months, composting at more than 55°C for four hours, lime stabilization). If the public will have access to the site within a year of sludge application, or if the edible portion of a food-chain crop that is grown within eighteen months of application will contact the sludge (e.g., root crops such as beets and potatoes or low-growing crops such as bush beans and strawberries), a "Process to Further Reduce Pathogens" (PFRP) is required (e.g., composting at more than 55°C for three days or heat drying). While it is possible that a D&M sludge product will be used in a manner that will restrict public access for twelve months, because of the uncontrolled use and frequent human contact that characterize use of these products, sludges used in D&M programs must be treated by a PFRP, unless the POTW can ensure that the appropriate public access and food-chain crop restrictions will be met. Examples of D&M programs where PSRP treatment would be adequate are sale of sludge to the operators of a commercial Christmas tree farm who restrict public access to the sludge application sites, or give away of sludge to a parks and recreation department for use in areas where the public will not have access for twelve months.

7.2 TECHNOLOGY GUIDELINES

Due to the high potential for public contact in distribution and marketing operations, the technologies applied to the distribution and marketing of wastewater sludge are primarily those which meet the Federal criteria for Processes to Further Reduce Pathogens (PFRP) as defined in 40 CFR Part 257. If, however, the POTW can provide documentation that appropriate public

access and food-chain crop restrictions will be met, Processes to Significantly Reduce Pathogens (PSRP) may be considered. The PSRP criteria and procedures are outlined in Chapter 6. The PFRP criteria and other design and operational criteria for specific distribution and marketing technologies are presented later in this chapter. Heat-dried or composted sludges usually meet PFRP criteria and are commonly used in D& M programs because they have high solids content and are therefore easily handled by the user (EPA 1984a). Currently most POTWs with D&M programs compost their sludge.

Composting

In 1985, there were 115 sludge composting facilities in operation in the United States (EPA 1984a, 1985a). Wastewater sludge composting operations entail mixing dewatered sludge with a bulking agent, such as wood chips, straw, or previously composted sludge, and then allowing the mixture to decompose aerobically to produce a humus-like product which may be used as a soil conditioner or fertilizer. The purpose of the bulking agent is to lower the moisture content and to enhance sludge porosity so that air can be drawn through compost piles (EPA 1984a).

General guidelines for efficient biological processes in composting include the following:

- The incoming sludge should be dewatered and have a solids content in excess of 25 percent (Sludge Composting and Improved Incinerator Performance, EPA 1984b).

- The sludge-bulking agent mixture should have a volatile solids content greater than 50 percent, a moisture content no greater than 60 percent for static pile and windrow composting and 65 percent for within-vessel composting, and a pH in the range of 6 to 9 standard units. Composting is possible at higher pH values though more time is required (EPA 1985b).

- Sludge is normally composted for 21 to 30 days, during which time the temperature typically reaches temperatures of 55°C or higher (EPA 1984a). The high temperatures (thermophilic range of 50° to 70°C) provide efficient pathogen destruction. Within-vessel systems require less composting time, typically 14 to 20 days.

- After composting, the product is allowed to cure for approximately 30 days, and then is often stored for 60 to 90 days following curing to ensure that the final product is dry and has no residual odors (EPA 1984a). Within-vessel systems require less time for curing, typically 20 days (EPA 1984b).

- The product is typically screened before or after curing to recover as much bulking agent as possible.

The three composting methods most often employed in the United States are (1) windrow composting, (2) static aerated piles, and (3) within-vessel composting.

Window Composting

The window composting method involves placing the sludge-bulking agent mixture in long, open-air piles. The sludge is turned frequently to ensure an adequate supply of oxygen throughout the compost pile and to ensure that all parts of the pile are exposed to temperatures capable of killing all pathogens and parasites. Daily turning may be required at first when the system has a high oxygen demand, but turning three times per week should be sufficient thereafter. Windrow composting can be adversely affected by cold or wet weather and is difficult to control when raw sludge is used (EPA 1984a).

Static Aerated Piles

For static aerated piles, the sludge-bulking agent mixture is placed in rectangular piles that are supplied with air by blowers connected to perforated pipes running under the piles. The blowers draw or blow air through the piles, assuring even distribution of air throughout the composted sludge. An aeration rate of about 500 cubic feet per hour per ton of dry sludge is needed to maintain the desired oxygen level of 5 to 15 percent throughout the pile (EPA 1979). The aeration rate must be adequate to maintain aerobic conditions but may be decreased somewhat to prevent cooling and maintain adequate temperatures for pathogen destruction. Aeration rates of 300 to 350 cubic feet per hour per dry ton are recommended and 1/3 hp blowers are typically used for up to 30 dry tons of sludge (EPA 1984b). Many static pile systems use 1 to 5 hp blowers that are cycled on and off (EPA 1985b).

Placing a layer of previously composted sludge over the surface of the pile helps to insulate the pile and assure that sufficient temperatures are attained throughout the pile. Because the piles do not have to be turned, and because the sludge is insulated by an outer layer of previously composted sludge, static aerated piles are less affected by cold and wet weather than windrow composting (EPA 1984a).

Within-Vessel Composting

This technique involves placing the sludge-bulking agent mixture in completely enclosed containers, where environmental conditions such as temperature and oxygen supply can be closely monitored and controlled. This process is particularly desirable in cold climates or where land is limited.

The ratio of bulking agent to sludge is typically lower in within-vessel composting than with other methods. Ratios of bulking agent to sludge range from 3:1 to 4:1. Within-vessel systems have higher capital cost but allow better process control and often have lower operating cost (EPA 1984b).

Composting Processes to Further Reduce Pathogens

Composting operations must meet the following requirements to qualify as a PFRP as defined in 40 CFR Part 257:

> "Using the within-vessel composting method, the solid waste is maintained at operating conditions of 55°C or greater for three days. Using the static aerated pile composting method, the solid waste is maintained at operating conditions of 55°C or greater for three days. Using the windrow composting method, the solid waste attains a temperature of 55°C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow."

Monitoring is essential to ensure adequate composting performance. Parameters such as temperature, air flow, and CO_2 and/or oxygen levels (with tubes in piles or in the off-gas or within-vessel systems) should be checked regularly at a number of locations in the compost pile. Air flow for static aerated piles and particularly for within-vessel systems may be adjusted based on these measurements. An atmosphere containing 5 to 15 percent oxygen is required throughout the pile to ensure aerobic conditions (EPA 1985b).

Product maturity may be gauged by pathogen levels or odor, or by tracking a number of other parameters. These measures include CO_2, and the evaluation of changes in the carbon:nitrogen (C:N) ratio (EPA 1984b).

The composting conditions outlined in the regulations for PSRP and PFRP, when met, reduce all pathogenic viruses, bacteria and parasites to the desired densities. However, composting under these conditions may not adequately reduce vector attraction. Generally longer composting times of 7 days or more for within vessel and 17 or more days for static aerated pile and windrow should be sufficient to fully stabilize the sludge. (EPA 1989).

Heat Drying

Heat drying involves heating the sludge to a temperature of about 80°C for a short period of time to destroy pathogens and to reduce sludge volume by removing most of the water. Heat-drying is an expensive process and hence is typically used only where there is a good market for the resultant product which is a good soil conditioner/fertilizer. Heat-drying is typically accomplished with either a flash drier or a rotary kiln (EPA 1979). Heat-drying can result in contamination of the air by particulates and volatile compounds to the point that air pollution control devices may be necessary. Air pollution control equipment is discussed in Chapter 8. Since moisture creates an environment favorable for regrowth of organisms, heat-dried sludge should not be allowed to become rewetted.

A heat drying facility must meet the following requirements to qualify as a PFRP as defined in 40 CFR Part 257:

> "Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80°C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80°C."

Air Drying

Air drying of sludge is performed by placing sludge on under-drained sand beds, or paved or unpaved basins in which the sludge is placed at a depth of approximately six to twelve inches depending on factors such as: moisture content of the sludge; number of drying beds available; dewatering characteristics of the sludge, desired operating routine; and the weather (precipitation and evaporation rate) expected for the site. Dewatering typically proceeds for a minimum of three months with average temperatures over 0°C. Covered drying beds are preferred where annual rainfall rates approach or exceed annual evaporation rates.

Air drying is a fairly inexpensive and effective means of dewatering sludge. However, air drying does not qualify as a PFRP see 40 CFR Part 257 Appendix II) and hence air-dried sludge may not be suitable for many distribution and marketing programs without further treatment. Coupling air drying with pasteurization, gamma ray irradiation, beta ray irradiation, or other approved pathogen reduction methods can qualify as a PFRP.

Chemical Processes

Chemical processes may be used in conjunction with distribution and marketing operations to provide the supplemental disinfection necessary to make a process such as air drying qualify as a PRFP. Chemical processes such as CHEMFIX may also be used to solidify sludge into a cement matrix. Whether or not a sludge that has been treated by chemical processes is suitable for distribution and marketing will depend on the chemical properties of the sludge (pH, organic content, availability of plant nutrients, etc.) as well as the contaminants that remain in the product, and whether there is any market for this product.

7.3 CHARACTERISTICS OF SLUDGES SUITABLE FOR DISTRIBUTION AND MARKETING

D&M uses of sludge take advantage of the soil conditioning and fertilizer value of sewage sludge in a manner very similar to land application of sludge. Consequently, the exposure pathways and effects of sludge contaminants are similar for land application.

7.3.1 SLUDGE POLLUTANT CONCENTRATION LIMITS

Federal Regulations

The Federal regulations limit cadmium, PCBs, and pathogens in sludge applied to or incorporated into the surface of the land (40 CFR Part 257). Currently, no Federal requirements limit contaminants in D&M sludge products that are used on non-food-chain crops. (Recommended limits are summarized below.)

Cadmium

Federal regulations (40 CFR Part 257. 3 -5) provide a maximum allowable annual application rate of 0.5 kilograms of cadmium per hectare for all food chain crops including tobacco. The

maximum allowable cumulative loading rate is 5 kilograms per hectare, (kg/ha). If the soil and the mixture of soil and sludge has a pH of at least 6.5 standard units, the maximum allowable cumulative loading is 5 kg/ha for soil cation exchange capacities (CECs) less than 5 meq/100 g, 10 kg/ha for CECs between 5 and 15 meq/100 g, and 20 kg/ha for CECs over 15 meq/100g. Additionally, the pH restriction may be waived when the sludge contains cadmium at concentrations of 2 mg/kg (dry weight) or less. It should be noted that with distribution and marketing since the municipality typically has little control over what is ultimately done with the sludge, it would be difficult to ensure compliance with the cadmium loading requirements unless cadmium concentrations in the sludge were very low.

PCBs

The Federal regulation 40 CFR Part 257.3-5 stipulates that sewage sludge containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight) must be incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals producing milk. Incorporation of the solid waste into the soil is not required if it is assured that the PCBs content is less than 0.2 mg/kg (actual weight) in the animal feed or less than 1.5 mg/kg (fat basis) in the milk.

If the concentration of PCBs is 50 ppm or greater, the sludge is subject to the requirements of the Toxic Substances Control Act (40 CFR Part 761) and is not appropriate for distribution and marketing operations.

Pathogens and Disease Vectors

The Federal regulations set pathogen reduction requirements for sludges that are applied to the land surface or incorporated into the soil (40 CFR Part 257.3-6). Pathogen reduction is required whether or not food-chain crops are grown. If public access to the sludge application site is controlled for twelve months, and grazing by animals is controlled for one month, the sludge must only be treated by a PSRP. If the public will have access to the site within a year of sludge application, animals for human consumption will graze within one month, or if the edible portion of a food-chain crop that is grown within eighteen months of application will contact the sludge a PFRP is required.

Federal Guidance

In the Summary of Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methods and Results (EPA 1985a), EPA evaluated and prioritized the hazards posed by various pollutants for a number of exposure pathways. The incremental index values of toxicity to humans due to consumption of plants fertilized with sludge, or consumption of herbivorous animals that have ingested plants fertilized with sludge are presented in Table 7-1. These are included to provide insight into the types of contaminants that may cause problems in land application or distribution and marketing when they are present in high concentrations (incremental index values less than 1.0 represent negligible toxicity risk or a cancer risk of less than one in one million).

This list is not directly applicable to permitting, but it points out that wastewater sludges with high concentrations of certain compounds, such as PCBs, hexachlorobenzene, chlordane, benzo(a)pyrene, aldrin, dieldrin, and toxaphene should be given careful consideration before a sludge is used in a distribution and marketing program. Additionally, careful monitoring of the sludge product for pollutants with high hazard indices would be appropriate. The need for careful monitoring is especially true for distribution and marketing because the municipality or its contractor typically have little control over what is ultimately done with the sludge. Lack of control over use of the sludge product is also an incentive to limit distribution and marketing to sludges with low levels of heavy metals and toxic organic compounds (EPA 1984a).

Because in most cases the POTW cannot be certain that users will comply with application rates and management practices and because distribution and marketing sludges have a strong likelihood of human exposure, strict contaminant concentration limits, pathogen controls and labeling requirements are appropriate.

The 1984 report of EPA's Intra-Agency Sludge Task Force, Use and Disposal of Municipal Wastewater Sludge (EPA 1984a), recommends the following maximum heavy metal concentrations for wastewater sludge composts that are distributed and marketed without restriction:

Cadmium	12.5 -30 mg/kg (dry weight)
Copper	500 -900 mg/kg (dry weight)
Lead	285 -1,000 mg/kg (dry weight)
Nickel	100 -200 mg/kg (dry weight)

TABLE 7-1

INCREMENTAL INDEX VALUES OF TOXICITY TO HUMANS

Toxicity from Plant Consumption		Toxicity from Animal Ingestion	
Compound	Incremental Index	Compound	Incremental Index
PCBs	14,953	PCBs	84,953
Hexachlorobenzene	4,295	Hexachlorobenzene	1,345
Chlordane	3,100	Chlordane	1,095
Benzo(a)pyrene	2,880		
Aldrin/Dieldrin	1,300	Chlordane	180
Toxaphene	1,245	DDT	151
		Aldrin/Dieldrin	100
Cadmium	95		
DDT	51	Selenium	15.7
Zinc	16 4	Heptachlor	7 0
Heptachlor	15	Zinc	3.7
Nickel	11 9	Mercury	2.75
Lead	8 2	Cadmium	2 5
Selenium	6 8		
Arsenic	1 5		
Iron	1 1		
Mercury	1 0		
Fluoride	0 4		

Source: EPA 1985a.

Zinc	1,250 -1,800 mg/kg (dry weight)
Mercury	5 mg/kg (dry weight)

To support these recommendations the Task Force cites the 1981 joint EPA, Food and Drug Administration (FDA) and U.S. Department of Agriculture (USDA) Land Application of Municipal Sewage Sludge for the Production of Fruits and Vegetables: A Statement of Federal Policy and Guidance (EPA 1981), the Maryland Environmental Service operating manual for sewage sludge compost for the Blue Plains wastewater treatment plant (MES 1984) and others. EPA believes that these recommended limits for composts are suitable for other forms of D&M sludge products as well (e.g., heat-dried sludges). Thus, with the exception of the lead limit (discussed in the next paragraph below), permit writers should consider requiring POTWs to meet the heavy metal concentrations recommended in the 1984 Task Force Report in all D&M sludge products, unless the POTW provides labels or handouts stating that the sludge product is not to be used on home vegetable gardens.

Since 1984, EPA has learned more about the subtle, negative effects of lead at very low concentrations in the blood, and the Agency is concerned about the implications for sensitive populations which include children and young adults. While it appears that the risk posed by lead in D&M sludge products is low, particularly when compared to other sources of exposure to lead, permit writers should consider imposing D&M lead limits at the lower end of the range recommended in the Task Force report, unless the POTW provides labels or handouts stating that the sludge product is not to be used on home vegetable gardens.

Another good source of Federal guidance is the 1984 USDA Agricultural Research Service publication Utilization of Sewage Sludge Compost as a Soil Conditioner and Fertilizer for Plant Growth. This document recommends maximum sludge metal applications for privately-owned croplands as shown in Table 7-2. The document cites a 1982 paper by R.L. Chaney of the USDA as a source for these recommendations (Chaney, 1982).

The guidance on annual and cumulative application limits will help the permit writer determine the appropriate application rate for D&M sludges (as described more fully below in the section on recommended management practices, the permit writer should consider requiring the POTW to include application rate information in labels or handouts given to the user of D&M sludges.)

TABLE 7-2
MAXIMUM METAL APPLICATION[1] (KG/HA) FOR UNAMENDED SOIL AT INDICATED SOIL CATION EXCHANGE CAPACITY (CEC)

	CEC[2]		
Metal	0.5	5-15	15
Cadmium	5	10	20
Nickel	50	100	200
Copper	125	250	500
Zinc	250	500	1,000
Lead	500	1,000	2,000

[1]Cadmium limits have the force of regulation (40 CFR Part 257). Annual Cd application should not exceed 0.5 kg/ha. All recommendations apply only to soils adjusted to pH 6.5 when sludge is applied and maintained at no less than pH 6.5 thereafter.
[2]meq/100 g.

For toxic organic compounds in sludges applied to lands, the Federal government has only set the regulatory limits for PCBs described above. The Intra-Agency Task Force report recommends that distribution and marketing is most appropriate for sludges with low levels of toxic organic compounds. However, it does not provide any recommended maximum contaminant concentrations levels. The 1981 joint EPA/FDA/USDA policy on sludge use for producing fruits and vegetables recommends a 10 mg/kg PCB concentration limit. This guidance assumes that carrots are washed and peeled prior to consumption.

State Requirements

Pollutant Concentration Limits

Specific pollutant concentration limits addressed in State regulations are provided in Appendix E, Table E7-1. State information is taken from the EPA sludge database (EPA 1987). Permit writers should verify concentration limits with the State regulatory agency to ensure that the limits are current.

Sludge Loading Limits

Seven States have loading limits for distribution and marketing. The reported loading limits include: 10 dry tons per acre with cadmium levels less than 25 mg/kg (Illinois); site approval

requirement if over 100 yd^3 is to be used (New Jersey); 2 cubic yards per year-person (Pennsylvania); a notation that loading limits are required for uncontrolled use (Texas); and 5 to 20 kg/ha of cadmium on food chain crops (Washington). Virginia and New Hampshire also have restrictions on sludge loading.

Case-by-Case Recommendations

The permit writer should review applicable State contaminant concentration limits for sludges used in D&M programs (Table 7-3). For the heavy metals addressed by EPA, the median and mode of State limits fall within the range of limits EPA recommends. For PCBs, the median and the mode of eight States' limits is 2 mg/kg -- 20 percent of EPA's management practice threshold for lands used to produce feed for food-chain animals and recommended limit for fruit and vegetable production. Nationally, EPA recommends that permit writers consider requiring D&M sludges to meet a 10 mg/kg PCB concentration limit. For POTWs in the seven States with stricter PCB limits (California, Maryland, New Jersey, New York, Ohio, Texas and Wisconsin), permit writers should consider imposing the State requirement but should consult with State officials to determine the basis for the more restrictive limit.

At this time, EPA defines a high quality sludge as one with heavy metal concentrations that fall within the ranges recommended in the 1984 Task Force Report (as noted above, lead concentrations should fall below the low end of the recommended range). PCB concentrations should not exceed 10 mg/kg (dry weight). However, if a POTW provides the user of its D&M product with a label (bagged product) or a handout (bulk distribution) that clearly states that the product is not to be used on food-chain crops, EPA believes that heavy metal and PCB concentrations could safely exceed the levels recommended for high quality sludges by a factor of two or three (lead concentrations should not exceed the 1984 recommendation by more than a factor of 1.5).

Because of the lack of control over the end use of D&M sludges, permit writers should opt for sludge quality limits rather than loading restrictions. Where this is not practical the permit writer should require the POTW to label the sludge product with application or loading specifications based on sludge quality. If pollutant concentrations are excessively high, the permit writer should prohibit the uncontrolled distribution and marketing of the sludge.

TABLE 7-3
SUMMARY OF CURRENT STATE SLUDGE CONTAMINANT LIMITS FOR DISTRIBUTION AND MARKETING

Contaminant	No of States Regulating	Max Product Conc. (mg/kg)		
		Median	Mode	Range
Aldrin/Dieldrin	1	1	1	1
Cadmium	10	23	25	2-40
Chlordane	1	.1	.1	1
Chromium	2	1,000	1,000	1,000
Copper	8	800	500	500-1,200
DDT/DDE/DDD	1	25	0 25	25
Heptachlor	1	1	1	1
Lead	10	500	500	300-4,800
Lindane	1	1	1	1
Mercury	5	5	5	5-10
Molybdenum	1	10	10	10
Nickel	8	200	200	100-1,250
PCB	8	2	2	5-10
Toxaphene	1	1	1	1
Zinc	8	1,663	1,250	1,000-2,500

Source EPA 1987

7.3.2 PHYSICAL PROPERTIES

Wastewater sludge should be dewatered prior to applying a process such as composting in order to assure a product suitable for distribution and marketing. Six States are reported to require sludge dewatering and five States are reported to require stabilization for distribution and marketing operations (Table E7-4, State Sludge Treatment/Management Requirements).

7.4 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

This section contains Federal regulations and guidance, State requirements and case-by-case recommendations for the permit writer to use in developing permit conditions for the operating conditions and management practices for distribution and marketing.

Distribution and marketing management practices reported by the States are presented in Table E7-2, State Management Practice Requirements, and Table E7-3, State Site Specific Requirements.

7.4.1 SURFACE WATER PROTECTION

Federal Regulations

A facility or practice shall not cause a discharge of pollutants that is in violation of the NPDES regulations, a discharge of dredged or fill material that is in violation of Section 404 of the CWA or cause non-point source pollution (40 CFR Part 257.3-3).

Federal Guidance

Runoff from compost facilities should be collected and treated. Sludge treatment facilities and sludge disposal sites for treated sludge must not cause non-point source pollution of waters of the United States or violate an areawide or Statewide water quality management plan that has been approved under Section 208 of the Clean Water Act, as amended.

State Requirements

Seven States report requirements for the minimum distance to the nearest surface water (Table E7-3). The reported requirements were a minimum distance of 200 feet (Illinois), 200 feet and not in a

water supply watershed (Rhode Island), 50 to 200 feet (Utah), 50 feet (Virginia), 25 feet for a drainage ditch, and 50 to 300 feet to a stream depending on its classification (Maryland).

Eleven States require run-off control (see table E7-2).

Case-by-Case Recommendation

The permit writer should evaluate whether the imposition of buffer zones or run-off collection structures are necessary to protect surface water.

7.4.2 GROUND-WATER PROTECTION

Federal Regulations

Federal regulation (40 CFR Part 257.3-4) forbids the contamination of existing or potential underground drinking water sources by the disposal of non-hazardous solid waste, including sludges generated by treatment of domestic sewage. Maximum ground-water contaminant levels are specified in Appendix I of 40 CFR Part 257.

Federal Guidance

Composting operations (mixing, composting, curing, and storage) should always be performed on impervious (i.e., concrete or asphalt) surfaces to prevent migration of leachate to the ground-water. Leachate collection facilities and/or ground-water monitoring should be considered for facilities where there is potential for contamination.

State Requirements

Eight States report requirements on an acceptable distance between composting facilities and nearby wells. The reported requirements for a minimum distance to a drinking water well range from 100 feet in Virginia to 1,000 feet in Rhode Island.

7.4.3 STORAGE

Federal Guidance

A significant amount of storage is provided by the composting operation itself. However, 6 to 9 months of additional storage may be necessary depending on site climate, seasonal fluctuation in the compost market, and the potential need for further drying or reduction of odors. To maintain product quality, storage facilities should protect the finished compost from contamination and rainfall that would create run-off or leachate (EPA 1984a).

Some storage of sludge prior to composting may also be necessary to facilitate system operation and to provide a back-up in the event of system problems.

State Requirements

Eight States have requirements for storage as a management practice (EPA 1987). States which specify a minimum storage time are New Hampshire (30 days), New York (50 days), and Virginia (60 days).

7.4.4 BUFFER ZONES/ACCESS CONTROLS

Federal Regulation

Federal regulations state that a facility shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards.

State Requirements

Eleven States require buffer zones/access control for compost facilities (see Table E7-3). The State of Nevada requires a minimum buffer of 500 feet to the property line and 1000 feet to the nearest road. The State of Rhode Island requires a minimum distance of 400 feet to the nearest dwelling. Three other States reported minimum distance buffer requirements.

7.4.5 CROP USE LIMITS

State Requirements

Thirteen States reported crop use limits (Table E7-3). These limits apply primarily to human food chain crops. The only reported numerical limit was a Maryland requirement that a product with over 45 percent iron (dry weight basis) must be labeled to warn against use on pasture. An example label is seen in Appendix C.

Case-by-Case Recommendations

Information gathered by EPA (EPA 1987) shows that three States (New Hampshire, Arkansas and Minnesota) prohibit use of D&M sludge products on vegetables or in home gardens. Three additional States prohibit applying sludge to home gardens (Connecticut), to fruits and vegetables (Oregon), or on all food-chain crops (Rhode Island) in land application programs, and may similarly restrict sludge use in D&M programs. While States may place whatever restrictions on sludge use they believe to be appropriate, as a national recommendation, EPA supports the use of high quality sludges by home gardeners on all food-chain crops including fruits and vegetables.

7.4.6 OTHER CONDITIONS

Case-by-Case Recommendations

Allowing only specific contractors to distribute and/or market sludge products would provide much better control over the final use than would general distribution to the public. Although this requirement may limit the size of the product market for the municipality, it may be appropriate nevertheless where variability of sludge quality makes the screening or qualification of D&M users a wise precaution in order to assure compliance with applicable requirements and the safe use and disposal of the product.

7.5 MONITORING, REPORTING, RECORD KEEPING AND LABELING

Monitoring the sludge, the treatment process, and the sludge product quality is essential in a distribution and marketing program from both an operational and marketability standpoint as well as for protection of the environment and the public health. The primary concern with D&M programs is contaminants in the sludge product and the subsequent public contact with the product.

From a regulatory standpoint, heavy metals, toxic organics and primary pathogens such as viruses, bacteria, protozoa, and parasites, are the major public health concerns.

The success of a D&M program is largely influenced by the ability to produce a consistent product quality, both physical (e.g., consistent moisture content) and chemical (e.g., consistently low contaminant concentrations). Producing a consistent product involves periodic monitoring of the sludge quality, the treatment process, and the final sludge product.

7.5.1 POLLUTANT CONCENTRATION MONITORING

Since composting is a biological process, it does not eliminate heavy metals. Any metals in the sludge will be present in the compost in virtually the same quantities although some metals and volatile organic compounds may be driven off in the off-gas from a heat-drying process. The distinction to be made between quantity and concentration is that while composting may cause the concentration of a contaminant to change, because bulking agents have been added and the moisture content has changed, the quantity of a conservative contaminant will remain essentially the same as a given mass of sludge undergoes composting. The heavy metals and other contaminants of concern in D&M sludge products were discussed in Section 7.2

Federal Regulations

The current regulations in 40 CFR Part 122.44(c)(2) require sludge monitoring and reporting at a frequency dependent upon the nature and effect of the permittee's sludge use or disposal activities, but at least once a year for every pollutant limited in the permit. This means that if the permit contains a limit for PCB's for example, the permittee, must monitor its sludge at least annually for this pollutant.

Federal Guidance

The Sewage Sludge Interim Permitting Strategy recommends annual monitoring of the 126 priority pollutants as well as more frequent monitoring of the pollutants for which numeric limits have been proposed in the 40 CFR Part 503 Technical Sludge Standards. For the reuse practice of Distribution and Marketing, these proposed 40 CFR Part 503 pollutants include:

Aldrin/Dieldren	Arsenic
Benzo(a)pyrene	Cadmium

Chlordane	Chromium
Copper	DDT/DDE/DDD (total)[1]
Heptachlor	Hexachlorobenzene
Hexachlorobutadiene	Lead
Lindane	Mercury
Nickel	PCBs
Selenium	Toxaphene
Zinc	

It is suggested that heavy metals and toxic organics be monitored initially in the sludge to determine the suitability of the sludge for distribution and marketing, and to decide if its use or distribution should be restricted because of the concentration levels of certain contaminants.

State Requirements

Ten States require sludge and/or sludge product quality monitoring. Three States specify parameters to monitor.

One State (Rhode Island) requires an annual EP toxicity test on the sludge.

Two States specify monitoring frequency. California bases sampling frequency on the size of the treatment plant. Monthly monitoring of the compost is required by Ohio. Each of the State monitoring programs for distribution and marketing are described in Table E7-5. State monitoring and reporting requirements for sludge and compost are provided in Table E7-5.

Case-by-Case Recommendations

The contaminants listed below should be considered in any sludge or sludge product quality monitoring program.

Cadmium	Nickel	Cyanide	Pathogens
Chromium	Zinc	PCBs	Salmonella
Copper	Nitrogen	Sodium	

[1] DDT-2,2-Bis(chlorophenyl)-1,1,1-trichloroethane
DDE-1,1-Bis(chlorophenyl)-2,2-dichloroethane
DDD-1,1-Bis(chlorophenyl)-2,2-dichloroethane

Lead	Phosphorus	BOD
Mercury	Potassium	pH

Permit writers should require monitoring for limited parameters in the sludge product rather than the sludge used to make a product. Because of the limited control over use of D&M products and, typically, the frequent human contact with these materials, monitoring should be required more frequently than is generally recommended.

7.5.2 TREATMENT PROCESS MONITORING

Federal Guidance

During the composting process, temperatures should be monitored regularly until temperatures recorded in the compost (or off-gas from a heat-drying process) exceed the level and duration required for adequate pathogen destruction.

Oxygen should also be monitored periodically to insure that aerobic conditions are maintained. Operating parameters of other pathogen reduction processes should also be closely monitored. Research has shown pathogen regrowth to occur in compost and drying facilities. This kind of a problem can be taken care of by additional composting, covering of the compost and additional monitoring of total coliforms.

Four states have temperature monitoring requirements. As noted in the previous discussion of technologies and operating guidelines, temperature monitoring is essential for composting and, of course, heat drying. Temperature monitoring is necessary to demonstrate compliance with the Federal requirements for Processes to Further Reduce Pathogens (PFRP).

7.5.3 SOIL MONITORING

Nebraska, which requires semiannual soil analysis for leachate detection, was the only State to report a soil analysis requirement.

7.5.4 REPORTING AND RECORD KEEPING

Federal Requirements

The recently promulgated revisions to the NPDES permitting regulation (54 FR 18716) require the permittee to report monitoring results with a frequency dependent upon the nature and effect of the sewage sludge use or disposal practice, but in no case less than one year. These revisions also require that records of monitoring required by the permit for the permittee's sewage sludge use and disposal activities must be retained for a period of at least 5 years [40 CFR Part 122.21(p)].

State Requirements

Fourteen States require some form of reporting and record keeping. Most States require records detailing who received the sludge, how much was received, and what the intended uses were. Some States require maintenance of all sludge and sludge product analytical records. Oklahoma requires all quantity, destination, quality, and use agreement records to be held for 5 years.

Reporting frequency varies from State-to-State and consists of monthly, quarterly, annual, and periodic reporting schedules (See Table E7-5).

Case-by-Case Recommendations

POTWs should be required to report the amount of product distributed in bulk form and in bags. Permit writers should also consider requiring POTWs to keep a log of persons or entities that receive more than 10 cubic yards of material per month (approximately the amount that would fill two large dump trucks).

7.5.5 PRODUCT LABELING

Federal Guidance

At a minimum, labels for bagged sludge or sludge products for D&M should specify the nitrogen, phosphorus, and potassium content of the sludge or sludge product as a percent of the sludge or sludge product's total weight. The labels do not have to specify the concentration of contaminants in the sludge but should state that the information is available upon request. The POTW (or retailer) should also be required to provide this information upon demand. The label should clearly

state any unacceptable uses of the D&M product and recommend application rates. See Appendix C for examples of D&M product labels.

State Requirements

Sixteen States require the labeling of D&M sludges. A compilation of these requirements is listed below.

- o Identify contents as a sludge product
- o Provide an analytical identification of contents (e.g., N, P, K, metals)
- o Place any necessary warnings or cautions in an obvious place
- o List restrictions on use
- o Recommend safe uses and application rates

West Virginia requires that the product be clearly labeled to indicate that it is not recommended for use in vegetable gardens.

Case-by-Case Recommendations

All bagged D&M products should be labeled. For products that are marketed as fertilizers (e.g., heat-dried sludge) rather than as soil conditioners (e.g., compost), labels should specify the nitrogen, phosphorus, and potassium content of the product as a percent of the total weight. If the product contains concentrations of contaminants exceeding the guidance for unrestricted distribution, the label should state that the product should not be used on vegetable gardens.

When writing a permit for a POTW that markets sludge products that are not suitable for home vegetable gardens (e.g., sludges with high levels of metals and PCBs), the permit writer should consult Tables 7-4 through 7-8. These tables show, for a given sludge application rate and a given heavy metal concentration, how many years a sludge product could be applied before exceeding the guidance on cumulative metal loadings to privately owned cropland. Typical application rates and sample calculations (for interpolating between the given application rates and metal concentrations) are also provided. If a sludge product contains contaminants at levels that could potentially preclude future use of the site as cropland after ten typical annual applications, or a single application to establish a soil (i.e., provide a nutrient base) followed by five years of use at maintenance rates, the permit writer should consider requiring that the label state:

TABLE 7-4

YEARS OF APPLICATION IN SI UNITS FOR CADMIUM AND NICKEL

Years of Sludge Application at:
1 tonnes/hectare of Heat-Dried Sludge
1.7 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	8	12	25	55	83	166
Ni	83	125	250	555	833	1,666

Years of Sludge Application at:
3 tonnes/hectare of Heat-Dried Sludge
5 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	2	4	8	18	27	55
Ni	27	41	83	185	277	555

Years of Sludge Application at:
6 tonnes/hectare of Heat-Dried Sludge
10 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	1	2	4	9	13	27
Ni	13	20	41	92	138	277

Years of Sludge Application at:
15 tonnes/hectare of Heat-Dried Sludge
25 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	1	3	5	11
Ni	5	8	16	37	55	111

Years of Sludge Application at:
30 tonnes/hectare of Heat-Dried Sludge
50 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	1	2	5
Ni	2	4	8	18	27	55

Years of Sludge Application at:
60 tonnes/hectare of Heat-Dried Sludge
100 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	1	2
Ni	1	2	4	9	13	27

Years of Sludge Application at:
180 tonnes/hectare of Heat-Dried Sludge
300 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	0	0
Ni	1	0	1	3	4	9

Years of Sludge Application at:
300 tonnes/hectare of Heat-Dried Sludge
500 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	0	0
Ni	0	0	1	1	2	5

Notes:

Composts typically contain 40-50% moisture by weight. This table assumes a 60% solids content, 0.5% total Nitrogen and a weight of 28 pounds per cubic foot.

Heat-dried sludges may contain 5-10% moisture by weight. This table assumes a 100% solids content and 6.0% total Nitrogen.

Based on recommended application rates for Comogro, a widely available sewage sludge compost, typical compost application rates are:

Lawn/Establish (one-time high rate application to build a fertile soil): 111-332 tonnes product per hectare (49-148 tons per acre)

Lawn/Maintenance: 28-56 tonnes product/hectare (12-25 tons/acre)

Ornamentals and Nursery Crops/Establish: 129-480 tonnes product/hectare (58-214 tons/acre)

Ornamentals and Nursery Crops/Maintenance: 18-37 tonnes product/hectare (8-16 tons/acre)

Based on recommended application rates for Milorganite, a widely available heat-dried sludge, typical application rates for heat-dried sludge are:

Lawn Maintenance: up to 6 tonnes product/hectare (2.7 tons/acre-yr)

Ornamentals: up to 2.4 tonnes product/hectare (1.1 tons/acre-yr)

TABLE 7-5

YEARS OF APPLICATION IN SI UNITS FOR COPPER, LEAD, AND ZINC

Years of Sludge Application at:
1 tonnes/hectare of Heat-Dried Sludge
1.7 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	23	34	46	69	83	125	138
Pb	92	138	185	277	333	500	555
Zn	23	34	46	69	83	125	138

Years of Sludge Application at:
3 tonnes/hectare of Heat-Dried Sludge
5 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	7	11	15	23	27	41	46
Pb	30	46	61	92	111	166	185
Zn	15	23	30	46	55	83	92

Years of Sludge Application at:
6 tonnes/hectare of Heat-Dried Sludge
10 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	3	5	7	11	13	20	23
Pb	15	23	30	46	55	83	92
Zn	7	11	15	23	27	41	46

Years of Sludge Application at:
15 tonnes/hectare of Heat-Dried Sludge
25 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	1	2	3	4	5	8	9
Pb	8	9	12	18	22	33	37
Zn	3	4	6	9	11	16	18

Years of Sludge Application at:
30 tonnes/hectare of Heat-Dried Sludge
50 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	1	1	2	2	4	4
Pb	3	4	6	9	11	16	18
Zn	1	2	3	4	5	8	9

Years of Sludge Application at:
60 tonnes/hectare of Heat-Dried Sludge
100 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	1	1	2	2
Pb	1	2	3	4	5	8	9
Zn	0	1	1	2	2	4	4

Years of Sludge Application at:
180 tonnes/hectare of Heat-Dried Sludge
300 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	1	1	1	2	3
Zn	0	0	0	0	0	1	1

Years of Sludge Application at:
300 tonnes/hectare of Heat-Dried Sludge
500 tonnes/hectare of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	0	0	1	1	1
Zn	0	0	0	0	0	0	0

Notes:

Composts typically contain 40-50% moisture by weight. This table assumes a 60% solids content, 0.5% total Nitrogen and a weight of 28 pounds per cubic foot.

Heat-dried sludges may contain 5-10% moisture by weight. This table assumes a 100% solids content and 6.0% total Nitrogen.

Based on recommended application rates for Compgro, a widely available sewage sludge compost, typical compost application rates are:

Lawn/Establish (one-time high rate application to build a fertile soil): 111-332 tonnes product per hectare (49-148 tons per acre)

Lawn/Maintenance: 28-56 tonnes product/hectare (12-25 tons/acre)

Ornamentals and Nursery Crops/Establish: 129-460 tonnes product/hectare (58-214 tons/acre)

Ornamentals and Nursery Crops/Maintenance: 18-37 tonnes product/hectare (8-16 tons/acre)

Based on recommended application rates for Milorganite, a widely available heat-dried sludge, typical application rates for heat-dried sludge are:

Lawn Maintenance: up to 6 tonnes product/hectare (0.65 tons/acre-yr)

Ornamentals: up to 2.4 tonnes product/hectare (1.1 tons/acre-yr)

TABLE 7-6

YEARS OF APPLICATION IN ENGLISH UNITS FOR CADMIUM AND NICKEL

Years of Sludge Application at:
3 lb/100 sq ft of Heat-Dried Sludge
5 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	5	8	17	37	56	113
Ni	56	85	170	379	568	1,137

Years of Sludge Application at:
5 lb/100 sq ft of Heat-Dried Sludge
8 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	3	5	10	22	34	68
Ni	34	51	102	227	341	682

Years of Sludge Application at:
15 lb/100 sq ft of Heat-Dried Sludge
25 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	1	1	3	7	11	23
Ni	11	17	34	75	113	227

Years of Sludge Application at:
30 lb/100 sq ft of Heat-Dried Sludge
50 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	1	3	5	11
Ni	5	8	17	37	56	113

Years of Sludge Application at:
60 lb/100 sq ft of Heat-Dried Sludge
100 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	1	2	5
Ni	2	4	8	18	28	56

Years of Sludge Application at:
150 lb/100 sq ft of Heat-Dried Sludge
250 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	1	2
Ni	1	1	3	7	11	22

Years of Sludge Application at:
420 lb/100 sq ft of Heat-Dried Sludge
700 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	0	0
Ni	0	0	1	2	4	8

Years of Sludge Application at:
600 lb/100 sq ft of Heat-Dried Sludge
1,000 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)					
Metal	600	400	200	90	60	30
Cd	0	0	0	0	0	0
Ni	0	0	0	1	2	5

Notes:

Composts typically contain 40-50% moisture by weight. This table assumes a 60% solids content, 0.5% total Nitrogen and a weight of 28 pounds per cubic foot.

Heat-dried sludges may contain 5-10% moisture by weight. This table assumes a 100% solids content and 6.0% total Nitrogen.

Based on recommended application rates for Compgro, a widely available sewage sludge compost, typical compost application rates are:

Lawn/Establish (one-time high rate application to build a fertile soil): 225-680 lb product per 100 sq ft

Lawn/Maintenance: 55-115 lb product per 100 sq ft

Ornamentals and Nursery Crops/Establish: 266-982 lb product per 100 sq ft

Ornamentals and Nursery Crops/Maintenance: 38-76 lb product per 100 sq ft

Based on recommended application rates for Milorganite, a widely available heat-dried sludge, typical application rates for heat-dried sludge are:

Lawn Maintenance: up to 12 lb product per 100 sq ft-yr

Ornamentals: up to 5 lb product per 100 sq ft-yr

TABLE 7-7

YEARS OF APPLICATION IN ENGLISH UNITS FOR COPPER, LEAD, AND ZINC

Years of Sludge Application at:
3 lb/100 sq ft of Heat-Dried Sludge
5 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	11	17	23	34	41	62	69
Pb	46	69	92	138	166	250	277
Zn	23	34	46	69	83	125	138

Years of Sludge Application at:
5 lb/100 sq ft of Heat-Dried Sludge
8 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	2	3	4	6	7	11	12
Pb	8	12	16	25	30	45	50
Zn	4	6	8	12	15	22	25

Years of Sludge Application at:
15 lb/100 sq ft of Heat-Dried Sludge
25 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	1	1	2	3	4	6	6
Pb	4	6	9	13	16	25	27
Zn	2	3	4	6	8	12	13

Years of Sludge Application at:
30 lb/100 sq ft of Heat-Dried Sludge
50 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	1	1	1	2	3
Pb	2	3	4	6	7	11	12
Zn	1	1	2	3	3	5	6

Years of Sludge Application at:
60 lb/100 sq ft of Heat-Dried Sludge
100 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	1	1	1	2
Pb	1	2	2	4	4	7	7
Zn	0	1	1	2	2	3	4

Years of Sludge Application at:
150 lb/100 sq ft of Heat-Dried Sludge
250 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	1	1
Pb	0	1	1	2	3	4	5
Zn	0	0	0	1	1	2	2

Years of Sludge Application at:
420 lb/100 sq ft of Heat-Dried Sludge
700 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	0	0	1	1	1
Zn	0	0	0	0	0	0	0

Years of Sludge Application at:
600 lb/100 sq ft of Heat-Dried Sludge
1,000 lb/100 sq ft of Composted Sludge

	Concentration of Metal in D&M Product (mg/kg)						
Metal	5400	3600	2700	1800	1500	1000	900
Cu	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0

Notes:

Composts typically contain 40-60% moisture by weight. This table assumes a 60% solids content, 0.5% total Nitrogen and a weight of 28 pounds per cubic foot.

Heat-dried sludges may contain 5-10% moisture by weight. This table assumes a 100% solids content and 6.0% total Nitrogen.

Based on recommended application rates for Compgro, a widely available sewage sludge compost, typical compost application rates are:

Lawn/Establish (one-time high rate application to build a fertile soil): 225-680 lb product/100 sq ft

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Ornamentals and Nursery Crops/Establish: 266-982 lb product/100 sq ft

Ornamentals and Nursery Crops/Maintenance: 38-76 lb product/100 sq ft

Based on recommended application rates for Milorganite, a widely available heat-dried sludge, typical application rates for heat-dried sludge are:

Lawn Maintenance: up to 12 lb product/100 sq ft·yr

Ornamentals: up to 5 lb product/100 sq ft·yr

TABLE 7-8

SAMPLE CALCULATIONS FOR YEARS OF APPLICATION

Parameters	SI Unit Tables	English Unit Tables
1. Sludge Loading Rate	1 tonne/hectare-yr	3 lb/100 sq ft-yr
2. Parameter concentration	30 mg Cd/kg sludge	30 mg Cd/kg sludge
3. Parameter cumulative loading limit	5 kg Cd/hectare	5 kg Cd/ hectare
4. Parameter deposition Rate	1 tonne/ha-yr x 1000 kg sludge/tonne x 0.0006 kg Cd/kg sludge = .03 Cd/hectare-yr	3 lb/100 sq ft x 0.045359 kg/lb x 0.00003 kg Cd/kg sludge =0 000041 kg Cd/100 sq ft-yr
5. Years of use at that rate =(Site life/Annual loading)	(5 kg Cd/ha)/(.03 kg Cd/ha/yr) = 166.66 > 166 yr (rounded down to next integer)	(5 kg/ha x ha/107640 sq ft) /(.000041 kg Cd/100 sq ft-yr) =113.29 > 113 yr (rounded down)

> The manufacturer/distributor certifies that this product meets the requirements specified under Federal regulations at 40 CFR Part 257 and has been tested using U.S. EPA protocols. Where the user desires to preserve future, private use of a site for producing crops, this product should not be applied more than ___ times at a cumulative amount of ___ tonnes per hectare (___ tons per acre or ___ pounds per 100 square feet).

All D&M product labels should provide directions for use and recommended application rates. Appendix C contains a number of labels currently in use that provide good information. In addition, permit writers should consider requiring that labels include a statement similar to the one below:

> As with any fertilizer or soil conditioner, this product should be used in a manner that will prevent it from washing into sewer drains or surface waters.

Any D&M product distributed to the public in bulk form (i.e., not bagged) should be accompanied by a flyer that contains the same information recommended for D&M labels. The POTW should also take measures to ensure that any redistributor or broker of the D&M product meets these recommendations for labels and flyers.

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CHAPTER 8
INCINERATION

8.1 INTRODUCTION

Chapter 8 provides the permit writer with a description of sludge combustion practices at POTWs, and also summarizes Federal requirements and guidance and State requirements pertaining to sludge incineration. The disposal of ash resulting from incineration is not covered by this Guidance Manual because ash is a solid waste that will continue to be regulated under 40 CFR Part 257 (or under 40 CFR Part 258, once promulgated, if disposed of in a municipal landfill). Appendix E, Tables E8-1 through E8-3 present State requirements in more detail.

Based on a recent EPA survey, 166 POTWs currently own or operate sewage sludge incinerators in the United States. While the aggregate human health effects of sludge incineration appear to be low, information gathered by EPA indicates that of the methods employed to re-use or dispose of sludge, incineration exposes the greatest number of people to levels of pollutants that may, over many years of exposure, lead to adverse health effects. Studies performed in developing EPA's proposed technical standards for sludge incineration indicate that about 140,000 people are exposed to theoretical Most Exposed Individual Risks of 10^{-3} or greater. For this reason, the Interim Permitting Strategy states that incinerators should be considered a "priority" (i.e., Class I) for permitting purposes when available information shows cause for concern.

A complexity immediately arises when permit writers begin writing NPDES permits for POTWs that incinerate the sewage sludge generated by wastewater treatment. The Clean Water Act provides the mandate for EPA to focus attention on potential threats to public health and the environment (e.g., sludge incinerators) while the expertise in regulating emissions from these sources rests with EPA, State or local officials who work in programs that have traditionally implemented the Clean Air Act. Regulating a POTW's incineration activities may be the most difficult multi-media responsibility assigned to the NPDES permit writer.

8.1.1 PERMITTING RESPONSIBILITIES

Regulation of air emissions at the National level is complex and often comprised of different requirements under different programs covering various pollutants, geographic areas, and industries. Sludge permit writers should work with State and regional air management authorities to ascertain which, if any, air emissions limits apply to the POTWs' incinerators. In some cases

sewage sludge incinerators may not be permitted. This will depend on the facility's age. Any incinerator which began operation before the air regulations were promulgated is not required to have a permit unless it is planning major modifications. In addition, many of the early incinerator permits do not contain emission limits or operation requirements. Whether emissions are formally limited through an air permit or not, NPDES permit writers are responsible to ensure that the ultimate disposal of sewage sludge is carried out in a manner that does not pose risks to public health and the environment. This will require considerable flexibility and coordination between offices of water and air regulation to establish institutional arrangements to address sludge incineration. At a minimum, for Class I POTWs, the NPDES permit writer should:

- Identify in the documentation accompanying the NPDES permit for a POTW that uses sludge incineration, the existing Federal and State requirements for sludge incineration that apply to the facility, or reference the air permit containing such requirements; and

- Consider writing additional recommended conditions into the permits for these POTWs (e.g., as suggested in this guidance). Air Office officials should be consulted when incorporating any of these recommendations. Arrangements between Air Office and Water Office personnel will need to be made for monitoring compliance with these conditions. (For a list of appropriate contacts, see Appendix B.)

- If, through consultation with the Air Office officials, a problem is identified with incinerator emissions and this problem is a result of sludge quality, pollutant-specific numerical limits may be developed with support from the Air Office and incorporated in the NPDES permit.

8.2 INCINERATION TECHNOLOGY

Incineration is the complete combustion of materials in a single step in the presence of oxygen. Incineration is the most commonly used combustion operation for destruction of wastewater sludge. Approximately 20 percent of POTW sludge is disposed of via sludge incineration. There are no Federal regulations specifying the type of incinerator that must be used to incinerate sewage sludge. However, the State of Kansas requires a multi-chamber system and Rhode Island requires multi-chamber, multi-hearth, fluidized-bed, or a cyclonic furnace.

The most common types of furnaces currently used for sludge incineration are the multiple-hearth furnace and the fluidized-bed furnace. Although a few electric-infrared furnaces have also been installed, the multiple-hearth furnace is the most widely used design, accounting for 75 to 80

percent of the sludge furnaces in operation today in the United States. Fluidized bed furnaces and electric-infrared furnaces account for approximately 16 and 4 percent, respectively, of the sludge furnaces installed in the United States (EPA, 1985a). Two other methods -- starved-air combustion and co-incineration -- are much less commonly used in the United States.

Multiple-Hearth Furnace

The multiple-hearth furnace is a vertically oriented, refractory-lined, steel cylinder containing a series of horizontal brick hearths, one above the other, and an air-cooled vertical shaft equipped with radial arms cantilevered over the hearths. Sludge is fed at the top of the furnace and sequentially scraped by plow-like blades mounted on the center-shaft arms across each hearth before dropping to the hearth below. The countercurrent flow of rising exhaust gases and descending sludge provides effective drying and combustion of the sludge.

Fluidized-Bed Furnace

The fluidized-bed furnace is a vertically oriented, refractory-lined steel cylinder that contains a sand bed that, at rest, sits upon a base plate equipped with an array of fluidizing air diffusers. Air is injected into the furnace through the diffusers at a pressure of 3 to 5 psig to lift and fluidize the sand. The sludge feed is either above or directly into the bed. Ash is carried out the top of the furnace with the exhaust gas.

Electric-Infrared Furnace

The electric-infrared furnace is a horizontally oriented, rectangular steel shell containing a moving horizontal, woven-wire belt. Sludge is fed into the electric-infrared furnace through a feed hopper that discharges onto the woven-wire belt. The layer of sludge moves under the infrared heating elements, which provide supplemental energy for the drying process. Combustion airflow is countercurrent to the sludge flow, and ash is discharged from the end of the belt to the ash handling system.

Co-incineration

Co-incineration is the burning of municipal sludge and refuse together. Only about one percent of the sludge incinerators in operation today are operated in a co-incineration mode. Co-incineration facilities may be subject to current Federal regulations for sludge incineration, refuse incineration,

and co-incineration depending on the relative amounts of material incinerated. In general, permit writers should defer to air office officials in developing co-incineration permit conditions.

Starved Air Combustion

In starved-air combustion, sludge is burned in a two-step process. In the first step, the volatile portion of the sludge is burned out leaving an ash, but there is insufficient oxygen to combust all of the gaseous compounds pyrolyzed out of the sludge. In the second step, combustion of these gases is completed in an afterburner chamber.

8.2.1 DEFINITIONS

Provided below are some definitions which may clarify some of the process-specific terminology.

Afterburner - pollution control equipment designed to burn hydrocarbons which have escaped the incineration process. Sometimes the upper hearth of a multiple hearth incinerator can be used in lieu of additional equipment.

Excess Air - the process of incineration depends on having enough excess oxygen to interact with the organic matter so that complete combustion will result. Excessive amounts of oxygen cause unnecessarily high gas velocities thereby increasing particulate emission.

Feed Rate - flow of dewatered sludge into the incinerator. Monitoring sludge feed rate continuously allows for more efficient incineration operation. A large increase in feed rate causes the combustion zone of the multiple hearth furnace to drop to a lower hearth and causes increased gas flow with increased particle emissions. A large decrease raises the combustion zone to a higher hearth which reduces residence time and increases the emission of unburned hydrocarbons.

Off gas - exit or exhaust gas from the incineration process.

Recombustion - the process to remove the products of incomplete combustion or the unburned hydrocarbons from the off-gas of the incinerator. Afterburners function as recombustion chambers.

8.3 CURRENT REGULATORY REQUIREMENTS

The existing Federal regulations related to sludge incineration are summarized below. It should be noted that State agencies can, and in some cases do, have requirements more stringent than the minimum Federal requirements.

8.3.1 NEW SOURCE PERFORMANCE STANDARDS (NSPS) (40 CFR Part 60)

EPA's Office of Air and Radiation or its counterpart programs in the States enforce the NSPS. Revised New Source Performance Standards were promulgated by EPA on October 6, 1988 (53 FR 39412).

Any incinerators that burn municipal sludge and that commenced construction or modification after June 11, 1973 are subject to NSPS. The rate of particulate discharge cannot exceed 1.30 pounds of particulates per ton (0.65 g/kg) of dry sludge feed and the gas discharged cannot exhibit more than 20 percent opacity (40 CFR Part 60 Subpart O). These requirements apply, even to co-incineration facilities, if the facility burns wastes containing more than 10 percent sewage sludge (dry basis) or charges more than 1,000 kg (2,205 lb) per day municipal sewage sludge (dry basis).

Co-incineration of sludge and municipal refuse in incinerators with a charging rate greater than 50 tons per day (45 metric tons/day) and with municipal refuse constituting 50 percent or more of the charge that commenced construction or modification after August 17, 1971, cannot emit more than 0.08 grains of particulates per dry standard cubic foot (0.18 g/dsm^3 dry) corrected to 12 percent carbon dioxide (Subpart E).

8.3.2 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPs) (40 CFR Part 61)

EPA's Office of Air and Radiation or its counterpart programs in the States enforce the NESHAPs. NESHAPs regulate mercury and beryllium. Any operation that burns or dries wastewater sludge cannot discharge more than 3,200 grams of mercury per 24-hour period (Subpart E). Incinerators that process beryllium containing waste shall not emit over 10 grams of beryllium over a 24-hour period (Subpart C).

It should be noted that the analytical detection limit for Be is 0.2mg/l. Thus the limit of 10 g/day is only detectable if the flow into the incinerator is less than 13.2 mgd. For higher flows non-

detectable levels would not ensure compliance. The analytical detection limit for Hg is also 0.2 mg/l. Thus the 3,200 g/day limit is detectable in all flows under 4,277 mgd, which ensure detection at all currently operating sewage sludge incinerators.

8.3.3 TOXIC SUBSTANCES CONTROL ACT (TSCA)

EPA's Office of Pesticides and Toxic Substances is responsible for enforcing requirements for incineration of sludge containing greater than 50 mg/kg PCB's. Incinerators burning sludges with PCB concentrations greater than 50 mg/kg must be approved by the Regional Administrator or Assistant Administrator for Pesticides and Toxic Substances. Incinerators for sewage sludges containing over 50 mg polychlorinated biphenyls (PCBs)/kg dry sludge solids must comply with the specific design and operational requirements of the Toxic Substances Control Act (TSCA).

8.3.4 NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) AND STATE IMPLEMENTATION PLAN (SIPs) (40 CFR Part 50)

The National Ambient Air Quality Standards (NAAQS) in 40 CFR Part 50 establish threshold levels for air pollutants which pose the greatest overall threat to air quality. The "criteria pollutants" include ozone, carbon monoxide, air borne particulates, sulfur dioxide, lead and nitrogen oxides (See Table 8-1). For these pollutants, the regulations set primary standards to protect human health (See Table 8-2) and secondary standards to protect "welfare" (crops, livestock, vegetation). The Clean Air Act (CAA) requires each State to develop a State Implementation Plan (SIP) for attainment of the standards. For those areas which are already meeting NAAQS, the implementation plans must include a program for Prevention of Significant Deterioration (PSD).

For those areas that are not in attainment for one or more of the criteria pollutants, SIPs provide for emission controls, transportation controls, source monitoring, ambient air quality, monitoring, and procedures for review and approval of new sources of air pollution prior to construction. Sewage sludge incineration emissions may be limited under a SIP if that incinerator is identified as a major source of the pollutant for which the area is in non-attainment.

TABLE 8-1

NATIONAL AMBIENT AIR QUALITY STANDARDS*

Pollutant	Averaging Time	Primary Standard	Secondary Standard	Measurement Method
Carbon Monoxide	8 hr 1 hr	10 mg/m³ (9 ppm) 40 mg/m³ (35 ppm)	- -	Nondispersive infrared spectroscopy
Nitrogen Dioxide	Annual average	100 µg/m³ (0.053 ppm)	Same	Colorimetric using NaOH
Sulfur Dioxide	Annual average 24 hr 3 hr	80 µg/m³ (0.03 ppm) 365 µg/m³ (0.14 ppm)	 1,300 µg/m³ (0.5 ppm)	Pararosaniline method
Suspended particulate matter	Annual geometric mean 24 hr	75 µg/m³ 260 µg/m³	60 µg/m³ 150 µg/m³	High-volume sampling
Ozone	1 hr	235 µg/m³ (0.12 ppm)	Same	Chemiluminescent method
Lead	3 months	1.5 µg/m³	Same	

* Standards, other than those based on annual average or annual geometric average, are not to be exceeded more than once a year. Note: National primary ambient air quality standards define levels of air quality which the Administrator judges are necessary, with an adequate margin of safety, to protect the public health. National secondary ambient air quality standards define levels of air quality which the Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. (40 CFR 50.2)

TABLE 8-2

HEALTH EFFECTS OF AIR POLLUTANTS

	Pollutant Levels							
Air Quality Level	TSP (24-hr), µg/m³	SO_2 (24-hr), µg/m³	CO (8-hr), mg/m³	O_3 (1-hr), µg/m³	NO_2 (1-hr), µg/m³	Health Effect Descriptor	General Health Effects	Cautionary Statements
Significant harm	1,000	2,620	57.5	1,200	3,750	Hazardous	Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic
Emergency	875	2,100	40.0	1,000	3,000		Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
Warning	625	1,600	34.0	800	2,260	Very unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity
Alert	375	800	17.0	400[c]	1,130	Unhealthful	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity
NAAQS	260	365	10.0	240	[a]	Moderate		
50 % of NAAQS	75[b]	80[b]	5.0	120	[a]	Good		
	0	0	0	0	0			

[a] No index values reported at concentration levels below those specified by "Alert Level" criteria.
[b] Annual primary NAAQS.
[c] 400 µg/m³ was used instead of the O_3 "Alert Level" of 200 µg/m³

8.3.5 NEW SOURCE REVIEW STANDARDS (NSRS) (40 CFR Part 51.160)

The new Source Review Standards require a preconstruction review of all new construction of or modification to stationary sources to determine if the source will meet all applicable emission requirements of the SIPs and the EPA's Emission Offset Policy. If the permit writer finds the POTW is planning new construction or modification to an incinerator, the air office should be consulted immediately. 40 CFR Part 51.160 and Appendix S of 40 CFR Part 51 contain additional information on the New Source Review Standards.

8.3.6 PREVENTION OF SIGNIFICANT DETERIORATION (PSD) (40 CFR Part 52.21)

The purpose of EPA's Prevention of Significant Deterioration (PSD) program is to preserve the air quality of areas currently attaining NAAQS. PSD review is the responsibility of the Office of Air and Radiation or its counterpart office in the States. The PSD regulation applies to sewage sludge incinerators constructed or modified after August 7, 1977 if the incinerator emits 250 tons per year or more of any pollutant subject to regulation under the CAA. Any stationary source capable of emitting 250 tons per year or more of any regulated air pollutant is defined as a major stationary source. In addition, particular stationary sources (e.g., municipal incinerators capable of charging more than 250 tons of refuse per day) which have the potential to emit 100 tons per year or more of any regulated air pollutant are defined as a major stationary source and subject to PSD review.

Major stationary sources undergoing modifications that would result in a significant increase in emissions of any of the pollutants listed in Table 8-3 would also be subject to PSD review.

PSD requirements for major stationary sources include:

- Installing **Best Available Control** Technology for each pollutant subject to regulation under the CAA **if the source** would have the potential to emit that pollutant in significant amounts.

- Demonstrating that the allowable emissions would not cause or contribute to air pollution in violation of air quality regulations.

The permit writer should contact the appropriate air regulatory office to determine if that office has performed a PSD review and required the incinerator install pollution control technologies.

TABLE 8-3

LEVELS OF NET EMISSIONS INCREASE THAT QUALIFY AS MAJOR MODIFICATIONS REQUIRING PSD REVIEW

- Carbon monoxide: 100 tons per year (tpy)
- Nitrogen oxides: 40 tpy
- Sulfur dioxide: 40 tpy
- Particulate matter: 25 tpy
- Ozone: 40 tpy of volatile organic compounds
- Lead: 0.6 tpy
- Asbestos: 0.007 tpy
- Beryllium: 0.0004 tpy
- Mercury: 0.1 tpy
- Vinyl Chloride: 1 tpy
- Fluorides: 3 tpy
- Sulfuric Acid Mist: 7 tpy
- Hydrogen Sulfide (H_2S): 10 tpy
- Total Reduced Sulfur (including H_2S): 10 tpy
- Reduced Sulfur Compounds (including H_2S): 10 tpy

8.4 CHARACTERISTICS OF SLUDGES SUITABLE FOR INCINERATION

The properties of sludges suitable for incineration include an adequately high concentration of combustible material, a low moisture content, and a low concentration of non-combustible contaminants such as certain heavy metals.

8.4.1 POLLUTANT CONCENTRATION LIMITS FOR SLUDGE FEED AND AIR EMISSIONS

Few regulations under the CAA specify sludge quality conditions, most address air emission levels. This sub-section provides a listing of specific pollutants along with their current Federal emissions or ambient air concentration limits (if any), and any general guidance and discussion of contaminant limits from Federal literature. Limits for specific States (if any) are tabulated in Appendix E, Tables E8-1 and E8-2.

In sludge incineration, the fate of heavy metals and chemical compounds depends largely on their ability to associate with small particles. Volatile elemental metals include Hg, Cd, Pb, As and Zn. These may be emitted at concentrations higher than the average of the bulk sludge ash if furnace temperatures are set too high.

EPA's Office of Air and Radiation or designated State agencies administer five regulatory programs that may limit sewage sludge incinerator emissions: National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), NSPS (40 CFR Part 60), New Source Review Standards (40 CFR Part 51.18), NESHAPS (40 CFR Part 61) and Prevention of Significant Deterioration (PSD) (40 CFR Part 52.21). Permit writers should consult with the officials responsible for these programs and should identify in the NPDES permit documentation any requirements imposed on a municipal sludge incinerator.

Federal Regulations

The only required pollutant concentration (or pollutant characteristic) limits for incinerated sewage sludges are: 1) the sludge shall not be a hazardous waste; and 2) the sludge shall not contain more than 50 ppm (mg/kg) of PCBs unless it is burned in an incinerator approved by EPA to burn PCBs. The Federal emissions limits and/or ambient air quality standards are described below. Table 8-4 presents an outline of contaminant concentrations in the Federal regulations.

TABLE 8-4

FEDERAL CONCENTRATION LIMITS FOR CONTAMINANTS*

Beryllium	Lead	Mercury	Opacity	Particulates	Sulfur Dioxide	Carbon Monoxide	Nitrogen Dioxide	Ozone
Emissions Limit of 10 g per 24-hr period	Ambient Air Limit of 1 5 $\mu g/m^3$ averaged over a calendar quarter	Emissions Limit of 3,200 g per 24-hr period	Emissions Limit of 20 percent opacity	Emissions Limit of 0 65 g/kg dry sludge feed	Ambient Air Limit of 80 $\mu g/m^3$ (annual average). 365 $\mu g/m^3$ (24-hr average)	Ambient Air Limit of 10 mg/m^3 (8-hr average). 40 mg/m^3 (1-hr average).	Ambient Air Limit of 100 $\mu g/m^3$ (annual average)	Ambient Air Limit of 235 $\mu g/m^3$ (1-hr average)
				Ambient Air Limit of 75 $\mu g/m^3$ (annual geometric mean) 260 $\mu g/m^3$ (24-hr average.)				

* Major stationary sources may also be subject to New Source Review Standards or Prevention of Significant Deterioration Regulations (see Section 9 1 2)

Beryllium

Incinerators that process beryllium containing waste shall not emit over 10 grams of beryllium over a 24-hour period. Beryllium containing waste is defined as material contaminated with beryllium and/or beryllium compounds used or generated by extraction plants, ceramic plants, incinerators or propellant plants that process beryllium ore, beryllium oxide, or beryllium alloys, or by machine shops that process beryllium, beryllium oxides, or any alloy when such alloy contains more than 5 percent beryllium by weight (40 CFR Part 61 Subpart C).

Facilities may request a variance from this requirement provided that at least 3 years of data are available to demonstrate that the future ambient concentrations of beryllium is the vicinity of the stationary source will not exceed 0.01 ug/m^3, averaged over a 30-day period. (40 CFR Part 61.32(b)).

Carbon Monoxide

Emissions should not cause ambient concentrations of carbon monoxide in the vicinity of the stationary source to exceed the NAAQS of 10 mg/m^3 on an 8-hour average and 40 mg/m^3, 1-hour average. Additionally, New Source Review Standards or PSD may apply to large facilities.

Lead

Emissions of lead should not cause ambient concentrations of lead in the vicinity of the stationary source to exceed the NAAQS of 1.5 ug/m^3, averaged over a calendar quarter. Additionally, New Source Review Standards or PSD may apply to large facilities.

Mercury

Subpart E of the NESHAPs states that sludge incinerators, sludge dryers, or combinations of these facilities shall not emit more than 3,200 grams of mercury in a 24-hour period. Unless a waiver of emission testing is obtained under the general NESHAP waiver provisions (40 CFR Part 61.13), each owner or operator shall determine mercury emission concentrations within 90 days of start-up (existing sources were required to make the determination within 90 days of the rule's effective

date in 1975). The determination shall be made either by stack gas sampling or by a calculation based on sludge-feed sampling where it is assumed that all mercury in the sludge is volatilized.

Operators of incinerators with mercury emissions exceeding 1,600 grams/day are required to monitor or calculate mercury emissions annually. Prior to any changes in operation that would potentially increase emissions above that determined by the most recent source test, a new emissions level must be estimated by calculation and the results reported to the Administrator.

Nitrogen Oxides

Emissions should not cause ambient concentrations of nitrogen dioxide in the vicinity of the stationary source to exceed the NAAQS of 100 ug/m^3 annual average. Additionally, New Source Review Standards or PSD may apply to large facilities.

Opacity

Gas discharged from incinerators that burn municipal wastewater sludge shall not have more than 20 percent opacity. Where the presence of uncombined water is the only reason for failure to meet the 20 percent opacity limit, such failure shall not be a violation of this requirement. (40 CFR Part 60, Subpart O)

Ozone/Photochemical Oxidants

Emissions should not cause ambient concentrations of ozone in the vicinity of the stationary source to exceed the NAAQS of 235 ug/m^3 1-hour average. Additionally, New Source Review Standards or PSD may apply to large facilities.

Particulates

Particulates discharged from incinerators that burn municipal wastewater sludge cannot occur in excess of 1.30 pounds per ton dry sludge input (0.65g/kg dry sludge input) (40 CFR Part 60, Subpart O). The standard applies to sludge incinerators that have been constructed or modified after June 11, 1973. During start-up of operations, incinerator operators must demonstrate compliance with the standard. Incinerator operators must also install, calibrate, maintain, and operate a flow measuring device that can be used to determine the mass or volume of sludge charged to the incinerator. The flow measuring device shall have an accuracy of plus or minus 5

percent over its operating range. For more information, consult Subpart A of the NSPS (40 CFR Part 60).

Co-incineration of sludge and municipal refuse with a charging rate greater than 50 tons per day (45 metric tons/day) and with municipal refuse comprising 50 percent or more of the charge cannot discharge more than 0.08 grains of particulates per dry standard cubic foot (0.18 g/dsm^3) corrected to 12 percent carbon dioxide (40 CFR Part 60, Subpart E).

Emissions should not cause ambient concentrations in the vicinity of the stationary source to exceed the NAAQS of 75 ug/m^3 annual geometric mean and 260 ug/m^3 24-hour average. Additionally, New Source Review Standards or PSD may apply to large facilities.

Polychlorinated Biphenyls (PCBs)

Incinerators that burn sludges containing more than 50 mg PCBs/kg dry sludge solids shall comply with 40 CFR Part 761.70. This regulation has very strict emission requirements and must be consulted if the permit writer needs to incorporate these requirements in the NPDES permit. The appropriate air regulatory authority should be consulted first.

Sulfur Oxides

Emissions should not cause ambient concentrations of sulfur dioxide in the vicinity of the stationary source to exceed the NAAQS of 365 ug/m^3 24-hour average and 80 ug/m^3, annual average. Additionally, New Source Review Standards or PSD may apply to large facilities.

Federal Guidance

Arsenic

In the EPA listing of hazard indices to assess human toxicity/cancer risk resulting from the inhalation of incinerator emissions, one of the compounds that posed the highest increase in human health risk was arsenic (EPA, 1985b). If there is reason to believe that there is arsenic in the sewage sludge that is to be incinerated, the permit writer should consult with the appropriate Air Office to determine the type of controls needed.

Cadmium

In the EPA listing of hazard indices to assess human toxicity/cancer risk resulting from the inhalation of incinerator emissions, one of the compounds that posed the highest increase in human health risk was cadmium (EPA, 1985b). If there is reason to believe that cadmium is present in the sewage sludge to be incinerated, the permit writer should consult with the appropriate Air Office to determine the type of controls needed.

Chromium

In the EPA listing of hazard indices to assess human toxicity/cancer risk resulting from the inhalation of incinerator emissions, one of the compounds that posed the highest increase in human health risk was hexavalent chromium (EPA, 1985b). If there is reason to believe that there is chromium in the sewage sludge that is to be incinerated, the permit writer should consult with the appropriate Air Office to determine the type of controls needed.

Vinyl Chloride

Although vinyl chloride limits in 40 CFR Part 61 do not presently apply to wastewater sludge incinerators, it is noteworthy that this regulation limits the vinyl chloride exhaust gas emissions to 10 ppm for vinyl chloride plants, polyvinyl chloride plants, and ethylene dichloride plants.

State Requirements

No State reported any specific maximum sludge contaminant concentrations above which incineration would not be allowed. All reported State requirements addressed emission levels. Most State emissions standards for sewage sludge incinerators simply repeat the Federal requirements. However, a few individual States have set other emission standards. State standards are listed in Appendix E, Table E8-1.

Beryllium

New Jersey and New Hampshire report a beryllium emissions limit.

Carbon Monoxide

Two States report a carbon monoxide limit.

Mercury

Georgia, Kentucky, New Jersey and Tennessee were the only States that reported requirements for a mercury limitation (all reported a 3,200 grams mercury per day limit).

Opacity

The States of Alaska, Delaware, Georgia, Iowa, Kentucky, New York, Ohio, Oklahoma, and Wisconsin reported a 20 percent opacity limit as a State regulation.

Particulates

Many States have limits for particulates. However, the reported limits vary both numerically and in the specified units. For example, reported State limits range from 0.08 to 4.6 grains/dry standard cubic foot (DSCF) (0.005 to 0.3 grams/DSCF), 1.3 lb/ton dry sludge input, 2 lb/100 lb refuse, a limit of 0.5 lb/million BTU heat output, and a range of 0.2 to 0.1 percent of the charging rate.

8.4.2 SLUDGE PHYSICAL PROPERTIES

Federal Regulations

There are no current Federal regulations regarding the physical properties of sludges suitable for incineration.

Percent Combustible Solids

Federal Guidance

The combustible content of the sludge affects the amount of fuel required for incineration. With higher combustible content less fuel and/or dewatering are required and less material remains for final disposal. Because wastewater sludge typically has an adequately high percent of combustible

solids and a high heat content per unit weight of combustibles, the limiting factor in fuel consumption is the moisture content of the sludge.

State Requirements

There are currently no State regulations governing percent combustible solids.

Moisture Content and Dewatering

Federal Guidance

Efficient dewatering is essential prior to sludge incineration to avoid high costs for supplemental fuel. Sludge typically must be dewatered to between 25 and 35 percent solids to approach autogenous (self-sustaining) combustion. Higher solids levels are needed for autogenous combustion when the concentration of ash (or inert conditioners such as lime, ferric chloride, or recycled ash) is high. The incineration of low percent solids sludge could require large amounts of expensive supplemental fuel. It is important to avoid fluctuations in moisture content. An equalization chamber in front of the incinerator would help with moisture content and feed rate fluctuations.

State Requirements

The States of Kentucky and New Jersey reported requirements for sludge dewatering.

8.5 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

As Stated in the Sewage Sludge Interim Strategy, permit writers should consider any POTW that incinerates its sludge a Class I POTW for permitting purposes unless after considering the following factors, a BPJ determination can be made that the incinerator emissions pose no threat to human health and the environment. The factors to consider are: POTW sludge quality, the compliance history of the incinerator, height of the incinerator stack, whether there are tall buildings in the vicinity of the incinerator that may cause a downwash of emissions, whether any features of the surrounding geography are high enough in relation to the stack to cause the emissions plume to contact the ground near the incinerator, and the population density downwind from the incinerator in the direction(s) that prevailing winds blow.

Permit writers should request the assistance of air office officials when evaluating the potential risk posed by incinerators. Permit writers should also work closely with air office officials to determine the appropriateness of the following operation conditions at a particular incinerator. Arrangements between air office and water office personnel will need to be made for monitoring compliance with conditions placed into NPDES permits.

Following is a description of various operation conditions and management practices relevant to incineration. The first section covers Federal and State requirements and recommendations. The second section describes operating parameters specific to particular technologies and highlights the differences in operating efficiencies between the different technologies. The third section describes the different types of emission control technologies.

8.5.1 GENERAL OPERATING CONDITIONS AND MANAGEMENT PRACTICES

Emissions from a sludge incinerator vary depending on the type of incinerator technology. Other factors effecting emissions include (1) physical properties of the sludge as described in Section 8.4.1 of this manual, (2) the sludge feed rate (3) temperature profile of the incinerator, particularly the combustion and exhaust temperatures, (4) the amount of excess air used for incineration, (5) combustion efficiency and residence times, (6) operator control, and (7) the type and operation of emissions control system. Appropriate regulation of each of these parameters minimizes the impact of sewage sludge incineration on public health and the environment.

Federal Guidance

Sludge Feed Rate

A constant sludge feed rate is desirable because changes in feed rate can cause smoke or increase emissions. Loadings of wastewater skimmings, scum, grease and other materials with a high heat content should be equalized to minimize high-temperature excursions and pockets of oxygen-deficient combustion within the furnace. Equalization chambers added in front of the incinerator will smooth out fluctuations in feed rate.

Permit writers should consider requiring POTWs that use incinerators to minimize fluctuations in sludge feed rate. These POTWs should be required to report 25 percent or greater variations in sludge feed rate in a one-hour period excepting start-up and shut-down of the incinerator. The purposes of reporting large fluctuations in feed rate are: (1) to focus operator attention on an

important parameter that can affect the proper setting of other operating parameters; and (2) to focus EPA's compliance monitoring resources on incinerators that are operated in a way that has the potential to increase emissions.

Combustion Temperature

A minimum combustion temperature of approximately 1,300 to 1,400°F is adequate for oxidation of high molecular weight organics, and a maximum temperature of about 1,800°F is often necessary to limit ash melting and damage to refractories. It has been observed that high temperatures lead to increased emissions of metals. Operation of a fluidized-bed furnace at a combustion temperature of 980°C (1,800°F) is reported to normally produce 200 to 400 percent more emissions than operation at 760°C (1,400°F) (EPA, 1985a), although it should be noted that most fluidized-bed furnaces are operated at 1,500-1,600°F to avoid bed defluidization. Combustion temperature in particular affects the amount of NOx, CO, and hydrocarbons emitted. Loadings of high heat content material such as wastewater skimmings, scum, and grease should be controlled to minimize high temperature excursions and localized oxygen deficiency.

Most, if not all POTWs operating sludge incinerators monitor combustion zone temperature. Permit writers should consider requiring POTWs (1) to operate within a combustion zone temperature range of 1,350 to 1,650°F, and (2) to report periods when combusting zone temperatures exceeded 1,625°F or fall below 1,375°F, excepting start-up and shut-down.

Excess Air

It is critical to supply enough air to ensure complete combustion; it is also important to limit the amounts of excess air. When large quantities of excess air are used, the resulting high gas velocities are believed to increase the total amount of suspended particulates in the exhaust gas. Supplemental fuel requirements are also needed to heat excess air. Consequently, operators often go to the other extreme and do not provide enough excess air for complete combustion.

Conventional sludge incineration systems typically use 20 to 150 percent excess air above the theoretical amount needed for oxidation because it is virtually impossible to ensure complete and even mixing of air and sludge (EPA, 1984). However, with careful operation, excess air flows can range from 20 to 45 percent for fluidized-bed furnaces, and 29 to 70 percent for electric-infrared furnaces (EPA,1985c). Multiple-hearth furnaces typically require higher levels of excess air, depending on how carefully they are operated.

Combustion Efficiency

Combustion efficiency measurement is one way to monitor and report upon proper incinerator operation where frequent sampling for the specific contaminant is not feasible. Combustion efficiency (calculated by dividing the concentration of carbon dioxide by the sum of the concentrations of carbon dioxide and carbon monoxide in the off-gas) is a measure of the percentage of completion of oxidation.

EPA requires a combustion efficiency of 99.9 percent for hazardous waste incinerators burning over 50 ppm PCBs (40 CFR Part 761.70). However, this permitting approach has not been applied to sewage sludge incinerators, and the correlation between combustion efficiency as described above and destruction of certain pollutants in sewage sludges is not well established.

Operator Training and Controls

One of the most important factors in achieving and maintaining a low rate of emissions from a sludge incinerator is having an experienced, well-trained, conscientious operator attend to the incinerator at all times that the incinerator is running. Depending on the composition of the sludge (volatile solids and moisture content), which can vary by hour, day, or season, an operator may need to adjust the temperature regime within the incinerator and the amount of excess air used.

Permit writers should consider writing a condition requiring that an experienced, well-trained, competent operator attend to the incinerator at all times that the incinerator is on line. Also important for achieving and maintaining low emissions is the ability of the operator to adject parameters within the combustion process. Permit writers should consider writing a condition requiring that the proper controls be provided.

Emission Controls

Approximately 20 pounds of uncontrolled particulates per ton of sludge and 0.0038 pound of particulates per gallon of fuel oil are generated in multiple-hearth furnaces. The Federal New Source Performance Standard of 1.30 pounds of particulates per dry ton of sludge (0.65 g/kg) can be met with modern high energy wet scrubbers, such as the venturi. Removal efficiency in scrubbers is a direct function of particle size and the pressure drop across the scrubber system, although some further gains in collection efficiency are claimed for some specific hardware

configurations. For a pressure drop in excess of 30 inches of water, scrubbers will remove over 99 percent of particulates larger than 1 micron.

General guidelines for emissions control equipment include:

- Use after-burners where necessary to satisfy strict carbon monoxide and unburned hydrocarbon emission limitations.

- Specify a minimum pressure drop across the scrubber system (e.g., 30 inches or greater pressure drop for a venturi impingement tray water scrubber system) if exceptional control levels for particulates are desired.

- Specify a maximum air/cloth ratio for fabric filter baghouses (such as the 3.0 maximum ratio specified for the Hyperion Energy Recovery System in Los Angeles, CA; EPA, 1985a) if exceptional emission control levels are sought. As above, one should consider the alternative of performance specifications.

Emission control equipment at existing incinerators subject to the NSPS for particulates and opacity should be operated so as to maintain the operating conditions (e.g., pressure drop for scrubbers, air/cloth ratio for fabric filters) during the facility's compliance determination test-burn. If emission control equipment is in place at older incinerators not subject to NSPS, a permit condition should be written requiring the POTW to maintain and operate the equipment so as to optimize particulate removal efficiency. For POTWs planning to use new incinerators, language should be inserted which will allow reopening the permit after the start-up compliance determination. Emission control equipment operating parameters maintained during start-up would then be mandated as a condition in the permit.

Table 8-5 suggests a pattern of sludge incinerator operating parameters that should minimize the emission of heavy metals, soot, and odorous/undesirable organic compounds. The most important theme is the maintenance of a high degree of stability of conditions coupled with reasonable sensitivity to the key stoichiometric and temperature criteria that provide a suitable combustion environment to minimize both generation and emission (survival) of organic compounds. This must be recognized by both POTW management and operational personnel as a plant problem/challenge, not just a furnace problem. Close attention must be paid to tight and insightful control of all aspects of the wet end of the process train in order to deliver the constancy in rate and material (let alone superior performance in dewatering to minimize fuel usage) needed for good

TABLE 8-5

SUMMARY OF SUGGESTED INCINERATOR OPERATING GUIDELINES

Parameter	Goal	Reason	Tolerance
Feed solids content	keep it constant	stabilize energy balance in system	within 2% of avg
Feed rate	keep it steady	stabilize system	within 10% of avg
Temperature	keep it steady keep it high	stabilize process to burn organics	within 50°F >1,400°F
	keep it low	to minimize metal volatilization	<1,600 °F
Oxygen content of exhaust gases	keep it low keep it high	reduce fuel consumption assure oxygen for combustion	<10% O_2 >7% O_2
Scrubber pressure drop	keep it high	collect fine particulates	at/above where compliance tested
Burning Zone	keep it steady	stabilize system	1 hearth

furnace operation. Thus, cooperation among the operators of almost all aspects of the plant and the incinerator is a critical ingredient in successful, minimum cost, and low emission sludge incineration systems.

Storage Requirements

Sufficient sludge storage should be provided to allow for a constant feed rate to the incinerator and to allow for an adequate amount of down-time for repairs and preventive maintenance.

Ash Disposal

Approximately 7 million dry tons of sludge are generated by U.S. municipal wastewater plants each year. More than 1.3 million tons of this sludge are incinerated, resulting in about 400,000 tons of ash that must be disposed of in an environmentally acceptable manner (EPA, 1985a). Ash is a solid waste that should be disposed of in accordance with the requirements of 40 CFR Part 257 (Appendix D). Permit writers should consider writing such a requirement into the permit.

State Requirements

Combustion Temperature

Four States have minimum temperature requirements. Specific information was not provided by Connecticut or Iowa, but Georgia requires 800°F Primary Temperature and 1,500°F Secondary and Nevada requires 1,400°F for not less than 0.3 seconds.

Combustion Residence Time

The State of Nevada requires not less than 0.3 seconds at 1,400°F, and Connecticut reported an unspecified minimum combustion residence time requirement.

Emission Controls

The States of Maryland, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, South Carolina, Virginia, Washington, Rhode Island, and Tennessee impose special requirements relative to emission controls; some specify that minimum air pollution control techniques such as "Best Available Control Technology" must be applied. This approach may be particularly appropriate

where certain pollutant emission levels are expected to be a problem (i.e., when the sludge has high concentrations of the more volatile metals such as mercury, cadmium, lead, or zinc which may be emitted at concentrations higher than the average of the bulk sludge ash if furnace temperatures are set too high).

Management Practices

State agencies report a number of management practices in addition to the incineration and pollution control guidelines previously discussed. These management practice requirements and/or guidelines are summarized below and in Table E8-2. Management practices required by just one or two States are presented in page four of Table E8-2. States with no reported management practices are omitted from Table E8-2. Prohibited sludge incineration practices that were reported by various States are summarized in Table 8-6.

Access Control

The States of New Hampshire, Oregon, and Wisconsin reported minimum requirements for access control, such as fences and gates.

Air Monitoring

Nine States reported some requirements for air monitoring. Current Federal requirements and further discussion of potential monitoring requirements are presented later in this section.

Air Modeling

Air modeling may be desirable for large facilities or facilities that may pose a particular hazard. The State of New Jersey (the only State to require air modeling) is reported to require air modeling for carbon monoxide, SO_2, NO_2, total suspended particulates, lead, and VOCs.

Air Turbulence

Increases in air turbulence allow higher levels of pollutant emissions to be assimilated through dispersion. However, providing for the effect of air turbulence in permit language may not be possible except in locations where detailed air modeling is required. Iowa was the only State that reported a requirement for addressing air turbulence.

TABLE 8-6

PROHIBITED SLUDGE INCINERATION PRACTICES

State	Incineration Practice
Massachusetts	Open burning prohibited
Maine	Open burning prohibited at landfills serving over 1,000 persons
Tennessee	Incineration prohibited without permit
Indiana	Open burning prohibited
Kansas	Open burning prohibited
Nebraska	Open burning prohibited without license
Colorado	Open burning prohibited at landfills without permit
Idaho	Open burning prohibited

Source: EPA 1987

Site Development Plans

Twelve States reported requirements for site development plans.

8.5.2 OPERATING GUIDELINES FOR SPECIFIC INCINERATION TECHNOLOGIES

Multiple-Hearth Furnace

Federal Guidance

Multiple-hearth furnaces are typically operated with high levels (100 percent or more) of excess air to encourage complete combustion. If the flame of combustion is creeping up the hearths, the temperature should be lowered or the feed rate should be changed. Exhaust gas temperatures should be maintained at less than 900°F (482°C) to prevent distillation of odorous greases and tars from the drying solids. Multiple-hearth furnaces may require afterburners (simple combustors used to oxidate organic compounds not destroyed in the primary incinerator chamber) in cases where there are very stringent emission limitations for unburned hydrocarbons (EPA, 1979). Where there is concern about organics emissions (e.g., large loadings of industrial organics), sludge may be added to the third hearth of a multiple-hearth furnace, and the top two hearths may be used as an afterburner.

Fluidized-Bed Furnace

Federal Guidance

The quantity of excess air supplied to a fluidized-bed furnace is typically in the range of 20 to 45 percent. The correct amount of airflow is critical with a fluidized-bed furnace. Airflow must be sufficient to expand the bed by the appropriate amount, provide uniform distribution of fuel and air, and provide the desired amount of excess air to ensure complete combustion. The fluidized-bed furnace operates at lower excess air rates than typically required for multiple-hearth furnaces. Normal operation of the fluidized-bed furnace produces exhaust temperatures in excess of 1,400°F (760°C). Because the exhaust gases are exposed to this temperature for several seconds, carbon monoxide and unburned hydrocarbon emissions are usually very low, even without the use of an afterburner (EPA, 1979). However, more particulates must be removed by the emission control devices of fluidized-bed furnaces because ash is removed from the flue gas, unlike the multiple-hearth and electric-infrared furnaces where ash is removed from the combustion chamber.

Electric-Infrared Furnace

Federal Guidance

In electric furnaces, the sludge is not stirred or mixed during incineration, and the particulate loading to the emissions control system is typically much lower than for fluidized-bed furnaces and somewhat lower than for multiple-hearth furnaces.

Excess airflows for electric-infrared furnaces typically range from 29 to 70 percent (EPA, 1985a). Since electricity is used to provide the supplemental energy, no fuel is burned in the primary furnace although fuel is often burned in a post-furnace afterburner.

Starved-Air Combustion

Federal Guidance

In starved-air combustion, the amount of air in the furnace is less than the theoretical requirement for complete combustion (30 to 90 percent of the stoichiometric requirement). This makes starved-air combustion a fuel-efficient operation. When a starved-air combustion multiple-hearth furnace is combined with an afterburner, an overall excess air rate of 25 to 50 percent can be maintained, as compared with excess air rates of more than 100 percent for conventional multiple-hearth incinerators with an afterburner (EPA, 1984).

It has been demonstrated that starved-air combustion is an effective method for burning sludge in a furnace, but it is still a relatively new technology that is not widely practiced.

Co-incineration

Federal Regulations

Co-incineration facilities may be subject to current Federal contaminant regulations for sludge incineration, refuse incineration, and co-incineration depending on the amounts of material incinerated. Some co-incineration facilities may also be subject to Subpart D-(b), NSPS for industrial boilers. No specific management practices are currently regulated. In general, unless the

proportion of sludge to other material fed to a co-incineration facility is very high, permit writers should defer to the Air Office.

Federal Guidance

Only about one percent of the sludge incinerators in operation today are operated in a co-incineration mode, where wastewater sludge is burned with municipal refuse. Problems encountered have been related to the different storage requirements of the two "fuels" (wastewater sludge odor/septic problems) and to the different design requirements for the handling and incineration equipment (municipal refuse may require equipment that can handle large objects, rags, wires, etc. without clogging excessively and "hot" loads of plastics and paper without having excessive temperature excursions). However, there are potential benefits from co-incineration, such as reduced sludge dewatering requirements and reduction of municipal refuse volume.

8.5.3 GUIDELINES FOR POLLUTION CONTROL SYSTEMS

Federal Regulations

If the sludge contains more than 50 mg PCBs/kg of dry sludge solids then pollution control devices for hydrochloric acid emissions are required under TSCA.

Federal Guidance

There is a considerable amount of Federal guidance on pollution control systems as presented in the subsequent sections. These pollution control devices are required to attain emission limitations. Descriptions of the various emission control technologies are presented below, followed by guidelines for these pollution control technologies.

Wet Scrubbing Systems

The venturi scrubber with an impingement tray is one of the most common types of exhaust gas scrubbers. The exhaust gas is cooled with water and then passes into a venturi section where particles are removed from the gas stream by a fine mist of water. The exhaust gas is then passed through a flooded elbow, an impingement tray separator, and a demister to separate the liquid containing the particles from the gas.

Scrubbing water can be recycled, and supplemented with make-up water. Waste scrubbing water from a multiple-hearth furnace is normally recycled into the main process train in a wastewater treatment plant. An appreciable amount of volatile compounds or metals such as Cd, Pb, and Zn may be concentrated in the scrubber wastewater and caution should be exercised in recycling and/or disposing of this waste stream. Scrubbing water with a fluidized-bed furnace contains large amounts of ash and is normally treated and sent to an ash lagoon.

The efficiency of scrubbers for particulate removal is related to the pressure drop across the particulate removal equipment. Most incinerators now use a venturi impingement tray water scrubber that develops 30 inches or greater of water pressure drop across the system (EPA 1985a). Scrubber pressure drop typically falls in the range of 15 to 45 inches of water.

Wet scrubbing systems have the advantage of cooling the exhaust gases. Flue gas cooling and wet scrubbing are effective in removing condensible particulates. Subcooling below the saturation vapor temperature in the scrubber system will remove substantial amounts of water from the flue gas and aid in steam plume suppression. Cooling the flue gases will also increase removal of polar gas molecules that can be expected to dissolve in the water phase (EPA 1985a).

The EPA has evaluated the results of tests on nine sludge incinerators with wet scrubbing systems in which the following metals were monitored: cadmium, iron, nickel, lead, chromium, silver, copper, manganese, zinc, and arsenic (EPA 1985a). The findings of this investigation (reported in 1981, but not published) restated the findings of an earlier EPA task force that concluded in 1972 that "properly operated incinerators produce acceptable stack emissions of particulate matter, nitrogen oxide, sulfur oxides, and odor" (EPA 1972). Only one of the eight incinerators significantly exceeded EPA's new source performance standard for particulates of 0.65 g of particulates per kg of dry sludge solids feed. Scrubbers showed very good removal for particulates larger than 1 micron diameter. However, efficiencies ranged from 50 to 90 percent for the 0.1 to 1 micron range. The level of heavy metal discharges to the atmosphere was found to be insignificant when compared to ambient atmospheric concentrations unless the incinerators operated at very high (1,700^{o}F) temperatures where losses of the more volatile metals (Pb, Cd, As) increase markedly. Removal of the metals corresponded somewhat to the removal of particulates. Silver, zinc, cadmium, lead, and presumably arsenic had relatively high concentrations in the fine particulate fraction of 0.1 to 1 microns, which was believed to account for their lower removal efficiencies in the scrubbers (EPA 1985a).

Filters

In the EPA evaluation of nine sludge incinerators discussed previously, it was suggested that the use of a 0.1 micron filter downstream of the wet scrubbers would assure virtually complete collection of metals except mercury (EPA 1985a). The fabric filter baghouse at the Hyperion Energy Recovery System, Los Angeles, CA, was reported to exhibit particulate reductions to less than 0.005 grams/m^3 (0.002 grains/DSCF) using a maximum air/cloth ratio of 3.0.

Dry Scrubber Systems and Electrostatic Precipitators

Neither dry scrubbers or electrostatic precipitators are commonly used on sludge incinerators. A multiclone is a typical dry scrubber system that may precede a fabric filter baghouse. Electrostatic precipitators achieve considerable removal of particulates by ionizing the particles between two large charged plates (configured like an electric capacitor). The ionized particles migrate to the oppositely charged plate and the fall out of the exhaust gas. The exhaust gas must be cooled to 250°C (480°F) prior to entering the electrostatic precipitators (EPA 1985a).

Stack Height

Adequate stack height assures dispersion of the exhaust plume by avoiding capture of the stack discharge in the downwash eddy downwind of structures. "Good Engineering Practice stack height" is defined in 40 CFR Part 51.1 as the greater of:

- 65 meters, measured from the ground level elevation at the base of the stack;
- The height of nearby structure(s) measured from the ground-level elevation at the base of the stack plus 1.5 times the lesser dimension (height or projected width of nearby structures); or
- The height demonstrated by an approved fluid model or a field study which ensures that the emissions from a stack do not result in excessive concentrations of any air pollutants as a result of atmospheric downwash, wakes, or eddy effects created by the source itself, nearby structures, or nearby terrain features.

8.6 MONITORING, REPORTING AND RECORD KEEPING

8.6.1 MONITORING

Federal Regulations

The current NPDES regulations require sludge monitoring at a frequency dependent upon the nature and effect of the permittee's sludge use and disposal activities but at least once a year for every pollutant limited in the permit. This means that if the permit contains a limit for mercury, the permittee must be required to monitor sludge at least annually for this pollutant.

Particulates and Opacity

The monitoring requirements for particulates and opacity from Subpart O of the NSPS (40 CFR Part 60) are:

- Install, calibrate, maintain, and operate a flow measuring device which can be used to determine the mass or volume of sludge charged to the incinerator. The flow measuring device shall have an accuracy of plus or minus 5 percent over its operating range.

- Provide access to the sludge charged so that a well-mixed representative grab sample of the sludge can be obtained.

- Use the test methods and procedures in Appendix A of 40 CFR Part 60 to demonstrate compliance with the limitations on particulates and opacity.

- The required frequency of monitoring is presently just a one-time analysis during system start-up.

A one-time stack test for particulate emissions is all that is required for particulates and opacity at present due to the interference of uncombined water in the determination of opacity.

Opacity

It is desirable to require facilities to monitor opacity to allow the plant staff to better track and control incinerator performance.

Mercury

Monitoring requirements for mercury from 40 CFR Part 61 Subpart E are as follows:

- Unless a waiver of emission testing is obtained under 40 CFR Part 61.13, each sludge incinerator owner or operator shall test mercury concentrations within 90 days of start-up. The test shall either be stack gas sampling or sludge-feed sampling as described in 40 CFR Part 61 Subpart E.

- The required frequency of monitoring per 40 CFR Part 61 is the one-time stack gas analysis within 90 days of system start-up plus annual monitoring of mercury emissions or sludge concentration for sources for which mercury emissions exceed 1,600 g/day, demonstrated either by stack sampling according to 40 CFR Part 61.53 or sludge sampling according to 40 CFR Part 61.54, which assumes all mercury in the sludge is volatilized.

Beryllium

Monitoring requirements for beryllium from 40 CFR Part 61 Subpart C are as follows:

- Unless a waiver of emission testing is obtained under 40 CFR Part 61.13, each owner or operator of a facility incinerating a waste containing beryllium shall test beryllium concentrations within 90 days of start-up. The emissions test shall be performed according to Method 104 or Method 103 of Appendix B of 40 CFR Part 61.

- The required frequency of monitoring per 40 CFR Part 61 is the one-time stack analysis within 90 days of system start-up, then every 30 days at an air sampling site located in such a manner as is calculated to detect maximum concentrations in the ambient air.

The requirements for beryllium monitoring apply only to facilities receiving waste from plants which process beryllium, beryllium ore, beryllium oxide, beryllium alloys, or beryllium-containing waste.

Polychlorinated Biphenyls (PCBs)

Incinerators that burn sludges containing more than 50 mg PCBs/kg of dry sludge solids must comply with the monitoring requirements of 40 CFR Part 761.70.

Operating Parameters

Revisions to 40 CFR Part 60 require the monitoring of a number of key operating parameters. They require all sludge facilities subject to NSPS to:

- Continuously monitor and maintain records of sludge feed rate, temperature profile of the incinerator, excess air levels/oxygen content of the exhaust gas and pressure drop across the emission control device, and daily monitoring of the moisture and volatile solids content of the sludge being incinerated; or

  Continuously monitor and maintain records of the incinerator exhaust gas volumetric flow rate and the pressure drop across the emissions control device.

  If the values of these parameters then deviate significantly from their values during the initial testing for particulates, the facility would be required to report the deviation.

- Initially test the sludge total solids content, volatile solids content, and metals concentrations (arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc) by grab samples.

- Testing of metals content (arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, beryllium, and lead) in emissions (in addition to the present initial testing of particulate content of emissions).

- Performance tests of monitoring devices after they are installed.

Federal Guidance

The Sewage Sludge Interim Strategy recommends that for Class I facilities, the permit should require an annual property pollutant scan and more frequent monitoring of the pollutants limited in the proposed Sludge regulations (40 CFR Part 503). These pollutants include: arsenic, beryllium,

cadmium, chromium, lead, mercury, nickel and total hydrocarbons. Some of the factors permit writers should use in determining frequency of monitoring includes size, compliance history, influent, industrial users, population density and sensitivity of ecosystems surrounding incinerator.

State Regulations

The reported State-by-State monitoring requirements are summarized in Table E8-3. States with no reported monitoring requirements are omitted from Table E8-3. Monitoring and reporting requirements are broken out in Table E8-3 into five categories: emissions, sludge, ash, sludge feed rate, and incinerator temperature. Of the 16 States included in Table E8-3, 10 have monitoring/reporting requirements for stack emissions, 9 monitor the sludge itself, 2 monitor the ash, 3 monitor the incinerator temperature, and 2 monitor the sludge feed rate.

Case-by-Case Recommendations

On a case-by-case basis, permit writers should consider requiring POTWs that use incinerators to conduct the same monitoring as is required under NSPS, if such monitoring is deemed necessary to protect public health and the environment from incinerator emissions.

Any deviations of parameters for which monitoring is required should be reported as such at the same times that the facility is required to submit Discharge Monitoring Reports (DMRs) to the State or to EPA.

8.6.2 REPORTING AND RECORD KEEPING

Federal Regulations

The recently promulgated revisions to be NPDES permitting regulations (54 FR 18716) require that the permit contain a requirement that the permittee report monitoring results with a frequency dependent upon the nature and effect of the sewage sludge use or disposal practice but in no case less than once a year (40 CFR Part 122.44(i)(2). The regulations also require that records pertaining to the POTWs sludge use and disposal activities (as set forth in 40 CFR Part 501.15(2)(2)) be retained for 5 years (40 CFR Part 122.21(p)).

The current Federal reporting requirements for particulates, mercury, beryllium, and PCBs are discussed below.

Particulates

The owner or operator must provide the Administrator at least 30 days prior notice of the start-up performance test and furnish the Administrator a written report of the results of the performance test.

Mercury

The Administrator shall be notified at least 30 days prior to the stack emission test required within 90 days of start-up. The samples from this test must be analyzed and mercury concentrations determined within 30 days after this test. All determinations must be reported to the Administrator by a registered letter dispatched before the close of the next business day following such determination.

A new emissions level must be estimated by calculation and the results reported to the Administrator prior to any changes in operation that would potentially increase emissions above that determined by the most recent source test.

Facilities required to perform sampling at least once per year shall have the samples from each test analyzed and mercury concentrations determined within 30 days after the test, and all determinations shall be reported to the Administrator by a registered letter dispatched before the close of the next business day following such determination.

Beryllium

The Administrator shall be notified at least 30 days prior to the stack emission test required within 90 days of start-up. The samples from this source test shall be analyzed and beryllium concentrations shall be determined within 30 days after this test. All determinations shall be reported to the Administrator by a registered letter dispatched before the close of the next business day following such determination. Beryllium air sampling site test results are to be reported every 30 days.

Polychlorinated Biphenyls (PCBs)

Incinerators that burn sludges that contain more than 50 mg PCBs/kg of dry sludge solids must comply with reporting and record keeping requirements of 40 CFR Part 761.70. Permit writers should consult with the Office of Pesticides and Toxic Substances.

Revisions to 40 CFR Part 60 require reporting of the following performance test data every six months:

- Every period of 15 minutes or more for which the pressure drop of the emissions control device falls below a specified value.

- Every period of 1 hour duration or more when oxygen content of the exhaust gas exceeds 10 percent (wet basis) and the corresponding one hour average oxygen content of exhaust gases.

- Incinerators achieving compliance with the New Source Performance Standards in a performance test with over 10 percent oxygen in the exhaust gas would be allowed to reach oxygen contents 3 percent above that of the most recent performance test on a one-hour average before the exceedance must be reported.

- Facilities monitoring pollution control device pressure drop, oxygen content of exhaust gases, and temperature profiles would report for each day there is a decrease in pollution control device pressure drop or increase in content of oxygen in exhaust gas, report temperature profiles, sludge feed rate, fuel use averaged over an 8-hour operating period, and moisture and volatile solids content of the sludge samples. Facilities monitoring pollution control device pressure drop and exhaust gas flow rate would report for each day there is a decrease in scrubber pressure drop or increase in exhaust gas flow. The report would include hourly average pressure drop and hourly average exhaust gas volumetric flowrate for the entire day either violation occurred.

State Requirements

The State of Connecticut requires reporting for particulates, SO_2, NO_2, CO, and hydrocarbons. The State of Georgia requires reporting for particulates, SO_2, NO_2, CO, ozone, and hydrocarbons. The State of Tennessee requires reporting for beryllium, lead, mercury, vinyl chloride, and

"others". The States of New Hampshire, Oregon, and Iowa also noted reporting requirements. The State of Kentucky requires reporting for mercury if emissions or sludge analysis is greater than 1,600 g/d. The State of Maryland requires a permit from Air Management Administration and Waste Management. The State of Missouri requires performance testing with representative samples of material to be burned. The State of New Jersey requires modeling for risk assessment of arsenic, chromium, cadmium and nickel.

REFERENCES

EPA 1972. Sewage Sludge Incineration, U.S. Environmental Protection Agency, R2-72-040, Washington, D.C., August 1972, 95p.

EPA 1979. Process Design Manual for Sludge Treatment and Disposal, Technology Transfer Series, U.S. Environmental Protection Agency 625/1-79-011, Cincinnati, OH, September 1979, 1135p.

EPA 1984. Environmental Regulations and Technology: Use and Disposal of Municipal Waste Water Sludge, U.S. Environmental Protection Agency 625/10-84-003, Cincinnati, OH, 1984.

EPA 1985a. Municipal Wastewater Sludge Combustion Technology, U.S. Environmental Protection Agency 625/4-85-015, Cincinnati, OH, 1985.

EPA 1985b. Summary of Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methods and Results, U.S. Environmental Protection Agency Office of Water Regulations and Standards, July 1985.

EPA 1987. State Requirements for Sludge Management, U.S. Environmental Protection Agency, Office of Municipal Pollution Control and Office of Water Enforcement and Permits. (Revised 1989.)

CHAPTER 9
SURFACE DISPOSAL

9.1 INTRODUCTION

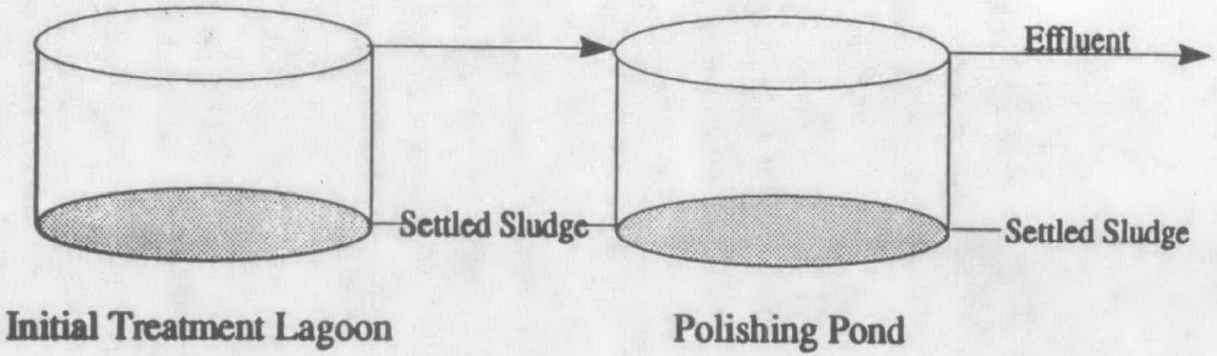
EPA has identified approximately 2,400 POTWs that use surface disposal sites (54 FR 5946). Currently, these sites are regulated by 40 CFR Part 257 as solid waste disposal facilities or practices. Like the other use and disposal options discussed in this manual, surface disposal was identified as one of the options needing regulation under 40 CFR Part 503. The proposed 40 CFR Part 503 defines surface disposal as an area of land on which only sewage sludge is placed for a period of one year or longer. This disposal practice includes sludge lagoons and stockpiles. The agency further decided to regulate surface disposal because when these practices are employed for more than just temporary storage, they pose threats to public health and the environment that are similar to those arising from improperly managed monofills.

For purposes of classification as surface disposal, sludge lagoons are impoundments where liquid sludge is placed. Sludge lagoons by definition are not a part of the wastewater treatment train. They do not include stabilization ponds or final polishing ponds. The sludge use and disposal regulations are not intended to regulate wastewater treatment. Figure 9-1 illustrates the difference between a wastewater treatment lagoon and a sludge lagoon.

Sludge stockpiles are frequently little more than above ground piles of relatively dry sludge. Sometimes these stockpiles have impervious surfaces under the sludge. They may or may not have run-off control structures. Sludge may be stored in piles temporarily before final disposal or indefinitely.

If improperly managed, surface disposal sites can contaminate surface water via run-off or washout during storms. Surface disposal practices contaminate ground-water by leaching through the soil. As lagoons dry out, the seal formed by the bottom layer of sludge may crack and migration of pollutants may occur. These practices can also cause public health and safety hazards. Decomposition of unstabilized sludge can create explosive atmospheres. Unstabilized sludge also causes vector attraction which can increase transmission of disease and pose a bird hazard to airports near surface disposal sites. It is because of these potential problems that surface disposal operations need to be regulated if the sludge is left for more than one year.

a) Wastewater Treatment Lagoon



b) Sludge Storage/Disposal Lagoon

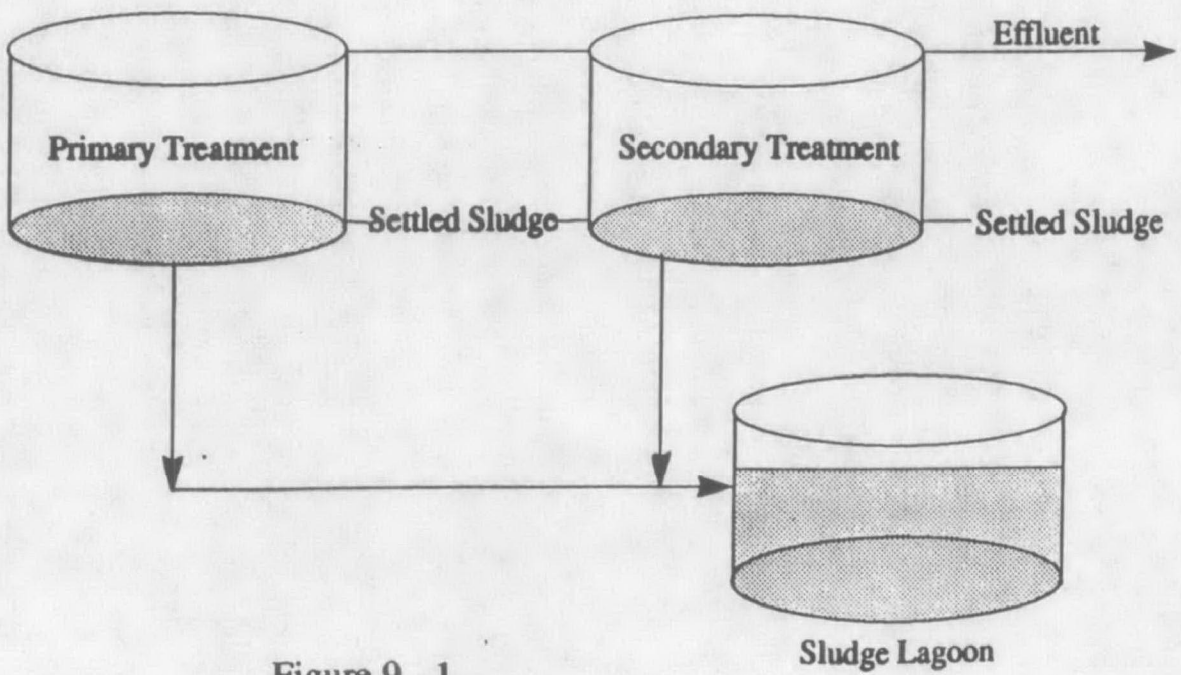


Figure 9 - 1.

Because most surface disposal sites were developed as a temporary or stop-gap sludge storage/disposal facility. EPA does not consider them to be environmentally acceptable solutions for ultimate disposal. The use of these practices for more than short-term storage should be discouraged, particularly by POTWs with sludges that contain significant levels of contaminants. In some circumstances, the permit writer should also consider evaluating the effects of surface impoundments where sludge is stored for less than one year. Situations where a review might be appropriate include lagoons that are continually replenished and almost always filled with sludge, sludge quality is generally poor, or site conditions are conducive to migration of contaminants from the lagoon. Sludge storage piles also have the potential for adverse effect.

This chapter summarizes the tools available to the permit writer for regulation of surface disposal practices. It discusses sludge quality and facility operation and management practices. For each topic, Federal regulations and State requirements are identified. Additional guidance is provided for development of case-by-case permit conditions for Class I sludge management facility permits.

9.2 CHARACTERISTICS OF SLUDGES SUITABLE FOR SURFACE DISPOSAL

9.2.1 SLUDGE POLLUTANT CONCENTRATION LIMITS

Federal Regulations

There are currently no Federal regulations limiting specific contaminant in sludge that is placed in surface impoundments. Two Federal regulations identify characteristics which require special treatment of sludge: (1) if the sludge contains concentrations of PCBs equal to or greater than 50 ppm, provisions of the Toxic Substances Control Act (40 CFR Part 761) apply; and (2) if the sludge is a hazardous waste it must be disposed of in accordance with RCRA Subtitle C. See Section 5.4 for a brief description of tests used to certify that sludge is not a hazardous waste.

State Requirements

One State (New Hampshire) prohibits the mixing of hazardous, toxic, or oily waste with sludge in a sludge lagoon.

9.2.2 SLUDGE PHYSICAL PROPERTIES

Federal Regulations

There are currently no Federal regulations with regard to sludge physical properties.

State Requirements

Six States have regulations addressing sludge physical properties for stockpiled sludge: Connecticut and Wyoming require sludge dewatering; Minnesota allows liquid sludge storage at municipally controlled sites; Nebraska allows the stockpiling of sludge with greater than 60 percent solids; New Hampshire requires sludge dewatering to at least 20 percent solids; and Vermont requires stockpiled sludge to have at least 15 percent solids.

9.3 OPERATING CONDITIONS AND MANAGEMENT PRACTICES

Required Permit Conditions

As mentioned above, the existing Federal regulations that apply to sludge lagoons and stockpiles are set forth in 40 CFR Part 257. These regulations are summarized in Table 5-1. The permit writer should consult the text of the rule for details and definitions (see Appendix D). As minimum Federal permit conditions for sludge, the permit writer should write into the permit or reference these existing Federal requirements for Class I POTWs that hold sludge in lagoons or stockpiles for more than one year. Rather than simply reference the 40 CFR Part 257 standards, permit writers should reference a valid solid waste permit for the facility that includes these standards, if one exists. The permit writer should be aware that many Federal regulations apply to the initial siting rather than operation of the surface disposal facility. There may be some cases where the permit writer will need to require the POTW to identify an alternate sludge use or disposal option because the current option violates the Federal regulations.

9.3.1 FLOODPLAIN RESTRICTIONS

Federal Regulations

Federal Regulations (40 CFR Part 257.3-1) do allow the location of sludge lagoons in the floodplain, provided they do not restrict the base (100-year) flood, reduce the temporary water

storage capacity of the floodplain, or result in the washout of solid waste to the extent that a hazard would be posed to human life, wildlife, or water resources.

State Requirements

As shown in Appendix E, Table E9-1, 24 States have regulations addressing sludge lagoons/stockpiles in floodplains. Thirteen States prohibit sludge lagoon/stockpile siting within the 100-year floodplain. Two States have restrictions based upon the 25-year and 10-year flood line. Twenty-two States require some kind of controls on surface flow, usually by the use of dikes or berms (see Appendix E, Table E9-1).

Case-by-Case Recommendations

Surface disposal operations pose a variety of problems during flood conditions. Sludge lagoons which utilize some of the storage capacity of the floodplain may increase the velocity of the flood which may in turn cause greater damage downstream. Sludge stockpiles are especially vulnerable to washout. Whenever possible surface disposal sites should not be located in a floodplain. If they are, structures to prevent run-on and run-off should be constructed to eliminate the threat of washout of sludge during a flood. These structures should be sufficient to control and divert the 24-hour 25 year storm.

9.3.2 SURFACE WATER PROTECTION

Federal Regulations

Federal regulations (40 CFR Part 257.3-3) require that the facility shall not cause a discharge of pollutants to surface waters that is in violation of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act, as amended. Discharges from sludge lagoons to waters of the U.S. must have NPDES permits. If run-off from a sludge stockpile constitutes a point source discharge, the stockpile must also have a NPDES permit. In addition, a facility shall not cause a discharge of dredged or fill material that is in violation of the requirements under Section 404 of the Clean Water Act, as amended. Lastly, a facility or practice shall not cause non-point source pollution of waters that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the EPA Administrator under Section 208 of the Clean Water Act, as amended.

State Requirements

Based on a summary of State requirements for sludge use and disposal, there do not appear to be any State regulations or guidance on the discharge of pollutants from sludge lagoons beyond the normal NPDES requirements. Nine States have minimum requirements for the distance to surface waters ranging from 50 feet in Virginia to 1,000 feet in Minnesota. Minnesota provides for a variance if there is run-off control at the facility.

Case-by-Case Recommendations

The appropriate distance to surface water is a site-specific determination. A minimum distance of 100 ft between the lagoon or stockpile and surface water is recommended, provided adequate run-on and run-off controls are in place.

9.3.3 GROUND-WATER PROTECTION

Federal Regulations

40 CFR Part 257.3-4 requires that a facility or practice not contaminate an underground drinking water source beyond the solid waste boundary. The solid waste boundary is the outermost perimeter of the solid waste as it would exist at completion of the disposal activity.

Contamination is defined as introducing a substance that would cause the concentration of that substance in the ground-water to exceed the Maximum Contaminant Level (MCL) specified in Appendix I of 40 CFR Part 257, or to increase the concentration of a substance already exceeding the maximum contaminant level specified in Appendix I.

See Appendix D of this document for the maximum contaminant levels specified in Appendix I of 40 CFR Part 257.

State Requirements

Several States indicated that soil type had some importance for the operation of sludge disposal facilities. To protect ground-water, Connecticut and Wyoming both require an analysis of soil type; Maryland requires a soil with low to moderate permeability, or a soil that will be sealed by

biological activity underlie the lagoon. Soil type requirements for Maine are rated by slope, permeability, flooding, drainage, and depth to bedrock.

Twelve States require minimum depths to ground-water (see Appendix E, Table E9-2): 2 feet (Maryland and Wyoming); 3 feet (North Carolina); 4 feet (Massachusetts and Nevada); 5 feet above highest anticipated ground-water level (New York and California); 6 feet (Vermont); and 10 feet to annual high water level (Colorado). Minnesota requires 8-inches of water holding capacity above the seasonal high water table. South Carolina requires a consideration of hydrogeologic conditions in the design of a storage lagoon.

Twenty-five States have regulations addressing the need for liners for sludge lagoons (Appendix E, Table E9-1). Ten States require some form of leachate collection. Minnesota waives loading and permeability requirements if leachate collection is employed.

Case-by-Case Recommendations

Many factors need to be considered with regard to ground-water protection when siting a lagoon or stockpile. Stockpiles should be located on an impervious surface. Permit writers should evaluate whether sludge lagoons should have liners or leachate collection systems. Important factors to consider are sludge quality, distance to drinking water wells, depth to ground-water, ground-water flow direction and velocity, aquifer classification based on the EPA Ground-water Protection Strategy (see Chapter 6), and underlying soil type and permeability. Permit writers should seek the advice of an experienced engineer/hydrologist.

A minimum soil buffer (or overburden) of 4 feet is recommended between the bottom of any lagoon or stockpile and the seasonal annual high ground-water table. Some of the important factors to consider in determining whether depth to ground-water is appropriate are sludge quality, the presence/absence of liners or leachate collection systems, the permeability of the soil buffer, and the value of the ground-water underlying the facility.

While lagoons may be theoretically self-sealing, in practice they are an unreliable means of isolating contaminants from the environment. If a lagoon is allowed to dry out, the seal formed in the bottom layer of a sludge lagoon could crack. If the lagoon is subsequently refilled, those cracks could allow the migration of sludge contaminants into the groundwater. For this and many other reasons, sludge lagoons are not considered to be an environmentally acceptable solution for ultimate disposal, and the use of lagoons for more than short term storage should be discouraged.

particularly for for POTWs with sludges that contain significant levels of contaminants. In the end, the permit writer will have to evaluate lagoons on a case-by-case basis taking into consideration such factors as 1) the thickness of the bottom seal and the likelihood of drying and cracking, 2) soil properties and their influence on contaminant migration, and 3) the properties of the sludge itself.

9.3.4 BUFFER ZONES

Federal Regulations

Federal regulation regarding buffer zones is found in 40 CFR Part 257.3-8. This regulation requires any facility or practice dispensing of putrescible wastes that is within 10,000 feet of a runway used by turbojet aircraft, or within 5,000 feet of any airport runway used only by piston-type aircraft shall take steps to avoid a bird hazard to aircraft.

State Requirements

Buffer zones are required in many States to protect surface water, ground-water, and public safety. State Requirements for buffer zones fall into four areas: distance to surface water, distance to the nearest dwelling, distance to wells, and distance to property lines.

As was described in section 9.3 2, nine States have minimum requirements for the distance to surface water. Nineteen States have a requirement for a minimum distance to the nearest dwelling. Five States require a minimum of 500 feet and six States require a minimum of 1/4 mile to the nearest dwelling. Other State requirements are included in Appendix E, Table E9-1.

Five States require minimum distances to the nearest well ranging from 300 feet in Maine to 2,500 feet in Massachusetts. Two States (Massachusetts and Arizona) specify greater distances from public drinking water wells than from private wells due to the increased size of the cone of depression during withdrawal. One State requires the consideration of local water supply wells in the sludge lagoon design. These State requirements are summarized in Appendix E, Table E9-1.

Five States require setbacks from the property line ranging from 25 to 375 feet. These State requirements are summarized in Appendix E, Table E9-1.

Case-by-Case Recommendations

In the absence of appropriate State requirements, the following minimum buffer zones from lagoons and stockpiles are recommended:

- Nearest Dwelling - 500 feet
- Nearest Drinking Water Well - 1,000 feet. The appropriate distance to the nearest water well will depend on site specific factors including those discussed in the section on liners, depth to ground-water, and ground-water monitoring.
- Property Line - 50 feet

9.3.5 ACCESS CONTROL

Federal Regulations

Federal regulation regarding access to a sludge disposal area is found in 40 CFR Part Part 257.3-8. These requirements state that a facility or practice shall not allow uncontrolled public access that would expose the public to potential health and safety hazards at the site. Unless prescribed by State requirements, specific measures for access restriction should be determined on a case-by-case basis.

State Requirements

Eleven States seek to control access to a site by the required use of fencing, locks, gates, and/or signs (see Appendix E, Table E9-2).

Case-by-Case Recommendations

Access control measures (e.g., fences, gates, locks, and signs) should be imposed based on the population density of the surrounding area.

9.3.6 PATHOGEN AND DISEASE CONTROL

Federal Regulations

To protect the public health, Federal regulations in 40 CFR Part 257.3-6 require that a facility or practice minimize the on-site population of disease vectors through the periodic application of cover material or other appropriate techniques. Although cover material would not be appropriate for a lagoon, other techniques such as sludge stabilization might be appropriate in order to reduce the presence of disease vectors at the facility.

State Requirements

No State requirements were noted in regard to the control of disease vectors. However, Connecticut and Colorado require stabilization of sewage sludge that will be stored or disposed of in lagoons or stockpiles.

9.3.7 AIR QUALITY CONTROL

Federal Regulations

Federal regulation 40 CFR Part 257.3-7 prohibits the open burning of sludge. This would not be a concern for a sludge lagoon.

State Requirements

Only three States, New York, Virginia and Minnesota, place restrictions on air pollution from lagoons. Although no specific information was provided, these restrictions probably pertain to the control of odors.

9.3.8 ENDANGERED SPECIES PROTECTION

Federal Regulations

Federal regulation 40 CFR Part 257.3-2 prohibits the establishment of a sludge lagoon that will cause or contribute to the taking of any endangered or threatened species of plant, fish, or wildlife (See Table 6-1 and Appendix D). In addition, the facility or practice may not cause the destruction

or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.

9.3.9 EXPLOSIVE GASES

Federal Regulations

Federal regulation 40 CFR Part 257.3-8 requires that the concentration of explosive gas not exceed 25 percent of the lower explosive limit for the gases in facility structures (excluding gas control or recovery system components) or 100 percent of the lower explosive limit for the gases at the property boundary. Accumulation of explosive gases are not usually a problem at open-air surface disposal sites.

Case-by-Case Recommendations

If there is a potential for generation of explosive gases, the permit writer should require monitoring and the development of a safety action plan for responding to unsafe levels of explosive gases in the atmosphere.

9.3.10 OTHER SLUDGE LAGOON RESTRICTIONS

State Requirements

Other State restrictions of sludge lagoons not covered in the preceding sections are described below.

Three states require a minimum freeboard for sludge lagoons (Idaho, Texas, and New York). Seven States require a site development plan. Two States require sludge stabilization or pathogen control. Two States have a loading limit. Five States require a closure plan. Six States require the emptying or inspecting of the sludge lagoons. Six States have miscellaneous requirements that are shown in Appendix E, Table E9-1.

Case-by-Case Recommendations

- If an existing or future sludge lagoon or stockpile is going to be used for ultimate disposal, development of a closure plan is recommended. The closure plan should address access

restriction, cover, and ground-water monitoring requirements (see 40 CFR Part 257, Appendix I, for contaminants recommended for monitoring). Sludge lagoons and stockpiles should be discouraged as ultimate disposal practices.

- Minimum freeboard: The sidewall of the lagoon should always extend at least two feet above the level of sludge/supernate in the lagoon.

- Sludge stored for more than one year in stockpiles should be stabilized by one of the sludge stabilization processes described in Chapter 2.0. Where odor is a concern, i.e., in populated areas, sludge that is stockpiled or stored in a lagoon should be stabilized regardless of the amount of time it is stored.

9.4 MONITORING, REPORTING, AND RECORD KEEPING

9.4.1 MONITORING

Federal Regulations

The current regulations require sludge monitoring and reporting at a frequency dependent upon the nature and effect of the permittees' sludge use or disposal activities, but at least once a year for every pollutant limited in the permit. This means that if the permit contains a limit for PCBs, the permittee must monitor its sludge at least annually for this pollutant (40 CFR Part 122.44(c)(2)).

Federal Guidance

For Class I sludge management facilities the Sewage Sludge Interim Strategy recommends annual monitoring of the 126 priority pollutants, as well as more frequent monitoring of the pollutants for which numeric limits have been proposed in the 40 CFR Part 503 technical sludge standards. For surface disposal sites, these pollutants include:

Arsenic	Dimethyl nitrosamine
Benzene	Lead
Benzo(a)pyrene	Lindane
Bis(2-ethylhexyl)phthalate	Mercury
Cadmium	Nickel

Copper
DDT/DDE/DDD (Total)[2]
Polychlorinated Biphenyls
Toxaphene
Trichloroethylene

State Requirements

As shown in Appendix E, Table E9-2, State monitoring and reporting requirements can be divided into the following categories: sludge monitoring, ground-water monitoring, surface water monitoring, and reporting.

Eleven States require sludge monitoring. Three States require annual monitoring (Colorado, Illinois and Wisconsin). One State requires monitoring of metals, PCBs, and pathogens (Connecticut). Maryland, Virginia, New Hampshire, New Jersey, Missouri and Wyoming also have sludge monitoring requirements.

Eighteen States require ground-water monitoring (see Appendix E, Table E9-2). Eight States have some sort of conditional ground-water monitoring requirement. One State requires monitoring of specific parameters (Vermont). One State sets specific site requirements for monitoring wells (Maryland).

Case-by-Case Recommendations

Based on a review of site conditions, permit writers should consider requiring installation of properly sited upgradient and downgradient ground-water monitoring wells for those sludge lagoons with the potential for contaminating valuable aquifers. The important factors to consider are listed above under the liner and depth-to-ground-water paragraphs. See Section 5.4 for more information on assessing the need for ground-water monitoring systems and on appropriate system designs.

[2]DDT-2,2-Bis(chlorophenyl) -1,1,1-trichloroethane
DDE-1,1-Bis(chlorophenyl)-2,2-dichloroethene
DDD-1,1-Bis(chlorophenyl)-2,2-dichloroethane

9.4.2 REPORTING AND RECORD KEEPING

Federal Regulations

The recently promulgated revisions to the NPDES permitting regulations (54 FR 18716) require that the permit contain a requirement that the permittee report monitoring results with a frequency dependent upon the nature and effect of the sewage sludge use or disposal practice but in no case less than once a year (40 CFR Part Part 122.44(i)(2)). These regulations also require that records of any monitoring information that is required by the permit must be retained for at least five years.

State Requirements

Thirteen States require reporting of some type for sludge lagoons. One State requires reporting for only permanent lagoons (Iowa). Two States require a quarterly summary of management records. Other State reporting requirements can be found in Appendix E, Table E9-2.

REFERENCES

EPA 1986. U.S. Environmental Protection Agency, Subtitle D Study, Phase I Report, October 1986.

EPA 1987. U.S. Environmental Protection Agency, State Requirements for Sludge Management, U.S. Environmental Protection Agency, Office of Municipal Pollution Control and Office of Water Enforcement and Permits, Washington, D.C., 1987.(Revised 1989.)

APPENDICES

APPENDIX A

SEWAGE SLUDGE INERIM PERMITTING STRATEGY

APPENDIX A

SEWAGE SLUDGE INTERIM PERMITTING STRATEGY

The attached "Sewage Sludge Interim Permitting Strategy" (Interim Permitting Strategy) describes EPA's plans to help ensure the safe use and disposal of sewage sludge prior to the promulgation of technical sludge standards. This Interim Permitting Strategy implements Section 406 of the Water Quality Act of 1987, P.L. 100-4 (codified at Section 405 (d)(4) of the Clean Water Act), which provides that, prior to sludge technical standards, EPA must "impose sludge conditions in (NPDES) permits issued to (POTWs)... or take such other measures as the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge."

The Interim Permitting Strategy:

- Discusses how to identify priority facilities for sludge permitting and basic permit requirements;
- Describes the permit writers' guidance document for writing interim sludge conditions;
- Describes EPA/State coordination of interim sludge permitting activities; and
- Provides model documents for use in implementing the Interim Permitting Strategy (boiler-plate permit language and State/EPA agreements, etc.)

A copy of the Interim Permitting Strategy document, including Attachments, can be obtained from the Permits Division (EN-336), 401 M Street S.W., Washington D.C. 20460. For further information concerning the strategy, contact Martha Kirkpatrick (202) 475-9529.

Sewage Sludge
Interim Permitting Strategy

Office of Water

Office of Water Enforcement and Permits

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SEWAGE SLUDGE INTERIM PERMITTING STRATEGY

STATEMENT OF POLICY

In order to implement the requirements of Section 405(d)(4) of the Clean Water Act, it is EPA policy that:

1. All NPDES permits issued or reissued to POTWs after February 4, 1987 shall at a minimum: require that the permittee comply with all existing federal regulations governing the use and disposal of sewage sludge, and with applicable 40 CFR Part 503 Standards for the Use and Disposal of Sewage Sludge when promulgated; contain a statement that upon promulgation of 40 CFR Part 503 the permit may be reopened and modified or revoked and reissued to incorporate applicable requirements of 40 CFR Part 503; and require that the permittee notify the permit authority of any significant change in its sludge use or disposal practices.

2. Priority POTWs for the purposes of interim sludge permitting are "Class 1 sludge management facilities," defined as POTWs 1) that are required to have pretreatment programs, or 2) that have any other known or suspected problems with their sludge. Sludge incinerators are presumed to have "known or suspected problems" unless available information shows no cause for concern.

3. All NPDES permits issued to priority POTWs after February 4, 1987 shall contain, in addition to the minimum conditions in Paragraph 1, additional conditions developed on a case-by-case basis to ensure protection of the public health and environment.

4. Permit writers should use EPA's "Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge" for developing case-by-case permit conditions for priority POTWs.

5. All permits issued or reissued to POTWs should contain sludge monitoring requirements in accordance with the Sewage Sludge Interim Permitting Strategy.

6. States are encouraged to participate to the fullest extent possible in interim sludge permitting.

7. The proposed 40 CFR Part 503 numeric limits for the use and disposal of sewage sludge should not be relied on for developing interim permit conditions, because these numeric limits may change as a result of public comment or peer review. However, other information and methodologies found in the proposed Part 503 rule and preamble, and its Technical Support Documents, may be used if the permit

writer determines their appropriateness for the sludge practice at issue.

8. States may obtain formal approval of their sludge programs prior to promulgation of the Part 503 standards. They may also elect to participate in interim permitting through agreements with their EPA Regional offices, pursuant to the Sewage Sludge Interim Permitting Strategy.

9. Where the State is issuing sludge permits pursuant to an agreement with the EPA Regional office, the Region will review all permits issued to priority facilities to determine if the permit meets CWA requirements. If the permit satisfies the CWA, the Region shall so certify and attach the certification to the permit.

I

INTRODUCTION

Section 405 of the Clean Water Act embodies Congress' concern with the environmental threats posed by unsafe sewage sludge use and disposal. Congress re-emphasized its concern in 1987 by amending this section to require EPA to develop detailed technical standards for sludge use and disposal that would be adequate to protect public health and the environment from sludge pollutants. The technical standards (to be codified at 40 CFR Part 503) will, when promulgated, identify pollutant levels of concern in sludge for the major use and disposal methods. However, before the standards are finalized, we need a program to identify and address potential problems that may be caused by contaminated or improperly disposed sludge, and to prepare for the implementation of the standards.

In the 1987 amendments to the Clean Water Act Congress recognized the need to take immediate action to regulate sludge. CWA Section 405(d)(4), as amended, requires that prior to the sludge standards, EPA must "impose sludge conditions in [NPDES] permits issued to [POTWs] ... or take such other measures as the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge." Thus, the amendments direct EPA to protect the environment from unsafe sludge, and initiate sludge permitting. This phase of the program, which began with passage of the Water Quality Act on February 4, 1987, is referred to as the "interim" sludge program and is the primary subject of this Strategy.

The Act establishes a two-phase approach to regulating sludge use and disposal. The first phase, interim implementation, commenced with the passage of the amendments. The second phase, long-term implementation, begins with final promulgation of the first round of the technical standards. Those standards are to identify toxic pollutants of concern in sewage sludge, and specify numerical pollutant limits and management practices for sludge to ensure environmentally-sound use and disposal. The Clean Water Act requires that users and disposers of sewage sludge comply with the standards within one year from promulgation (two years if construction is required). The Act also requires that the standards be incorporated into permits issued to POTWs and other treatment works treating domestic sewage. The proposed standards were published on February 6, 1989 at 54 FR 5746; final regulations are scheduled to be promulgated in October 1991.

The purpose of interim implementation is to establish a program for long-term implementation, and to ensure that the environment is protected from improper sludge use and disposal

prior to promulgation of the technical standards. This Strategy provides the details of implementing the interim phase. The requirement to take immediate action to regulate sludge use and disposal takes on critical importance since technical regulations are not scheduled to be promulgated until 1991.

This document explains EPA's approach to sludge permitting prior to issuance of the technical standards. To best achieve the objectives of the Clean Water Act, the interim program utilizes existing experience, expertise, and permitting processes to focus permitting efforts on the facilities which, on the basis of available information, are thought to present greater risk. There are three principal components to the Interim Strategy:

1. All NPDES permits issued to POTWs after February 4, 1987 are to contain certain basic requirements for managing sludge. Many of these requirements were included as part of the May 2, 1989 Sludge State Program and Permitting Final Rule.

2. For certain "priority" ("Class 1") POTWs, additional permit conditions developed on a case-by-case basis are needed to satisfy CWA Section 405(d)(4).

3. Permits containing sludge conditions are to be issued by EPA, or by a State pursuant to a State/EPA agreement, or by a State program that has been approved pursuant to 40 CFR Parts 123 or 501, as appropriate.

Part II of this Strategy identifies permit conditions that are to be included in all POTWs' NPDES permits as they are reissued. The most significant change in the final Interim Strategy from the draft that was made available for public comment in a May 31, 1988 Federal Register notice is the discussion of standard permit requirements. The Sludge State Program and Permitting Requirements Final Rule, among other things, codifies the interim requirements of CWA Section 405(d)(4), and establishes standard requirements and application deadlines for including sludge conditions in all POTW permits. Thus, many of the permitting provisions in the draft Interim Strategy are now regulatory requirements. Part II describes the new requirements, additional recommendations, and sludge monitoring provisions.

A discussion of "Class 1" POTWs and the development of additional, case-by-case conditions for these facilities is found in Part III.

Part IV discusses State/EPA coordination on sludge permit issuance during this interim period. Many States currently have sludge permit programs. One of the objectives of this Interim Strategy is to build on these existing programs as much as

possible, while meeting the requirements of the Act. The purpose of this is to take advantage of the State experience and expertise in sludge control and reduce redundant and unnecessary permitting. Thus, where a State has a sludge permitting program in place but is not yet seeking formal approval, the Strategy provides for CWA Section 405(d)(4) interim permitting under a State/EPA Agreement. These agreements should be in place by December 30, 1989.

In summary, EPA and the States need to begin immediately to identify and address potential sludge problems, to lay the foundation for an effective permitting program that protects the environment and promotes resource recovery. EPA's statutory responsibility to take interim measures with respect to sludge requirements for POTWs became effective upon enactment of the Water Quality Act on February 4, 1987. This Strategy is designed to carry out these objectives as quickly as possible, focusing on the facilities of concern and building on existing experience and expertise. Throughout the interim period, the Office of Water Enforcement and Permits (OWEP) will be providing additional information and guidance on sludge program implementation through permits. OWEP is currently providing both technical guidance and contractor assistance to Regions and NPDES States to conduct permit writing. OWEP also has been holding permit writers workshops for the Regions and States on developing interim permit conditions. Implementation of this Strategy not only enables EPA and the States to carry out the immediate responsibilities under the Act to protect public health and the environment, but also furthers the objectives of facilitating compliance with the technical standards when promulgated and approving State programs to carry out the requirements of Section 405.

II

GENERAL REQUIREMENTS FOR ALL POTW PERMITS

This Part describes the requirements for sludge permitting that were promulgated on May 2, 1989 (54 FR 18716) and became effective on June 1, 1989. These regulations, called the sludge State program and permitting regulations, among other things codify the requirements for interim sludge permitting in CWA Section 405(d)(4). (See §122.1(g)(5)). In addition, this Part contains some additional recommendations for standard interim conditions for all POTWs. (Part III discusses additional permit conditions for "Class 1" facilities.)

All reissued POTW permits must include some general requirements for sludge use and disposal, whether or not the facility needs additional case-by-case limits. These are the minimum provisions necessary to begin permit coverage of sludge use and disposal practices in anticipation of the long-term program, and to enable sufficient oversight of these activities in the interim. Most of these provisions are now required specifically by regulation. See 54 FR 18716 (May 2, 1989). The four primary areas each permit must address are: compliance with existing requirements; reopening the permit when the 503 regulations are promulgated; notification of change in sludge practices; and sludge quality monitoring. Attachment 1 contains a list of NPDES boilerplate conditions revised to include sludge conditions in accordance with the May 2, 1989 final rule, establishing new sludge permitting requirements.

Application Deadline

Section 122.21, which contains the NPDES permit application requirements, was revised by the May 2, 1989 notice to include permit application deadlines and application requirements for sludge. Under §122.21(c)(2), all POTWs with NPDES permits must submit information (including: sludge production, sludge use and disposal practices, and existing information on sludge quality, as set forth in §501.15(a)(2)) with their application for NPDES permit renewal, or 120 days after promulgation of the technical sludge standards, whichever occurs first. (All other "treatment works treating domestic sewage" do not need to submit an application for sludge permit coverage until 120 days after promulgation of applicable sludge technical standards, unless requested by the permit authority where necessary to protect public health and the environment. §122.21(c)(2)(ii).)

Boilerplate Conditions

The first standard permit condition is a compliance provision: the permit must require the POTW to comply with all existing requirements for sludge use and disposal.

§122.44(b)(2). For example, a POTW that applies its sludge to land is subject to the applicable requirements of 40 CFR Part 257. This compliance must be required in the permit and monitored by permit oversight.

Permit writers should ascertain the existence of any other permit governing the facility's sludge use or disposal practices before developing sludge conditions for the NPDES permit, whether the facility is a priority or not. Under the new regulations, applicants are required to submit a list of other permits governing their sludge management activities issued or applied for under other laws (§122.21(d)(3)(ii); §501.15(a)(2)(v)). For example, an incinerator may currently be subject to a permit under the Clean Air Act, a landfill under a RCRA permit, or the facility may be subject to a State permit. If these are adequate to satisfy Section 405(d), the NPDES permit need only reference the other permit, and add any additional requirements if necessary to protect public health and the environment. Also, in the course of developing the other permit, the permitting agency may have information on the sludge quality or use and disposal practices that may save the NPDES permit writer considerable time and effort.

This compliance provision also requires compliance with the sludge technical standards by the deadlines established in those standards. This provision restates (and puts the permittee on notice of) the CWA Section 405 requirement that users and disposers of sewage sludge comply with the technical standards for sludge use and disposal by the statutory compliance deadlines (i.e., within one year after promulgation of the standards, or within two years if the standards require construction), even if the permit has not been modified to include such requirements. See §122.41(a)(1). Any "permit-as-shield" provision in the permit also should be revised to indicate that compliance with "interim" permit conditions does not excuse noncompliance with subsequently promulgated technical sludge standards. See §122.5.

Another permit condition is a reopener clause, which authorizes reopening a permit to include technical standards if the technical standards are more stringent or more comprehensive than the conditions in the permit. See §122.44(b)(2) and (c)(4). This enables, but does not require, reopening the permit if the permit writer feels it is necessary to encorporate final Part 503 requirements. Consistent with the sludge State program and permitting regulations, reopening the permit when the technical standards are promulgated is discretionary with the permitting authority, not mandatory. Thus, the permitting authority will have flexibility to establish permitting priorities for implementing the technical standards. OWEP anticipates issuing additional guidance on this subject when Part 503 is promulgated.

The reopener provision notifies the permittee of future legal obligations under the Act, and of the potential need to modify the permit to incorporate Part 503 requirements once they are promulgated. The reopener provision also enables the permitting authority to develop permit conditions to assure compliance with the technical standards by the deadlines established in Section 405(d)(2) of the CWA. Revisions to §122.62(a)(7) now specifically authorize permit modifications pursuant to the reopener provision. The statement of basis or fact sheet for the permit should include a reference to the compliance provision and any other provisions that are in the permit to implement Section 405.

A notification provision, now codified in revisions to §122.41(l)(1)(iii), must be included in all reissued permits. This requires the permittee to give notice to the permitting authority when a significant change in the sludge use or disposal practice occurs (or is planned) that could require permit modification under 40 CFR 122.62(a)(1). The permittee need not notify the permit authority of every change, however slight, to its sludge use and disposal activities. However, a change in the POTW's sludge disposal methods, for example from landfilling to land application, is certainly significant as it could be cause for permit modification. Notice of, and possible permit modification for, new use or disposal sites not previously identified to the permitting authority (except land application sites covered by an approved land application plan) is also required (§122.41(l)(i)(iii)).

In addition to the standard sludge boilerplate conditions described above, (see Attachment 1 for permit language), the preamble to the recent revisions to the Part 122 regulations explains that many of the standard permit conditions that apply to effluent discharge activities will also apply to sludge use and disposal activities (e.g., duty of proper operation and maintenance; entry and inspection duties). Conversely, a few of the Part 122 regulations have been revised to limit their applicability only to effluent discharge activities (e.g., the "anti-backsliding" provision in §122.41(l)). Additionally, several provisions remained unchanged because the existing language was sufficient to include or exclude sludge use and disposal activities, as appropriate. The preamble discussion at 54 FR 18743 explains which provisions apply and do not apply to sludge activities. Permit writers should make revisions to the standard boilerplate conditions consistent with the revised regulations.

Monitoring Conditions

Another important component of interim permitting is sludge quality monitoring. Sludge monitoring to establish baseline data on each facility for future permit requirements is especially

critical as most interim permits, at least in the beginning, will contain few, if any, concentration limits for pollutants in sludge (and therefore, compliance monitoring will yield only limited information). Thus it is important for fulfilling the statutory requirement to protect public health and the environment that the permit writer have current information on pollutant concentrations, to alert the permit writer as to excessive loadings that may make a given sludge use or disposal method unsafe.

The regulations now require sludge monitoring and reporting at a frequency dependent on the nature and effect of the permittee's sludge use or disposal activities, but at least once a year (§122.44(i)(2)). This means that where the permit contains pollutant limits (e.g., the permit to a POTW that applies its sludge to land must contain the 40 CFR Part 257 limits for cadmium and PCBs, and pathogen requirements), the permit must require the permittee to sample and analyze those pollutants at least once a year. Beyond compliance monitoring, the regulations do not specify which pollutants in sludge must be monitored in the interim before promulgation of the technical standards. Similarly, the sludge application requirements do not specify standard monitoring results which must be submitted for permit issuance (although they do require applicants to submit all available data).

Because the regulations only require compliance monitoring, and because compliance monitoring, given the fact that few permits are likely to contain pollutant limits, will not yield enough information, the permit writer should require monitoring of additional pollutants, based on his/her best professional judgment. In some cases the permit may already require sludge sampling and analysis, and the permit writer may have a good idea as to the quality of the sludge and the levels of pollutants it contains. In the absence of such information, EPA recommends that at a minimum, the permit writer include the following monitoring requirements in the permit:

- For Class 1 POTWs, an annual scan of the 126 priority pollutants, and more frequent monitoring of the pollutants for which numeric limits have been proposed for the POTW's particular use or disposal practice in the proposed Part 503 regulations (see Attachment 4).

- For non-Class 1 POTWs with industrial users, a priority pollutant scan at the time of permit application, and annual monitoring of the pollutants for which numeric limits have been proposed for the POTW's particular use or disposal practice in the proposed Part 503 regulations (see Attachment 4).

- For non-Class 1 POTWs with no industrial users, annual monitoring of six metals: cadmium, copper, chromium, lead, nickel, and zinc.

Of course, monitoring requirements would be tailored to the particular POTW and would take into consideration site-specific factors, such as the types of industrial wastes the POTW receives. At the discretion of the permit authority, if a pollutant is not detected or is detected at low levels that clearly show no cause for concern after repeated tests, future testing for those pollutants need not be required unless a change occurs at the POTW.

The reason for monitoring for the pollutants proposed to be limited in the Part 503 proposed rules is so the POTW and the permit authority will have sufficient information on sludge quality with regard to those pollutants when the Part 503 rules are finalized. This is particularly important in light of the one-year compliance deadline mandated by the Clean Water Act. (Note that once the Part 503 regulations are promulgated, monitoring parameters will be governed by those rules (and 40 CFR Part 122.44(i)(2)). The Guidance for Writing Case-by-Case Permit Conditions for Municipal Sewage Sludge (described in Part III) contains further recommendations for developing conditions for additional baseline monitoring for pollutants of concern and compliance monitoring for each major use and disposal practice. (A list of the pollutants proposed to be regulated in 40 CFR Part 503, by use or disposal method, is provided in Attachment 4.)

This Strategy recommends that non-Class 1 POTWs with no industrial users at a minimum sample for six metals that are commonly found in sewers at significant levels due to commercial and domestic discharges to the treatment works. If the permit writer has pre-existing data on the sludge quality of the facility that shows no cause for concern with particular pollutants for that POTW's sludge practices (i.e., routine readings of particular pollutants which are very low or not detected), monitoring for that pollutant does not need to be continued unless there is a change at the POTW. Another exception is for POTWs that use wastewater stabilization lagoons as the sole treatment process. For these facilities, where the sludge will not be removed from the lagoon during the permit term, the permit need not contain any sludge monitoring provisions unless the permit writer determines they are needed. (If such permit does not require monitoring, it should contain a requirement that the permittee notify the permit authority if it happens that the sludge is pumped out of the lagoon within a one-year period.)

The permit should also specify appropriate sampling protocols. To develop these requirements, permit writers are directed to two sources. The first is entitled "POTW Sludge

Sampling and Analysis Guidance Document," EPA, Office of Water Enforcement and Permits, 1989. This document is designed to provide information on the sampling and analysis of municipal sewage sludge, and contains discussions of procedures and protocols, and current developments on specific topics such as pathogen equivalency determinations. The second document is entitled "Sampling Procedures and Protocols for the National Sewage Sludge Survey," EPA, Office of Water Regulations and Standards, 1988. The sampling procedures and protocols included in this document were compiled specifically for the National Sewage Sludge Survey, which the Agency has initiated to gather additional information on the pollutants in sewage sludge to support the Part 503 rulemaking.

The permit also should specify the acceptable analytical methods. A notice published at 53 FR 39133 (October 5, 1988) lists all pollutants, and the methods used to analyze them, that were tested in the national sewage sludge survey. The question of appropriate analytical methods for determining pollutant concentrations in sewage sludge has been an ongoing one. Methods 624 and 625, found in 40 CFR Part 136, are essentially adapted from wastewater analytical methodologies. These methods have been in longer use and thus are more widely available. EPA's newer isotope dilution, gas chromatography/mass spectrometry (GC/MS) methods 1624 and 1625 have been developed specifically for sewage sludge. The permit writer may specify these methods or other EPA-approved methods, or methods that are deemed comparable based on their precision, accuracy, lab availability, interlab variability, and the level of detection needed to monitor compliance.

Most of the general monitoring and recordkeeping requirements in Part 122 apply to sludge monitoring and recordkeeping (e.g., §§122.41(j) and 122.48). There are two important differences, however. First, the regulations do not currently prescribe specific monitoring reporting forms. Instead, the permitting authority has discretion to determine an appropriate form (§122.41(l)(4)(i)), which should be specified in the permit. Second, the record retention time for sludge records is five years, rather than the three-year period that applies to effluent discharge recordkeeping. (§122.21(p) and §122.41(j)(2)). (The rule provides a longer record retention time for sludge because of the need to track cumulative loadings for metals in sludge that is applied to land over a longer period. The five-year record retention time will enable this information to be "carried over" when the permit is reissued.)

Summary

In sum, to fulfill the objectives that Congress has established in Section 405(d), we must begin as soon as possible to establish permit requirements for sludge. All POTW permits

must include compliance provisions, notification language, and monitoring requirements as described above and specified in the regulations, and should include sludge quality monitoring as set forth in this Strategy. In addition, case-by-case permit requirements will need to be developed as appropriate. This is discussed in Part III.

III

CASE-BY-CASE CONDITIONS FOR CLASS 1 POTWS

The previous section discusses basic permit requirements for all NPDES permits issued or reissued to POTWs after February 4, 1987. There are situations, however, where more comprehensive, site-specific permit coverage may be warranted. This may mean more frequent monitoring or other site-specific conditions such as management practices or numeric limitations developed on a case-by-case basis. This gives rise to two questions: which POTWs should receive more comprehensive permit coverage during this interim period, and what should be included in the permits issued to such facilities.

Identifying Permitting Priorities: Class 1 Sludge Management Facilities

A major purpose of requiring case-by-case sludge limits only for certain POTWs is to target available resources for sludge permitting on critical sites. In earlier versions of this Strategy, which generally referred to POTWs with known or suspected problems with sludge quality or use/disposal practices, or those warranting more comprehensive sludge permit conditions for other reasons. The draft Strategy suggested that pretreatment POTWs, POTWs incinerating their sludge, POTWs using or disposing of sludge in ecologically-sensitive areas such as estuaries, and new POTWs should be evaluated closely to determine if they should be included in the priority category.

The recently promulgated sludge management regulations also identify a group of POTWs targeted for closer oversight because of the greater potential for their sludge use and disposal to adversely affect public health or the environment. These are called "Class I sludge management facilities." Thus, this definition and the earlier "priority" POTW designation serve similar purposes and are based on the same rationale. To facilitate long-term implementation, "Class I sludge management facilities" will be presumed to need case-by-case sludge interim limits (i.e., they should be considered permitting priorities), unless the permitting authority determines, based on information about the facility's sludge quality and use or disposal practices, that the sludge is adequately controlled already. In this Strategy, the terms "priority" and "Class 1" facility are used interchangeably.

A Class I sludge management facility is defined as:

> ...any POTW identified under 40 CFR 403.8(a) as being required to have an approved pretreatment program (including such POTWs located in a State that has elected to assume local program responsibilities

> pursuant to 40 CFR 403.10(e)) and any other treatment works treating domestic sewage classified as a Class I sludge management facility . . . because of the potential for its sludge use or disposal practices to adversely affect public health and the environment.

Pretreatment POTWs were included in the definition of "Class I sludge management facility" in response to numerous requests for more specificity in defining priorities. In addition, the same factors that determine whether a POTW should be required to develop a local program (i.e., size, industrial users subject to pretreatment standards, or necessary to prevent pass-through or interference with the POTW's operations) also suggest that sludges from pretreatment POTWs have a greater potential for having significant impacts on public health and the environment.

"Class I sludge management facility" also includes other treatment works with known or potential sludge problems. In assessing the risks associated with the various sludge use and disposal options, EPA has found that the potential risk levels are highest for incinerators. In addition, in a recent Agency study of comparative risks, sewage sludge incinerators were identified as one of the potentially more harmful sludge use and disposal practices. Overall, the risk was assessed to be in the middle range in comparison to other environmental problems. See "Unfinished Business: A Comparative Assessment of Environmental Problems," U.S. EPA, Office of Policy, Planning and Evaluation, February 1987. Because of this, POTWs using incineration should be presumed to need case-by-case sludge permit limits, unless the permit writer has information demonstrating that there is no cause for concern. (Note: Most POTWs incinerating their sludge are also pretreatment POTWs. Therefore, only those POTWs using incineration which are not required to have pretreatment programs will need to be considered additionally. See Attachment 3.)

Attachment 2 contains listings of pretreatment permits that have expired or expire in FY89 and FY90. A separate listing shows the POTWs that incinerate their sludge and gives the expiration dates for the NPDES permits.

Other POTWs may have known or potential sludge use and disposal problems. A POTW in non-compliance with existing federal regulations (e.g., 40 CFR Part 257) is one example. When the NPDES permit is due to be reissued, the permitting authority will need to make a determination whether the facility will need case-by-case limits. Case-by-case limits should not be rejected simply because the permitting authority has no knowledge of any sludge problems. Instead, the permit writer should take reasonable steps to ascertain the nature of the facility's sludge and sludge disposal practices. Under the May 2, 1989 sludge management regulations, POTWs are required to submit basic background information and available monitoring results on their

sludge and use and disposal methods with their NPDES permit renewal application. 40 CFR 122.21(c)(2). Other available information also should be examined, such as pretreatment audit reports and investigations into interference problems at the POTW, to see if any problems with sludge have been identified. Also, POTWs conducting sludge use or disposal in ecologically sensitive areas, such as estuaries, may warrant more comprehensive sludge permit conditions beyond the basic boilerplate and monitoring requirements.

Permits issued to POTWs with new sludge treatment facilities should also be carefully considered for development of case-by-case sludge conditions. Although known problems may not exist, preventing problems through careful controls at new facilities is generally easier for both the permitting authority and permittee than taking remedial action after a problem has developed. (Note: this paragraph does not refer to situations where a POTW has switched to another existing facility, for example, to a different monofill, but rather, refers to treatment facilities that are newly constructed.)

One commenter on the draft strategy suggested that the nine sewerage authorities in New York and New Jersey that dispose of their sewage sludge in the ocean should also be identified as a "priority" for interim sludge permitting. The Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) regulates ocean disposal, and prohibits ocean dumping without a permit issued pursuant to MPRSA. In November 1988, Congress passed the Ocean Dumping Ban Act, amending MPRSA. Among other things, the purpose of this Act is to terminate the ocean-dumping of sewage sludge by December 1991. The significance of this legislation for the implementation of Section 405 of the CWA is that after December 31, 1991, it will be unlawful to dispose of sewage sludge in the ocean, and those POTWs that currently ocean-dispose of their sewage sludge will have to develop land-based sludge management alternatives, which will be subject to the jurisdiction of Section 405 of the Clean Water Act. Prior to the termination of dumping, State and Regional NPDES and sludge permit writers should work with the POTWs and MPRSA authorities to identify the quality of the sewage sludge and assist the POTWs in developing land-based sludge use or disposal methods. This involvement is not for purposes of regulating the practice of ocean disposal, which will be effected through the MPRSA permit process, but rather, to assist the facility in implementing land-based disposal methods that will meet the requirements of CWA Section 405.

Case-by-Case Permit Conditions

To assist permit writers in developing more comprehensive permit conditions for Class 1 facilities, EPA has developed a "Guidance for Writing Case-by-Case Permit Requirements for

Municipal Sewage Sludge" ("CbC Guidance"). The purpose of the guidance is to assist permit writers in developing appropriate permit conditions for sludge and EPA permit writers in reviewing State permits issued to Class 1 POTWs.

As stated earlier, the most important task for the interim period is to ensure that existing requirements are written into permits. Use of the CbC Guidance ensures that existing applicable federal and State requirements are incorporated into permits issued to Class 1 POTWs. Its use should help to promote timely compliance with the Part 503 sludge regulations when issued, by those POTWs most likely to cause adverse effects from pollutants in sewage sludge. (The Part 503 sludge regulations will require compliance within one year from promulgation.) In addition, compliance with the monitoring requirements specified will provide information on sludge quality and the use and disposal practices at the POTW, and help to identify potential problems.

As a "best professional judgment" guidance document, the CbC Guidance presents: 1) a compilation of existing federal and State requirements for sludge; 2) existing guidance; and 3) recommendations for permit writers to consider writing into permits on a case-by-case basis using their best professional judgment. The CbC Guidance sets forth existing requirements for each of the major sludge use and disposal practices. Additionally, the Guidance contains recommendations for further permit conditions. In general these recommendations consist of management practices, although some recommended numeric limits are given, based on existing guidance. The CbC Guidance states that EPA permit writers must write existing federal sludge requirements into NPDES permits or incorporate them by reference to other permits.

The Guidance may be used by Regional and State permit writers to assist them in arriving at appropriate permit limits for priority facilities, and by the Regions in reviewing State-issued permits. The fact sheet or statement of basis accompanying the permit must explain the basis for arriving at the sludge requirements. EPA and States may take further action beyond what may be specified in the guidance, where appropriate to protect public health and the environment where particular problems are identified and a basis for the requirements is established.

Interim Conditions and the Proposed 503 Standards. EPA recently proposed technical standards for the use and disposal of sewage sludge (54 FR 5746; February 6, 1989). This rulemaking is being developed to meet the requirement in Section 405(d) that EPA promulgate regulations identifying sewage sludge use and disposal methods and concentrations of pollutants that interfere with each method. The proposed Part 503 regulations address sewage sludge incineration, land application, landfilling,

distribution and marketing, and surface disposal. EPA has also developed technical support documents for each method.

The Interim Strategy and the CbC Guidance are designed primarily for use before issuance of the final technical standards. The focus of the interim program is on identifying and addressing, through permits, existing or potential problems with sludge use or disposal, in the absence of promulgated technical standards. In developing permit limits for POTWs in the interim, the primary source of information for permit writers should be the Case-by-Case Guidance. Information from other sources, of course, may be considered and evaluated by the permit writer in the exercise of his or her best professional judgment. These include, for example, the proposed 503 rule and preamble, its technical support documents, and available information from the National Sewage Sludge Survey.

The proposed 503 standards are currently undergoing public comment and peer review. These processes, as well as the results of the National Sewage Sludge Survey may result in final standards that are significantly different from the proposal. In light of these circumstances, reliance on the proposed standards should be limited. The permit writer should not rely on the proposed numeric limits in developing case-by-case sludge conditions unless the permit writer can independently establish the appropriateness of such conditions based on the circumstances of the particular sludge practice at issue. As previously noted, any sludge conditions, other than those based on existing regulations, must have a sound technical basis explained in the fact sheet that accompanies the permit.

IV

STATE AND EPA COORDINATION ON INTERIM SLUDGE PERMITTING

EPA seeks to encourage States with existing, effective sludge management programs to carry out the program for implementing interim sludge permitting under the CWA to the extent that they are willing and able to do so. This Part describes the minimum requirements necessary for State interim permitting, and the procedures for establishing State/EPA coordination in the permitting process.

EPA interprets CWA Section 405(d)(4) to allow State/EPA coordination, whereby States with existing effective sludge management programs could carry out interim sludge permitting. This is beneficial for the national sludge program because States with effective programs are more likely to know which particular facilities or practices may be causing problems. Moreover, involving States now serves the dual purpose of minimizing disruption to existing State programs and reducing duplication of effort by EPA and the States.

The sludge State program and permitting regulations, promulgated on May 2, 1989, provide for formal submission of State sludge programs for review and approval by EPA. States may, but do not need to, seek formal approval, pursuant to the May 2, 1989 rules, during the interim phase to carry out interim and long-term permitting. They may also opt to rely on more informal arrangements with the EPA Regions, as this Part explains. States that are not yet seeking formal approval are encouraged to use this interim period to evaluate their programs in light of the requirements for approvable sludge State programs to identify areas where their programs may need to be changed or augmented in order to be approved.

Establishing State/EPA Coordination

A. Minimum Requirements

The 1987 CWA amendments give EPA the flexibility to rely on State sludge management activities to carry out the objectives of the Act for interim sludge requirements. Where the State chooses to participate in the interim program through an agreement, the Agency will take steps to ensure that any measures are adequate to protect public health and the environment by overseeing State efforts. To accomplish this, this Strategy adopts a two-pronged approach which targets facilities of concern for oversight.

For all NPDES POTWs that are defined as Class 1, the Region will review the sludge requirements in each State-issued permit (or other individual control mechanisms) to make sure they incorporate existing federal requirements and meet the objectives

of the Clean Water Act. The CbC Guidance is intended to assist the Regions in this review. The review of the sludge conditions could be built into the Region's process for reviewing State permits issued to NPDES majors.

Section 405(d)(4) authorizes only the Administrator to impose conditions in NPDES permits or take other appropriate measures. Thus, to be recognized under Section 405(d)(4), conditions imposed by States must be approved/adopted by EPA. To accomplish this, three steps are required. First, a State which issues a Class 1 permit would state in the public notice of the draft permit that the permit (or facility-specific plan) will contain sludge requirements to implement the requirements of Section 405 of the CWA and therefore will be federally enforceable pursuant to Section 309 of the Act. Second, the Region must review the permit and determine whether it satisfies the requirements of the interim program. Finally, the Region must affirmatively approve the permit by issuing a letter or certification to the State permitting agency. This written documentation of EPA approval should also be attached to the permit. (A sample certification letter is in Attachment 5.) Following these steps should enable EPA to take action to enforce interim sludge requirements in these permits where appropriate (e.g., joint enforcement actions with the State, cases of national significance, etc).

The public notice and permit-by-permit EPA approval requirements applicable to permits for Class 1 POTWs will not be required for non-Class 1 POTW permits. However, for interim implementation purposes, a State must be able to impose the minimum requirements for these other permits set out in Part II. EPA will also oversee the State's activities in imposing the minimum requirements on non-Class 1 permits. However, oversight will not be required on a permit-by-permit, or individual POTW, basis, but may be accomplished through other means, such as periodic file or permit reviews and annual program reviews.

B. State Eligibility

Any State with an effective sludge permitting program may participate in the implementation of interim sludge requirements, regardless of that State's NPDES participation or status. In seeking State involvement, EPA will need to determine the extent to which the State is willing and able to implement this Strategy for carrying out the responsibilities created by Section 405(d)(4). State participation should be encouraged to the maximum extent possible. Where States either cannot (for example, because they lack legal authority) or will not participate, EPA will remain responsible for imposing sludge requirements. Where the State will not undertake sludge permitting and EPA is the NPDES permitting authority, the EPA permit writer

would simply include sludge requirements in the reissued NPDES permit. Where the State has NPDES authority, EPA would issue a "sludge rider" to the State-issued NPDES permit or issue a separate Section 405 sludge permit. (Attachment 6 contains a model EPA "sludge rider".) Wherever possible, State and EPA sludge permitting activities should be coordinated to assure consistency and minimize duplication of efforts. (See, for example, 40 CFR 124.4 on joint permitting procedures.) In most cases, interim implementation will require the combined efforts of States and EPA Regional Offices to protect the environment adequately and put an effective sludge program in place. The degree of participation will likely vary from State to State. States need not assume full responsibility for interim permitting in order to participate. For example, a State may currently regulate only one disposal practice. In that case, the State could agree to cover interim sludge permitting for that particular practice, and EPA would issue permits for the other use and disposal practices.

C. Procedures for Establishing State/EPA Coordination

Establishing State/EPA coordination in interim permitting involves two steps: (1) the State must identify the extent to which it is able and willing to participate; and (2) the State and the Region would execute an agreement establishing the responsiblities of EPA and the State in the interim sludge permitting process.

Regional offices should contact each State about its capacity to undertake interim implementation activities. Execution of an agreement will be necessary with any State that agrees to participate. This agreement could be part of the Section 106 planning process or any other appropriate vehicle that defines EPA/State roles in program implementation.

(1) State's Declaration

Initially, the State should identify the capacity of its existing program to regulate the sludge use and disposal practices of its POTWs in comparison to the minimum requirements established in the CbC Guidance and Parts II and III of this Strategy. Generally, EPA will rely on the State's declaration of its capacity (i.e., resources and legal authority to impose and enforce interim sludge requirements). As noted above, a State need not assume full responsiblity for all sludge permitting in order to participate. For example, a State may currently regulate only land application of sludge. The State could agree to be responsible for permitting only the POTWs which use this disposal method now. Later, if the State's program expands to include regulation of other disposal options, it could expand its role in interim implementation. EPA will encourage States that cannot assume full sludge permitting immediately to increase

their permitting capabilities over time. Where a POTW uses more than one disposal option and the State does not regulate all options, EPA must "fill in the gaps" either by issuing a sludge rider to the State-issued permit (see Attachment 6) or a separate Section 405 permit. If known in advance, this specific situation should be addressed in the State/EPA sludge agreement.

(2) State EPA Sludge Agreement

After the State has expressed its willingness to participate in interim implementation, the Region should enter into an agreement with the State establishing their respective responsibilities for interim implementation of sludge requirements, especially permitting responsibilities and information exchange between the State and the Region. The agreement also may include provisions about other aspects of EPA-State coordination of sludge management activities as well (e.g., coordination of inspections and enforcement actions). The agreement may be flexible in many respects, but it should clearly identify permitting responsibilities of the State and EPA in establishing sludge requirements.

The agreement may be an annual workplan negotiated as part of the Section 106 process, but the Region and State should consider documenting longer term understandings for development of a full State program with EPA's assistance. The agreement may be executed as a revision to an existing agreement or as a separate agreement. In NPDES States, revisions to the NPDES Memorandum of Agreement (MOA) may also be necessary if it conflicts with any of the provisions described below. Also, if the MOA waives EPA review of minor POTW permits, this waiver would have to be modified to facilitate review of permits for minor POTWs which are classified as Class 1 permits for sludge purposes and thus require EPA review. See §123.24(d).

The State/EPA sludge agreement should include provisions to address the following:

- o Identification of the POTW permits the State will be responsible for, those EPA will be responsible for, and those for which EPA and the State will assume joint responsibility;

- o For permits for which EPA assumes responsibility, a description of how the Region will issue the sludge permit (i.e., by issuing a "sludge rider" to the State-issued NPDES permit, through joint issuance of the permit or by issuing a separate EPA NPDES sludge permit);

- o Provisions for joint issuance of permits, where appropriate;

- Provisions for EPA review and comment on all Class 1 permits drafted by the State, and agreement that if EPA determines that State limits are not adequate in any specific case, EPA will issue a "sludge rider" or separate sludge permit to the POTW;

- For sludge Class I permits with sludge conditions the State issues, agreement by the State to include in the public notice of the draft permit, in addition to other information that may be required by State or federal requirements, a statement that the draft permit includes conditions implementing interim sludge requirements pursuant to Section 405(d) of the CWA and, therefore, will be federally enforceable pursuant to Section 309 of the CWA after review and approval by EPA (see Attachment 7 for language);

- State's agreement to include in permits issued to non-Class 1 POTWs the minimum conditions described in the "Sewage Sludge Interim Permitting Strategy";

- Provisions that establish the State's compliance monitoring and enforcement activities for the permits it agrees to issue (See Attachment 7);

- An agreement to share, upon request, the results of any sludge monitoring activities (e.g., self-monitoring and inspection reports);

- Provisions that recognize that the agreement is not a substitute for formal program approval and that EPA approval of the State sludge program will be needed for purposes of long-term implementation (i.e., after final promulgation of the Part 503 technical criteria, which is scheduled for 1991); and

- Any agreements concerning activities to build up the State program in preparation for obtaining formal program approval.

A model State/EPA sludge agreement is found in Attachment 7.

Even when a State with an existing sludge management program does not actively participate in interim permitting, EPA permit writers should look to the State as a valuable resource and consider adopting by reference existing State permits and/or requirements. As with State requirements affirmatively approved by EPA, including State requirements in the NPDES permit means that EPA is adopting those requirements as its own and therefore must be be prepared to enforce and defend them.

D. Timetable

It is crucial that Regions and States begin now to work out the details for establishing State participation in interim implementation. The State/EPA sludge agreements should be executed as soon as possible, but no later than December 31, 1989. A copy of any agreements should be sent to the Cynthia Dougherty, Director, Permits Division, Office of Water Enforcement and Permits.

APPENDIX B

REGIONAL AND STATE AIR, SOLID WASTE AND GROUND WATER CONTACTS

Regional and State Solid Waste Program Contacts

Region	State	Name	Phone Number FTS	Phone Number Commercial
I		Ron Jennings	8-833-1687	617/573-9687
	CT	Barry Giroux		203/566-5712
	MA	Willa Kuh		207/289-2651
	ME	David Boulter		617/292-5980
	NH	Thomas Sweeney		603/271-2925
	RI	John Quinn		401/277-2797
	VT	William Ahearn		802/244-8702
II		Michael Debonis	8-264-0002	212/264-0002
		David Savetsky	8-264-0547	212/264-0547
	NJ	Robert Confer		609/292-5196
	NY	David O'Toole, P.E.		518/457-2051
	PR	Raquel Cortes		809/722-0493
	VI	Alfred Williams		809/773-0565
III		Thomas Merski	8-597-3159	215/597-8990
	DC	Byron Bacon		202/783-3193
	DE	Richard Folmsbee		302/736-5060
	MD	Georgina Havlik		301/225-5664
	PA	William Pounds		717/787-7381
	VA	Wladimir Gulevich		804/225-2667
	WV	Robert Seip		304/348-5935
IV		Craig Brown	8-257-3433	404/347-3433
	AL	Dewey Honeycutt		205/271-7761
	FL	Rick Wilkins		904/488-0190
	GA	James Dunbar		404/656-2836
	KY	Shelby Jett		502/564-6716
	MS	Bill Barrett		601/961-5062
	NC	Gordon Layton		919/733-2178
	SC	Hartsill Truesdale, P.E.		803-734-5200
	TN	Doyl Rowland		615/741-3424
V		Bill MacDowell	8-886-7452	312/886-7452
	IL	William Child		217/782-6760
	IN	Jacqueline Strecker		317/243-5015
		Dan Magoun		317/232-4473
	MI	Tim Wright		517/373-2730
	MN	James Warner		612/296-7340
	OH	Nancy Moore		614/644-2956
	WI	Lakshmi Sridharan		608/266-0520

Regional and State Solid Waste Program Contacts

Region	State	Name	Phone Number FTS	Phone Number Commercial
VI		Carl Bolden	8-255-6760	214/655-6760
	AR	Mark Witherspoon		501/562-7444
		Gary Martin		501/562-7444
	LA	Paul Miller		504/342-1216
	NM	Raymond Sisneros		505/827-2775
	OK	R. Fenton Rood		405/271-7159
	TX	Minor Hibbs (TWC)		512/463-8173
		T. A. Outlaw, Jr., P.E. (DOH)		512/458-7271
VII		Carl Blamgren	8:757-2856	913/236-2852
	IA	Peter Hamlin		515/281-8852
	KS	Ronald Hammerschmidt		913/296-1662
		Dennis Murphey		913/296-1592
	MO	Jim Hull		314/751-3176
	NE	Jack Sukoraty		402/471-4210
VIII		Jerry Allen	8-564-1670	303/293-1496
	CO	Joan Sowinski		303/331-4830
	MT	James Leiter		406/444-2821
	ND	Steve Tillotson		701/224-2366
	SD	Joel Smith		605/773-3153
	UT	William Sinclair		801/538-6170
	WY	David Finley, P.E.		307/777-7752
IX		Ayn Schmit	8-454-8141	415/974-8141
	AZ	Alan Roesler		602/257-2249
	CA	John Kerns		916/323-2942
	HA	Wilfred Nagamine		808/548-6410
	NV	Thomas Fronapfel, P.E.		702/885-4670
	G	Jose Techaira		671/646-8863/5
	Am. S	Pati Faiai		633-2304 (overseas opr.)
X		Mike Bussell	8-399-6501	206-442-2857
		Steve Sharp	8-399-6517	206/442-6501
	AK	David DiTraglia		907/465-2666
	ID	John Moeller		208/334-5829
		Michael Downs		503/229-5774
	OR	Steve Greenwood		503-229-5782
	WA	Leighton Pratt		206/459-6259

Regional and State Air Program Contacts:
For Sewage Sludge Incinerators

Region	State	Name	FTS Phone Number (Commercial Prefix)
I	CT	Mark Hultman	(203) 566-8230
	MA	Donald Squire	(617) 292-5618
	NH	Andrew Bodnarik	(603) 271-1370
	RI	Doug Mc Vay	(401) 277-2808
Region	John Courcier (Control Technology)		835-3260
	Lynne Hamjin (Air Regulations)		835-3246
			(617) 565-3246
II	NJ	Ms. Iclal Atay	(609) 984-0491
	NY	Jim Harrington	(518) 457-2044
Region		Steven Riva	264-4711
			(212) 264-4711
III	MD	Carl York	(301) 631-3230
	PA	Doug Lesher	(717) 787-9256
	VA	Bill Millwood	(703) 644-0311
	WV	Dale Farley/David Porter	(304) 348-4022
Region		Eileen M. Glen (PA & PSD/NSR Coord)	597-8379
		James B. Topsale	597-6553
			(215) 597-6553
IV	FL	Clair Fancy	(904) 488-1344
	KY	Bill Dills	(502) 564-3382
	GA	Marvin Lowry	(404) 656-6900
	NC	Mike Sewall	(919) 733-3340
	SC	Max Batavia	(803) 734-4750
	TN	Mervat Ahmed	(615) 741-3931
Region		Brian Beals (NESHAPS/NSPS)	257-2904
			(404) 347-2904
V	IL	Terry Sweitzer's Assoc	(217) 782-2113
	IN	John Doss	(317) 232-8427
	MI	David Ferrier	(517) 373-7023
	MN	Mr. Ohto Niemioja	(612) 296-7711
	OH	Robert Hodanbosi	(614) 644-2284
	WI	Dale Ziege	(608) 266-0113
Region		Ron van Mersbergen (PSD/NSR; legal and engineering)	886-6056
		Rizalino Castanares (engineering)	886-6047
			(312) 353-6047

Regional and State Air Program Contacts:
For Sewage Sludge Incinerators
(Continued)

Region	State	Name	FTS Phone Number (Commercial Prefix)
VI	AR	Cecil Herril	(501) 562-7444
	LA	Larry DeVillier	(504) 342-8926
	NM	Bruce Nicholson	(505) 827-0070
	OK	Doyle McWhirter	(405) 271-5220
	TX	Lawrence Pewitt	(512) 451-5711
Region		John Hepola	255-7220 (214) 655-7220
VII	IA	Bill Youngquist	(515) 281-8924
	KS	Lacey Hinther	(913) 296-1576
	MO	Mike Stanfield	(314) 751-4817
	NE	Glen Dively	(402) 471-2189
Region		Dan Rodriquez	757-2896 (913) 236-2896
VIII Region		John Dale (NSR)	564-1886 (303) 293-1886
IX	CA	Luis Woodhouse	(916) 445-2049
	HI	Wilfred Nagamine	(808) 548-6355
Region	Mike Stenburg (Chief Air Toxics)		454-8205 (415) 974-8205
X	AK	Len Verrelli	(907) 465-2666
	WA	Jay Willenberg	(206) 867-7117
Region		Ray Nye (Incinerators)	399-4226 (206) 442-4226

NOTE: Please call the State contact first. They will refer you to a district office if necessary.

Regional Ground-Water Representatives

Region	Name	Phone Number FTS	Phone Number Commercial
I	Robert Mendoza Office of Ground Water Water Management Division - Rm. 2113 JFK Federal Building Boston, MA 02203	835-3600	617 565-3600
II	John Malleck Office of Ground Water Water Management Division - Rm. 805 26 Federal Plaza New York, NY 10278	264-5635	212 264-5635
III	Stuart Kerzner Office of Ground Water Water Management Division 841 Chestnut Street Philadelphia, PA 19106	597-8826	215 597-8826
IV	Stallings Howell Office of Ground Water Water Management Division 345 Courtland Street, N.E. Atlanta, GA 30365	257-3866	404 347-3866
V	Jerri-Anne Gall Office of Ground Water Water Management Division 230 S. Dearborn Street Mail Code 5WG-TUB9 Chicago, IL 60604	886-1490	312 353-1490
VI	Erlece Allen Office of Ground Water Water Management Division 1445 Ross Avenue Dallas, TX 75202-2733	255-6446	214 655-6446
VII	Timothy Amsden Office of Ground Water Water Management Division 726 Minnesota Avenue Kansas City, KS 66101	757-2970	913 236-2970
VIII	James Dunn Office of Ground Water Water Management Division 999 18th Street - Mail Code 8 WMGW Denver, CO 80202-2405	564-1796	303 293-1703

Regional Ground-Water Representatives (Continued)

Region	Name	Phone Number	
		FTS	Commercial
IX	Patricia Eklund Office of Ground Water Water Management Division 215 Fremont Street Mail Code W-1-G San Francisco, CA 94105	454-0831	415 974-0831
X	William Mullen Office of Ground Water Water Management Division 1200 6th Avenue - M/S WD-139 Seattle, WA 98101	399-1216	206 442-1216

APPENDIX C
DISTRIBUTION AND MARKETING LABELS AND INSTRUCTIONS

Net Weight 2.3 Kilograms (5 lbs.)

NATURAL ORGANIC
FERTILIZER

Milorganite®

6-2-0

Activated Sewage Sludge

Read directions carefully before using

For use on lawns, shrubs and ornamentals only

Long lasting, will not burn

"The Golf Course Choice"

PACKAGED BY
SUNNILAND CORP.
SANFORD FLORIDA 32771

Read directions carefully before using

NATURAL ORGANIC FERTILIZER

Milorganite

Activated Sewage Sludge

2.3 Kilograms Net Weight (5 Lbs.)	
Milorganite the Natural Organic Fertilizer	
Activated Sewage Sludge 6-2-0	
Guaranteed Analysis	
Total Nitrogen	6.0%
5.5% Water Insoluble Nitrogen	
0.5% Water Soluble Nitrogen	
Available Phosphoric Acid (P_2O_5)	2.0%
Soluble Potash (K_2O)	0.0%
Iron (Fe)	4.0%
Milwaukee Metropolitan Sewerage District	
Milwaukee, Wisconsin	

Directions for use

Milorganite is an excellent fertilizer for turfgrasses and leafy ornamentals. Flowering plants may require supplemental phosphate and potash in some soils.

NOTICE Milorganite should not be used on vegetables due to possible uptake of the heavy metal cadmium. When home grown vegetables make up a large portion of the annual diet over a period of many years, cadmium may accumulate in the kidneys, resulting in possible dysfunction.

LAWNS

To assure an impressive start toward dense, healthy turf apply the contents of this bag to 170 square feet. Do this by applying Milorganite in two directions with the spreader wide open. The results will provide year-long feeding.

Golf courses use half rates but in two applications. This is done by setting the spreader to the largest opening and apply carefully in one direction. This bag will then cover about 340 to 425 square feet.

Cool season grasses respond best to late summer feeding. Another application just before freezing assures an early spring greenup without excessive growth.

Hot weather grasses, like bermudas, prefer midspring and early fall feeding. Summer applications should not exceed 5 lbs per 1,000 square feet each to avoid excessive soft succulent growth.

Whenever it is done, some of the nutrients are held in reserve for the next growing season, so Milorganite lawns become progressively better. Milorganite will not burn the turf, so it never needs to be watered in.

Lawn Spreader Settings

For Spring, Fall and Winter Use	
Highest Quality	
Spinner Spreader	Drop Spreader
Wide open	
Apply in two directions	#15
Good Quality	
Spinner Spreader	Drop Spreader
[illegible]	#10
For Summer Application	
Spinner Spreader	Drop Spreader
Open halfway and direction	#5

ORNAMENTALS

Apply at 3 to 5 lbs per 100 square feet. Scatter uniformly on the surface and work into the soil surface. A 3 lb coffee can holds 5 lbs. of Milorganite.

TREES

Use 5 to 10 lbs for each [illegible] diameter at chest height. Apply [illegible] to 2 inch diameter holes [illegible] ches deep, spaced 2 to [illegible] from the trunk to beyond the [illegible] spread of branches.

*EKO-COMPOST

EKO-compost is made and distributed by EKO-KOMPOST, INC. [illegible] Compost Road, Minnesota, MT [illegible]
Dr. Joseph C. Horvath, President, Resource Economist.

RE-POTTING SOIL MEDIA

ODORLESS! UNRESTRICTED USE!

EKO-COMPOST

NO CHEMICALS!

AN ORGANIC - NATURAL - POTTING SOIL

WHY USE EKO-compost?

EKO-KOMPOST, INC. is using waste materials to make a healthier and more beautiful world. EKO-compost is a concentrated RE-POTTING SOIL MEDIA processed from waste materials: Wood wastes, (softwood and hardwood sawdusts, shredded bark, planers dust, wood-chips); Municipal-digested sewage sludge; Tankage; and Granite dust. After mixing, a special biologically controlled process (New World & European Technology) makes these former ingredients into a superior compost at 185 F Degrees.

EKO-COMPOST

NET WEIGHT
8 qts.

*FORMULA AND PROCESS, FAMILY TRADE SECRET

INSTRUCTIONS TO USE

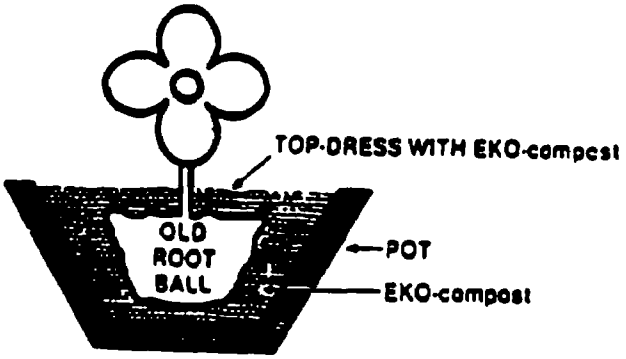
EKO-compost*

RE-POTTING SOIL MEDIA

*EKO-compost is a CONCENTRATED SOIL MEDIA, therefore, you can use the old root-ball of your plant.

RE-POTTING:

1. Use a larger pot, line it with at least one inch of EKO-compost on all sides and at the bottom.
2. Place the root-ball of your plant into the EKO-compost-lined pot. Tamp it down firmly.
3. Top-dress with at least one inch thick layer of EKO-compost.
4. Water the plant thoroughly, and as settling occurs, add more EKO-compost.



POTTING: For new plants use only ½ EKO-compost. Other half can be a combination of your own garden soil, sand, perlite, and vermiculite.

SEEDBEDS: Same as potting above. Or blend ½ EKO-compost with any other commercial potting mix.

TOP-DRESSING: Always top-dress existing or newly potted or re-potted plants with EKO-compost. Repeat twice a year.

CARE FOR THE UNUSED COMPOST: Please, keep EKO-compost bags tightly closed after each use.

OTHER FINE EKO-compost PRODUCTS: Look for the 20 and 40 lb. EKO-compost bags at your favorite store!

Potting Soil

A Complete Soil Replacement

For All Container Planting

Indoor Foliage•Hanging Baskets•Flowering Plants

Kellogg's Potting Soil

Net Contents 12 Quarts

Kellogg's

HORTICULTURAL POTTING MIXES

Recognizing that no one potting mix can satisfy the needs of all plants, Kellogg has developed a line of horticultural potting soil products. These scientifically developed mixes provide the proper planting medium for most plants tended by gardening enthusiasts. The following mixes are complete, nothing need be added, and can be used for indoor or outdoor containers.

POTTING SOIL—this general purpose potting soil can be used for indoor foliage plants, patio containers, color plants in window boxes, hanging baskets and other containers.

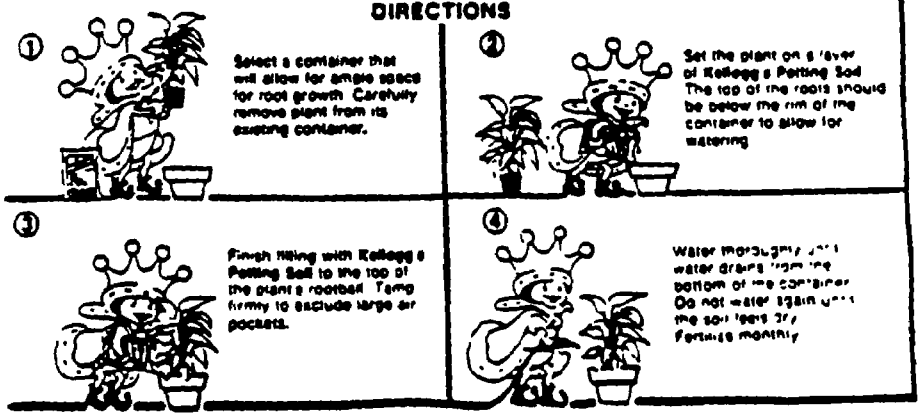
AFRICAN VIOLET MIX—this soil mix retains the much needed moisture and nutrients required by these popular flowery plants.

ORCHID MIX—this special mix provides the ideal soil environment for growing terrestrial orchids such as cymbidiums.

POTTING SOIL

KELLOGG POTTING SOIL is a mixture of materials which provide an ideal soil environment for growing plants in containers. Plants need a medium that is porous, yet absorbent for holding moisture, air and nutrients. POTTING SOIL can be used for indoor foliage plants, patio containers, color plants in window boxes, hanging baskets and other containers.

DIRECTIONS



INGREDIENTS: [illegible]

KELLOGG SUPPLY INC.
CARSON, CA 90749
PRODUCT OF U.S.A.

KELLOGG'S NITROHUMUS
1 1/2 Cubic Feet

KELLOGG'S NITROHUMUS®
Soil Conditioner

KELLOGG'S NITROHUMUS is one of the most widely used products in the lawn and garden industry in the Southwest. It is an all purpose soil conditioner used to improve the physical properties of soils. Results from using this material are increased workability, aeration and drainage of clay soils and increased water and nutrient retention of sandy soils.

Bedding Plants, Ground Covers, Bulbs	Cover planting beds with 1/2 to 1 inch of NITROHUMUS. (1 1/2 CF covers 20 to 40 sq. ft.). Rototill or spade to a depth of 6 to 8 inches or use 1 cup per individual plant or bulb mixed into the planting hole.
Soil Preparation Lawns:	Use 1 1/2 CF of NITROHUMUS and one 3 CF of KELLOGG REDWOOD COMPOST for each to to 100 sq. ft. Rototill or spade into the top 4 to 6 inches of soil.
Top Dressing	Cover newly planted seed with NITROHUMUS at the rate of 1 1/2 CF per 150 sq. ft. Keep moist until lawn is established.
Making Compost	Add 1 to 2-inch layers of NITROHUMUS to compost heaps to increase the rate of producing usable compost.

Ingredients: Composted, Centrifuged Sewage Sludge and Forest Products.
Total Nitrogen 0.5%

KELLOG SUPPLY, INC.
Carson, California 90745
Product of U.S.A.

KELLOGG'S AMEND
2 Cubic Feet

KELLOGG'S AMEND®
Vegetable and Flower Planting Mix

Enjoy the fruits of growing a successful garden through the use of KELLOGG's AMEND. This fully composted blend of organic materials improves water penetration and drainage and reduces compaction of soils. KELLOGG'S AMEND HELPS MAKE HARD CLAY SOILS SOFT and sandy soils retain moisture and nutrients.

KELLOGG'S AMEND is used for planting vegetables, flowers, ground covers and bedding plants.

VEGETABLE PLANTING	Spread one bag of KELLOGG's AMEND and 1/2 lb. of KELLOGG's KARE for Tomatoes and Vegetables for each 15 to 20 square feet. Rototill or spade to a depth of 6 to 8 inches, assuring adequate mixing. Water lightly after planting and daily during establishment.
FLOWER GARDENS AND BEDDING PLANTS	Spread one bag of KELLOG'S AMEND and two cups of KELLOGG'S KARE for Roses and Flowers for each 25 sq. ft. Spade to a depth of 6 to 8 inches, assuring adequate mixing. Water after planting and daily during establishment. Apply a 1 to 2 inch layer of GROMULCH after plants are established.
GROUND COVERS	Spread a minimum of one bag of KELLOGG'S AMEND and 4 cups of KELLOGG'S KARE for Blooming Plants per 50 square feet. Spade to a depth of 6" to 8" at each planting hole. Water after planting and daily during establishment.

INDIVIDUAL PLANTS

Prepare a mixture of 1/2 KELLOGG'S AMEND and 1/2 soil from the planting hole.

Form a watering basin around the base of the plant after planting.

Water thoroughly and daily during establishment.

INGREDIENTS: Rice Hulls and Nitrohumus (Composted, Centrifuged, Sewage Sludge and Forest Products)

KELLOGG SUPPLY, INC
Carson, California 90745
Product of U.S.A.

GARDEN CARE™

Quality Garden Products

Professional Growing Media

Contents: 8 Dry Quarts (8.8 Litres)

Professional Growing Media

GARDEN CARE™ A scientific blend of composted sludge, bark, Perlite, Micro Nutrients, and other ingredients. Provides the best possible growing environment for your indoor and outdoor ornamental plants. Humus rich compost, produced in a unique process system, is the very essence of GARDEN CARE™. GARDEN CARE™ is richer in natural nutrients than peat based media, and its high humus content nourishes plants while its friable texture improves soil aeration to promote stronger root growth. The increased cation exchange capacity of GARDEN CARE™ permits a more rapid and efficient transfer of nutrients to your plants. Use GARDEN CARE™ and see the results. Stronger, healthier, more vibrant plants than you've ever grown before.

Directions for Repotting

Selecting a Pot

- For plants in pots less than 10 inches in diameter, select a pot at least 1 inch larger than the pot being replaced. For plants in pots larger than 10 inches in diameter, select a pot at least 2 inches larger than the pot being being replaced.
- Always select a pot with ample drainage, never use pots that do not allow excess water to drain away.
- If the drainage hole is larger than 1 inch, use a piece of broken pottery to partially cover the drain hole.

Repotting

- A moist rootball is easier to remove. Water plant thoroughly 2-4 hours before repotting.

Directions for Outdoor Use

- When planting trees or shrubs, use GARDEN CARE™ mixed equally with top soil at the base and around your new planting.
- For flowers and ground covers, incorporate 2" of GARDEN CARE™ INTO THE SOIL.
- Water thoroughly after planting.

Helpful Hints for Houseplants

Avoid overwatering your plants. More plants die from overwatering than from neglect.

Allow the potting medium to become dry 1/2" to 1" deep. You can check this with your finger.

When watering use a sufficient amount so that some drains out the bottom of the pot. However, never allow the pot to stand in an excess of water.

Browning at the tips of older leaves or a white crust on the surface of the growing medium is an indication of improper watering.

Salt accumulations fostered by watering your plants from the bottom or not watering thoroughly. Flushing the plant thoroughly from the top with a few drops of detergent in the water will help clear up these symptoms.

Always place plants where they will receive sufficient light. Flowering plants generally require more light than foliage plants.

Repotting cont.

- To remove the plant from its pot, place your hand over the top of the pot and gently hold the stem between your fingers.

- Turn the pot upside down and gently tap its top edge on a table or bench.

- To encourage more rapid root growth, make 4 uniform cuts 1/2 inch deep through the outside layer of roots. Then remove as much loose soil as possible from the rootball.

- Place enough GARDEN CARE™ in bottom of the pot to bring the top of the rootball to within 1/2 inch of the top edge of the pot.

- Center the rootball in the pot and fill in around the outer sides with GARDEN CARE™. Gently tap the repotted plant on a flat surface to get rid of any air pockets.

Care of Your Repotted Plant

- Fill the newly potted plant with water and allow it to drain. If settling occurs, add more GARDEN CARE™.

- Because GARDEN CARE™ contains sufficient phosphorus, we recommend a low phosphorus fertilizer (25-5-20) such as GARDEN CARE™ Formula37 water soluble fertilizer.

Helpful Hints cont.

- Learn how to properly pinch back your plants. For most plants pinching off the top right above a leaf encourages the development of side shoots and results in healthier, more vigorous plant growth.

- Removing dead flowers and leaves from your plants will help curb seed formation and encourage new blooms.

- Periodically dunking the tops of plants in warm soapy water wil help control insects. Keeping the foilage dry at all other times will control most diseases.

- For more information on the care and culture of specific plants and for the control of specific insects and diseases visit your local garden center or contact your local master gardener representative.

NORTH AMERICAN SOILS, INC.
Recommends Using GARDEN CARE™
Only on Ornamental Plants

A Product of
NORTH AMERICAN SOILS, INC.
415 E. Paces Ferry Rd. N.E.
Atlanta, Georgia 30305

5303 N. Columbia Blvd.
Portland, Oregon 97203

CompGro

A proven, superior quality soil amendment

Nitrogen fortified, enriches soil

Helps aerate your soil, improves moisture retention

Planting can begin immediately after application

Directions for Use

Use		Amount of CompGro (cu.yd./1,000 sq. ft.)*	Instructions
Turfgrasses	Establishment	3 to 9	Incorporate with top 4 to 6 inches of soil. Use lower rate on relatively fertile soil and higher rate on infertile soil.
	Surface mulch	Approximately 1 1/4	Broadcast uniformly on surface before seeding small-seeded species (bluegrass) or after seeding large-seeded species (fescues).
	Maintenance	3/4 to 1 1/2	Broadcast uniformly on surface. On cool-season grasses, apply higher rate in fall and again in spring.
Sod		3 to 6	Incorporate with top 4 to 6 inches of soil.
Nursery Crops and Ornamentals	Establishment	3 1/2 to 13	Incorporate with top 6 to 8 inches of soil. Do not use where acid-soil plants (azalea, rhododendron, etc.) are to be grown.
	Maintenance	1/2 to 1	Broadcast uniformly on surface soil. Can be worked or used as mulch.
Mulch		1/2 to 1 1/4	Broadcast compost uniformly on surface after seeding.

* 3 cu. yds. per 1,000 sq. ft. is equal to a 1-inch layer spread over the surface.

Use		Amount of CompGro (cu.yd./1,000 sq. ft.)	Instructions
Potting Mixes		Equal ratio of material	Thoroughly water and drain mixes several times before planting. Some recommended mixes are: For floor standing plants - CompGro, peat moss, sand and Perlite (1:1:1:1) heavy mix. For hanging plants - CompGro, peat moss and Perlite (1:1:1) light mix. CompGro and commercially available potting soil (1:2)

Total Nitrogen:	0.5%
pH:	6.5
Maximum moisture content:	40.0%
Weight:	Approximately 28 pounds per cubic foot

An extensive quality control program developed by East Bay Municipal Utility District guarantees product uniformity and reliability. During the production process, weekly analyses of 20 constituents are conducted. Each month duplicate samples of the final product are submitted to an independent laboratory for verification of product quality. CompGro complies with all California State and Federal EPA guidelines.

Ingredients: Sewage sludge, bark chips

How CompGro is Produced

CompGro is produced by a composting process that has been used in the United States for over 60 years. Sludge, mixed with bark chips, is composted in large aerated piles for several weeks. During this time, compost temperatures exceed 130° Fahrenheit. This ensures that the final product is free of weed seed and all harmful soil organisms. Finally, the compost is screened to remove coarse chips, leaving a fine-grained, high-quality product-CompGro - clean, light-weight and odor-free.

Produced by
East Bay Municipal Utility District
P.O. Box 24055
Oakland, CA 94623
(415) 465-3700

Packaged by Redi-Gro Corp.
8909 Elder Creek Rd.
Sacramento, CA 95828

APPENDIX D

40 CFR 257 - CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

PART 257—CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

Sec.

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APPENDIX I
APPENDIX II

AUTHORITY: Sec. 1008(a)(3) and sec. 4004(a), Pub. L. 94-580, 90 Stat. 2803 and 2815 (42 U.S.C. 6907(a)(3) and 6944(a)); sec. 405(d), Pub. L. 95-217, 91 Stat. 1606 (33 U.S.C. 1345(d)).

SOURCE: 44 FR 53460, Sept. 13, 1979, unless otherwise noted.

§ 257.1 Scope and purpose.

(a) These criteria are for use under the Resource Conservation and Recovery Act (the Act) in determining which solid waste disposal facilities and practices pose a reasonable proba-

bility of adverse effects on health or the environment. Unless otherwise provided, these criteria are adopted for purposes of both Section 1008(a)(3) and Section 4004(a) of the Act.

(1) Facilities failing to satisfy criteria adopted for purposes of Section 4004(a) will be considered open dumps for purposes of State solid waste management planning under the Act.

(2) Practices failing to satisfy criteria adopted for purposes of Section 1008(a)(3) constitute open dumping, which is prohibited under Section 4005 of the Act.

(b) These criteria also provide guidelines for sludge utilization and disposal under Section 405(d) of the Clean Water Act, as amended. To comply with Section 405(e) the owner or operator of any publicly owned treatment works must not violate these criteria in the disposal of sludge on the land.

(c) These criteria apply to all solid waste disposal facilities and practices with the following exceptions:

(1) The criteria do not apply to agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners.

(2) The criteria do not apply to overburden resulting from mining operations intended for return to the mine site.

(3) The criteria do not apply to the land application of domestic sewage or treated domestic sewage. The criteria do apply to disposal of sludges generated by treatment of domestic sewage.

(4) The criteria do not apply to the location and operation of septic tanks. The criteria do, however, apply to the disposal of septic tank pumpings.

(5) The criteria do not apply to solid or dissolved materials in irrigation return flows.

(6) The criteria do not apply to industrial discharges which are point sources subject to permits under Section 402 of the Clean Water Act, as amended.

(7) The criteria do not apply to source, special nuclear or byproduct material as defined by the Atomic Energy Act, as amended (68 Stat. 923).

(8) The criteria do not apply to hazardous waste disposal facilit which are subject to regulation under Subtitle C of the Act.

(9) The criteria do not apply to disposal of solid waste by underground well injection subject to the regulations (40 CFR Part 146) for the Underground Injection Control Program (UICP) under the Safe Drinking Water Act, as amended, 42 U.S.C. 3007 et seq.

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.2 Definitions.

The definitions set forth in Section 1004 of the Act apply to this part. Special definitions of general concern to this part are provided below, and definitions especially pertinent to particular sections of this part are provided in those sections.

"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 ground waters.

"Facility" means any land and appurtenances thereto used for the disposal of solid wastes.

"Leachate" means liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such wastes.

"Open dump" means a facility for the disposal of solid waste which does not comply with this part.

"Practice" means the act of disposal of solid waste.

"Sanitary landfill" means a facility for the disposal of solid waste which complies with this part.

"Sludge" means any solid, semisolid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility or any other such waste having similar characteristics and effect.

"Solid waste" means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant,

or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved material in irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

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

[44 FR 53460, Sept. 13, 1979; 44 FR 58910, Oct. 12, 1979]

§ 257.3 Criteria for classification of solid waste disposal facilities and practices.

Solid waste disposal facilities or practices which violate any of the following criteria pose a reasonable probability of adverse effects on health or the environment:

§ 257.3-1 Floodplains.

(a) Facilities or practices in floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources.

(b) As used in this section:

(1) "Based flood" means a flood that has a 1 percent or greater chance of recurring in any year or a flood of a magnitude equalled or exceeded once in 100 years on the average over a significantly long period.

(2) "Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, which are inundated by the base flood.

(3) "Washout" means the carrying away of solid waste by waters of the base flood.

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 31, 1979]

§ 257.3-2 Endangered species.

(a) Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.

(b) The facility or practice shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.

(c) As used in this section:

(1) "Endangered or threatened species" means any species listed as such pursuant to Section 4 of the Endangered Species Act.

(2) "Destruction or adverse modification" means a direct or indirect alteration of critical habitat which appreciably diminishes the likelihood of the survival and recovery of threatened or endangered species using that habitat.

(3) "Taking" means harassing, harming, pursuing, hunting, wounding, killing, trapping, capturing, or collecting or attempting to engage in such conduct.

§ 257.3-3 Surface water.

(a) For purposes of Section 4004(a) of the Act, a facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act, as amended.

(b) For purposes of Section 4004(a) of the Act, a facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under Section 404 of the Clean Water Act, as amended.

(c) A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

(d) Definitions of the terms "Discharge of dredged material", "Point source", "Pollutant", "Waters of the United States", and "Wetlands" can be

found in the Clean Water Act, as amended, 33 U.S.C. 1251 et seq., and implementing regulations, specifically 33 CFR Part 323 (42 FR 37122, July 19, 1977).

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.3–4 Ground water.

(a) A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary or beyond an alternative boundary specified in accordance with paragraph (b) of this section.

(b)(1) For purposes of Section 1008(a)(3) of the Act or Section 405(d) of the CWA, a party charged with open dumping or a violation of Section 405(e) may demonstrate that compliance should be determined at an alternative boundary in lieu of the solid waste boundary. The court shall establish such an alternative boundary only if it finds that such a change would not result in contamination of ground water which may be needed or used for human consumption. This finding shall be based on analysis and consideration of all of the following factors that are relevant:

(i) The hydrogeological characteristics of the facility and surrounding land, including any natural attenuation and dilution characteristics of the aquifer;

(ii) The volume and physical and chemical characteristics of the leachate;

(iii) The quantity, quality, and direction of flow of ground water underlying the facility;

(iv) The proximity and withdrawal rates of ground-water users;

(v) The availability of alternative drinking water supplies;

(vi) The existing quality of the ground water, including other sources of contamination and their cumulative impacts on the ground water;

(vii) Public health, safety, and welfare effects.

(2) For purposes of Sections 4004(a) and 1008(a)(3), the State may establish an alternative boundary for a facility to be used in lieu of the solid waste boundary only if it finds that such a change would not result in the contamination of ground water which may be needed or used for human consumption. Such a finding shall be based on an analysis and consideration of all of the factors identified in paragraph (b)(1) of this section that are relevant.

(c) As used in this section:

(1) "Aquifer" means a geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of ground water to wells or springs.

(2) "Contaminate" means introduce a substance that would cause:

(i) The concentration of that substance in the ground water to exceed the maximum contaminant level specified in Appendix I, or

(ii) An increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the maximum contaminant level specified in Appendix I.

(3) "Ground water" means water below the land surface in the zone of saturation.

(4) "Underground drinking water source" means:

(i) An aquifer supplying drinking water for human consumption, or

(ii) An aquifer in which the ground water contains less than 10,000 mg/l total dissolved solids.

(5) "Solid waste boundary" means the outermost perimeter of the solid waste (projected in the horizontal plane) as it would exist at completion of the disposal activity.

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.3–5 Application to land used for the production of food-chain crops (interim final).

(a) *Cadmium.* A facility or practice concerning application of solid waste to within one meter (three feet) of the surface of land used for the production of food-chain crops shall not exist or occur, unless in compliance with all requirements of paragraph (a)(1) (i) through (iii) of this section or all requirements of paragraph (a)(2) (i) through (iv) of this section.

(1)(i) The pH of the solid waste and soil mixture is 6. or greater at the time of each solid waste application,

except for solid waste containing cadmium at concentrations of 2 mg/kg (dry weight) or less.

(ii) The annual application of cadmium from solid waste does not exceed 0.5 kilograms per hectare (kg/ha) on land used for production of tobacco, leafy vegetables or root crops grown for human consumption. For other food-chain crops, the annual cadmium application rate does not exceed:

Time period	Annual Cd application rate (kg/ha)
Present to June 30, 1984	2.0
July 1, 1984 to Dec. 31, 1986	1.25
Beginning Jan. 1, 1987	0.5

(iii) The cumulative application of cadmium from solid waste does not exceed the levels in either paragraph (a)(1)(iii)(A) of this section or paragraph (a)(1)(iii)(B) of this section.

(A)

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)	
	Background soil pH less than 6.5	Background soil pH more than 6.5
Less than 5	5	5
5 to 15	5	10
More than 15	5	20

(B) For soils with a background pH of less than 6.5, the cumulative cadmium application rate does not exceed the levels below: *Provided,* That the pH of the solid waste and soil mixture is adjusted to and maintained at 6.5 or greater whenever food-chain crops are grown.

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)
Less than 5	5
5 to 15	10
More than 15	20

(2)(i) The only food-chain crop produced is animal feed.

(ii) The pH of the solid waste and soil mixture is 6.5 or greater at the time of solid waste application or at the time the crop is planted, whichever occurs later, and this pH level is maintained whenever food-chain crops are grown.

(iii) There is a facility operating plan which demonstrates how the animal feed will be distributed to preclude ingestion by humans. The facility operating plan describes the measures to be taken to safeguard against possible health hazards from cadmium entering the food chain, which may result from alternative land uses.

(iv) Future property owners are notified by a stipulation in the land record or property deed which states that the property has received solid waste at high cadmium application rates and that food-chain crops should not be grown, due to a possible health hazard.

(b) *Polychlorinated Biphenyls (PCBs).* Solid waste containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight) is incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation of the solid waste into the soil is not required if it is assured that the PCB content is less than 0.2 mg/kg (actual weight) in animal feed or less than 1.5 mg/kg (fat basis) in milk.

(c) As used in this section:

(1) "Animal feed" means any crop grown for consumption by animals, such as pasture crops, forage, and grain.

(2) "Background soil pH" means the pH of the soil prior to the addition of substances that alter the hydrogen ion concentration.

(3) "Cation exchange capacity" means the sum of exchangeable cations a soil can absorb expressed in milli-equivalents per 100 grams of soil as determined by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the summation method for distinctly acid soils or the sodium acetate method for neutral, calcareous or saline soils ("Methods of Soil Analysis, Agronomy Monograph No. 9." C. A. Black, ed., American Society of Agronomy, Madison, Wisconsin, pp 891-901, 1965).

(4) "Food-chain crops" means tobacco, crops grown for human consumption, and animal feed for animals whose products are consumed by humans.

(5) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(6) "Pasture crops" means crops such as legumes, grasses, grain stubble and stover which are consumed by animals while grazing.

(7) "pH" means the logarithm of the reciprocal of hydrogen ion concentration.

(8) "Root crops" means plants whose edible parts are grown below the surface of the soil.

(9) "Soil pH" is the value obtained by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the electrometric method. ("Methods of Soil Analysis, Agronomy Monograph No. 9," C.A. Black, ed., American Society of Agronomy, Madison, Wisconsin, pp. 914–926, 1965.)

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979]

§ 257.3–6 Disease.

(a) *Disease Vectors.* The facility or practice shall not exist or occur unless the on-site population of disease vectors is minimized through the periodic application of cover material or other techniques as appropriate so as to protect public health.

(b) *Sewage sludge and septic tank pumpings (Interim Final).* A facility or practice involving disposal of sewage sludge or septic tank pumpings shall not exist or occur unless in compliance with paragraphs (b) (1), (2) or (3) of this section.

(1) Sewage sludge that is applied to the land surface or is incorporated into the soil is treated by a Process to Significantly Reduce Pathogens prior to application or incorporation. Public access to the facility is controlled for at least 12 months, and grazing by animals whose products are consumed by humans is prevented for at least one month. Processes to Significantly Reduce Pathogens are listed in Appendix II, Section A. (These provisions do not apply to sewage sludge disposed of by a trenching or burial operation.)

(2) Septic tank pumpings that are applied to the land surface or incorporated into the soil are treated by a Process to Significantly Reduce Pathogens (as listed in Appendix II Section A), prior to application or incorporation, unless public access to the facility is controlled for at least 12 months and unless grazing by animals whose products are consumed by humans is prevented for at least one month. (These provisions do not apply to septic tank pumpings disposed of by a trenching or burial operation.)

(3) Sewage sludge or septic tank pumpings that are applied to the land surface or are incorporated into the soil are treated by a Process to Further Reduce Pathogens, prior to application or incorporation, if crops for direct human consumption are grown within 18 months subsequent to application or incorporation. Such treatment is not required if there is no contact between the solid waste and the edible portion of the crop; however, in this case the solid waste is treated by a Process to Significantly Reduce Pathogens, prior to application; public access to the facility is controlled for at least 12 months; and grazing by animals whose products are consumed by humans is prevented for at least one month. If crops for direct human consumption are not grown within 18 months of application or incorporation, the requirements of paragraphs (b) (1) and (2) of this section apply. Processes to Further Reduce Pathogens are listed in Appendix II, Section B.

(c) As used in this section:

(1) "Crops for direct human consumption" means crops that are consumed by humans without processing to minimize pathogens prior to distribution to the consumer.

(2) "Disease vector" means rodents, flies, and mosquitoes capable of transmitting disease to humans.

(3) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(4) "Periodic application of cover material" means the application and

compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede vectors access to the waste.

(5) "Trenching or burial operation" means the placement of sewage sludge or septic tank pumpings in a trench or other natural or man-made depression and the covering with soil or other suitable material at the end of each operating day such that the wastes do not migrate to the surface.

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979]

§ 257.3-7 Air.

(a) The facility or practice shall not engage in open burning of residential, commercial, institutional or industrial solid waste. This requirement does not apply to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land-clearing debris, diseased trees, debris from emergency clean-up operations, and ordnance.

(b) For purposes of Section 4004(a) of the Act, the facility shall not violate applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the Administrator pursuant to Section 110 of the Clean Air Act, as amended.

(c) As used in this section "open burning" means the combustion of solid waste without (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) control of the emission of the combustion products.

[44 FR 53468, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979, as amended at 46 FR 47062, Sept. 23, 1981]

§ 257.3-8 Safety.

(a) *Explosive gases.* The concentration of explosive gases generated by the facility or practice shall not exceed:

(1) Twenty-five percent (25%) of the lower explosive limit for the gases in facility structures (excluding gas control or recovery system components); and

(2) The lower explosive limit for the gases at the property boundary.

(b) *Fires.* A facility or practice shall not pose a hazard to the safety of persons or property from fires. This may be accomplished through compliance with § 257.3-7 and through the periodic application of cover material or other techniques as appropriate.

(c) *Bird hazards to aircraft.* A facility or practice disposing of putrescible wastes that may attract birds and which occurs within 10,000 feet (3,048 meters) of any airport runway used by turbojet aircraft or within 5,000 feet (1,524 meters) of any airport runway used by only piston-type aircraft shall not pose a bird hazard to aircraft.

(d) *Access.* A facility or practice shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site.

(e) As used in this section:

(1) "Airport" means public-use airport open to the public without prior permission and without restrictions within the physical capacities of available facilities.

(2) "Bird hazard" means an increase in the likelihood of bird/aircraft collisions that may cause damage to the aircraft or injury to its occupants.

(3) "Explosive gas" means methane (CH_4).

(4) "Facility structures" means any buildings and sheds or utility or drainage lines on the facility.

(5) "Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases which will propagate a flame in air at 25°C and atmospheric pressure.

(6) "Periodic application of cover material" means the application and compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede disease vectors' access to the waste.

(7) "Putrescible wastes" means solid waste which contains organic matter capable of being decomposed by microorganisms and of such a character and

proportion as to be capable of attracting or providing food for birds.

§ 257.4 Effective date.

These criteria become effective October 15, 1979.

Appendix I

The maximum contaminant levels promulgated herein are for use in determining whether solid waste disposal activities comply with the ground-water criteria (§ 257.3–4). Analytical methods for these contaminants may be found in 40 CFR Part 141 which should be consulted in its entirety.

1. *Maximum contaminant levels for inorganic chemicals.* The following are the maximum levels of inorganic chemicals other than fluoride:

Contaminant	Level (milligrams per liter)
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10
Selenium	0.01
Silver	0.05

The maximum contaminant levels for fluoride are:

Temperature [1] degrees Fahrenheit	Degrees Celsius	Level (milligrams per liter)
53.7 and below	12 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

[1] Annual average of the maximum daily air temperature.

2. *Maximum contaminant levels for organic chemicals.* The following are the maximum contaminant levels for organic chemicals:

	Level (milligrams per liter)
(a) Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-Hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenyl) ethane)	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67 to 69 percent chlorine)	0.005
(b) Chlorophenoxys:	
2,4-D (2,4-Dichlorophenoxy-acetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01

3. *Maximum microbiological contaminant levels.* The maximum contaminant level for coliform bacteria from any one well is as follows:

(a) using the membrane filter technique:

(1) Four coliform bacteria per 100 milliliters if one sample is taken, or

(2) Four coliform bacteria per 100 milliliters in more than one sample of all the samples analyzed in one month.

(b) Using the five tube most probable number procedure, (the fermentation tube method) in accordance with the analytical recommendations set forth in "Standard Methods for Examination of Water and Waste Water", American Public Health Association, 13th Ed. pp. 662–668, and using a Standard sample, each portion being one fifth of the sample:

(1) If the standard portion is 10 millilitera, coliform in any five consecutive samples from a well shall not be present in three or more of the 25 portions, or

(2) If the standard portion is 100 milliliters, coliform in any five consecutive samples from a well shall not be present in five portions in any of five samples or in more than fifteen of the 25 portions.

4. *Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity.* The following are the maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity:

(a) Combined radium-226 and radium-228—5 pCi/l;

(b) Gross alpha particle activity (including radium-226 but excluding radon and uranium)—15 pCi/l.

Appendix II

A. Processes to Significantly Reduce Pathogens

Aerobic digestion: The process is conducted by agitating sludge with air or oxygen to maintain aerobic conditions at residence times ranging from 60 da at 15° C to 40

days at 20° C, with a volatile solids reduction of at least 38 percent.

Air Drying: Liquid sludge is allowed to drain and/or dry on under-drained sand beds, or paved or unpaved basins in which the sludge is at a depth of nine inches. A minimum of three months is needed, two months of which temperatures average on a daily basis above 0° C.

Anaerobic digestion: The process is conducted in the absence of air at residence times ranging from 60 days at 20° C to 15 days at 35° to 55° C, with a volatile solids reduction of at least 38 percent.

Composting: Using the within-vessel, static aerated pile or windrow composting methods, the solid waste is maintained at minimum operating conditions of 40° C for 5 days. For four hours during this period the temperature exceeds 55° C.

Lime Stabilization: Sufficient lime is added to produce a pH of 12 after 2 hours of contact.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

B. Processes to Further Reduce Pathogens

Composting: Using the within-vessel composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the static aerated pile composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the windrow composting method, the solid waste attains a temperature of 55° C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow.

Heat drying: Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80° C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80° C.

Heat treatment: Liquid sludge is heated to temperatures of 180° C for 30 minutes.

Thermophilic Aerobic Digestion: Liquid sludge is agitated with air or oxygen to maintain aerobic conditions at residence times of 10 days at 55–60° C, with a volatile solids reduction of at least 38 percent.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Any of the processes listed below, if added to the processes described in Section A above, further reduce pathogens. Because the processes listed below, on their own, do not reduce the attraction of disease vectors, they are only add-on in nature.

Beta ray irradiation: Sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Gamma ray irradiation: Sludge is irradiated with gamma rays from certain isotopes, such as ^{60}Cobalt and ^{137}Cesium, at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Pasteurization: Sludge is maintained for at least 30 minutes at a minimum temperature of 70° C.

Other methods: Other methods or operating conditions may be acceptable if pathogens are reduced to an extent equivalent to the reduction achieved by any of the above add-on methods.

APPENDIX E
STATE REQUIREMENTS AND GUIDANCE FOR SLUDGE USE AND DISPOSAL

Table ES-1. Landfilling - Sludge Treatment/Management

State	Sludge Dewatering	Sludge Stabilization
Alabama	Yes	Yes
Alaska	> 10% solids	Yes
Arkansas	> 30% solids	
California	20% solids if primary sludge 15% solids if secondary or mixture of sludge	
Colorado		No raw sludge or septage
Connecticut	Yes: case-by-case	Yes
Florida	For codisposal	
Georgia	Yes	Yes
Idaho	Solids content > 15%	
Illinois	For some landfills	
Iowa	> 75% solids	Yes
Kentucky	Yes - no free water	Yes - PSRP
Louisiana	No free liquids	
Maine	Minimum 20% solids	
Maryland	No free liquids - may mix with soil and retest	
Massachusetts	> 18% solids	Special handling required if not stabilized
Missouri	No free water	Yes
Nebraska	Special approval needed to take sludge containg moisture. If moisture > 60% lagoon storage required.	
New Hampshire	Minimum 20% solids	No
New Jersey	> 20%	Yes
New Mexico	Yes	
New York	To 20% solids	Yes
North Carolina	Yes, minimum 20%, no codisposal with solid waste after 3/1/89	Yes
Ohio	Yes	Yes, to the point that the material, while cohesive and viscous, slowly flows or loses its shape when unconfined, and does not readily release liquids under normal conditions
Oklahoma	No free liquids unless leachate collected and mixed with bulking material	Raw sludge must be disposed of remotely
Pennsylvania	Pass filter test	Yes
Puerto Rico	Yes	Yes
Rhode Island		Not meet hazardous waste criteria
South Carolina	Must be > 15% solids	Yes
Tennessee	Minimum 20% solids	Yes
Texas	15% minimum solids (trench and fill in sludge-only landfill)	Requires special handling if not stabilized

Table ES-1. Landfilling - Sludge Treatment/Management (Continued)

State	Sludge Dewatering	Sludge Stabilization
Utah	Sludge with no free moisture placed on the working face and covered with municipal solid waste	
Virginia	>20% solids; minimum of 6:1 solids:sludge ratio	Yes
Virgin Islands	Pending	
Washington	15-20% for fill above surface; 1:1 sludge:soil ratio	
West Virginia	Must have >30% solids	Yes
Wyoming	Yes - no free or standing water	

Table E5-2. Landfilling - Site Specific Considerations

State	Distance to Surface Water	Depth to Ground Water	Soil Type	Floodplain Restrictions	Buffer Zones/ Nearest Dwelling/ Distance to Wells
Alabama	Yes	5 ft	Yes	Yes	
Alaska			Yes	Yes	50 ft to site boundary Nearest dwelling - yes
California		Minimum 5 ft above highest anticipated GW elevation		Designed, constructed, operated, maintained to prevent washout. Diversion structures.	
Colorado				Sites prohibited in floodplains	Airports
Connecticut	Case-by-case determination	Minimum 5 ft to maximum high water table	Yes	Cannot restrict flow of base flood or cause washout - no specific prohibition	1,000 ft to wells Nearest dwelling - yes
Delaware	100 ft	20 inches from annual seasonal high GW level			
Florida	200 ft			Yes	1,000 ft to jet airport runway 5,000 ft for propeller 500 ft to nearest well
Georgia		Minimum of 5 ft depending on soil type	Yes	Yes	100 ft to site boundary 1/2 mi to private well 2 mi to public well
Hawaii				Allowed only with approval	
Idaho		10 ft			100 ft with permission 100-300 ft with vegetative screen
Illinois			case-by-case	Not in 100-yr floodplain	
Indiana					Nearest dwelling 600 ft
Iowa				Can't be situated in a floodplain	1000 ft to wells 500 ft to nearest dwelling
Kentucky	250-1000 ft	4 ft to GW 2 ft to bedrock	Permeability 0.2-20 in/hr	Not within 10-yr floodplain	250-1000 ft to wells and dwellings
Maine	300 ft 2-yr variances permitted	Minimum 5 ft above seasonal high water table and bedrock	Yes	Prohibited on floodplain	100 ft to public roads and property lines 1000 ft to residences, wells, springs
Massachusetts	If not draining water supply, case-by-case decision	4 ft from bottom of secondary liner		Prohibited-within 100-year floodplain	Buffer zone: case-by-case determination
Michigan	100 ft	4 ft for Type III sites 10 ft for certain Type II soil sites 12 ft for Type II lined sites/top cover	Clay characteristics	Type II landfills not in floodplain (some exceptions)	300 ft to existing dwelling 100 ft from property line

Table E5-2. Landfilling - Site Specific Considerations (continued)

State	Distance to Surface Water	Depth to Ground Water	Soil Type	Floodplain Restrictions	Buffer Zones/ Nearest Dwelling/ Distance to Wells
Mississippi		10-15 ft		Yes - Protect from 100-yr flood by levees	50 ft to property line; 2 mi to jet airport; 1 mi to propeller airport
Missouri		To be proposed Current case-by-case		20-yr rainfall design; dikes to protect facility from 100-yr flood	50 ft from property line; greater - case-by-case
Montana		10-20 ft minimum	Percolation rate cannot exceed 1.5 in/hr	Cannot be located in 100-yr floodplain	Distance to roads-100 ft No occupied building within 500 ft
Nevada		4 ft	Yes	Discouraged but not specifically prohibited	Nearest dwelling: · 1/4 mile Class I · 1/2 mile Class II · 3/4 mile Class III
New Hampshire	100 ft	6 ft to seasonal high water table	Estimate CECs	Yes	Private well or nearest dwelling: 300 ft Community wells: 500 ft Municipal well: 1000 ft Property line: 50 ft Public road: 100 ft
New Jersey	Yes	Yes	Yes	Yes	Yes
New York	100 ft	5 ft to seasonal high water table and 10 ft to bedrock		Prohibited unless protected from flooding	10,000 ft to jet airport 5,000 ft to piston airport
North Carolina	50 ft	4 ft	Soil scientist recommendation required	Cannot restrict 100-yr flood/reduce temporary water storage capacity	10,000 ft from airport 50 ft from property line 500 ft from private wells 500 ft from nearest dwelling
Ohio	200 ft except by means of a waiver granted by Ohio EPA director	>5 ft Depth to seasonally high ground water; also > 3 ft recompacted clay liner plus a synthetic liner	Suitable cover material incl. loam, sandy loam, silty loam, clay loam, silty clay or other demonstrated materials which are non-putrescible, having a low permeability to water, good compactability, cohesiveness, and relatively uniform texture	Prohibited in a regulatory floodplain except by means of a waiver granted by Ohio EPA director	1,000 ft from a water well in existence on the date the plans were received by the Ohio EPA except by means of a waiver granted by Ohio EPA director Case-by-case for nearest dwelling
Oklahoma	100 ft to streams or other water bodies	5 ft to seasonal high water table		100-year flood	250 ft to private wells 600 ft to public wells 500 ft to nearest dwelling
Oregon				Facility cannot restrict flow of base flood, etc.	200 ft to wells

Table E5-2. Landfilling - Site Specific Considerations (continued)

State	Distance to Surface Water	Depth to Ground Water	Soil Type	Floodplain Restrictions	Buffer Zones/ Nearest Dwelling/ Distance to Wells
Pennsylvania	100 ft to streams	8 ft beneath liner system		100-year flood	1/4 mi upgradient, 300 ft downgradient to surface water
Puerto Rico	Case-by-case determination		Yes Case-by-case	Designed, constructed to prevent washout diversion structure	Case-by-case distance to well determination
Rhode Island	200 ft and not in a water supply watershed	4 ft to highest water table or liner	Yes	100-yr floodplain	1,000 ft to wells 400 ft to any non-site building
South Carolina				Cannot be in a 100-yr floodplain	
Tennessee				Not subject to flooding	
Texas			Soil sampling: Cd, Cu, Pb, Se, Zn, Cr, N, Fe, Mn		200 ft from property line to landfill
Utah		Yes	Yes		
Vermont	500 ft	10 ft from level of landfill to seasonal high water table		Not in 100-year floodplain	1,000 ft to wells Minimum 300 ft to property line
Virginia	100 ft	5 ft to maximum seasonal water table	Yes	Cannot be in a floodplain	200 ft to nearest dwelling 500 ft to wells
Virgin Islands	Yes			Prohibited	1000 ft
Washington		4 ft "generally"			"Adequate"
West Virginia			Determine loading	Yes	
Wisconsin	1,000 ft to a lake 300 ft to a river		Maybe	Prohibited	Private property - 100 ft Highway or park - 1,000 ft Airport - 10,000 ft Wells - 1,200 ft
Wyoming	500 ft including wells and other sources of drinking water		Yes; case-by-case	Prohibited on floodplain	500 ft from wells and other drinking water supplies

Table E5-3 Landfilling - Management Practices

State	Cover	Pathogen Control	Access Control	Runoff Control	Liners	Gas Control	Leachate Collection
Alabama	Final slope < 2 %	Yes	Yes	Yes Final slope < 2%	Case-by-case differing permeability	Yes - structures must not allow gas to collect	Yes, case-by-case
Alaska	Use soil after deposit	Must be disinfected or incinerated in [illegible] areas		Dikes	Yes	Usually not a problem	
California				Yes	Permeability not > 1×10^{-6} cm/sec if hazardous > 2 ft thick clay		Yes
Colorado	2 ft final cover Vegetative				Compatible with wastes to be received		
Connecticut	Daily: min. = 6 in	Yes - pretreatment	Fences, gates	Erosion control Slope kept at 4%	Yes	25% of LEL for methane	Analysis required
Delaware	Layer of suitable material must cover solid waste by day's end			Min. 2% slope on completed fill. Max. slope that precludes erosion.	All leachate collection ditches and ponds must have impermeable liners	Must allow for it and control on site	Yes
Florida			Yes	Yes	Yes	Control if not readily disposed	Also includes treatment
Georgia	Minimum 6 in daily cover, 2 ft final cover		Yes	Yes	Yes - depends on soil type	Monitoring	Case by case
I	6-in cover Compaction at max. depth of 2 ft		Locked gate/fence	Yes			
Idaho		Yes		Yes		No regulation but 50% do it anyway	
Il s		Digested at various sites when used as or with a cover, others do not require digested sludge	Yes	Addressed in application Require cover and plans for evaluation	Sets max permeability 10 ft thick bathtub of the material	Depends on material	Yes, case-by-case
ndiana	Daily soil cover of waste		Access by roadways only			Must not migrate off-site	

Table E5-3. Landfilling - Management Practices (continued)

State	Cover	Pathogen Control	Access Control	Runoff Control	Liners	Gas Control	Leachate Collection
Iowa	1 ft earth covering at end of day Grade for runoff and dispersion		Yes	Yes		Only in residential areas	
Kansas			Yes			25% LEL in structure or property line	
Kentucky	Daily 6 in, final 30 in with 6 in clay	Yes - cover material	Yes	Yes	Yes	< 25% LEL in structures Monitor after closure	Yes
Louisiana	Daily and final cover. Daily. silty clays 6-in thick Final: 2 ft	Yes		Construction of levees, canals, and other diversion devices	3 ft of natural clay of stated permeability, or less, other	All solid waste with organic material connect to gas collection system	Control measures must be implemented
Maine	Daily soil cover Final 2 ft well graded 35% fines, + 6 in cap suitable for plant growth		Fence around facility			25% of LEL for gases in facility structures, at waste facility boundary	Yes
Maryland	Use as fertilizer and soil conditioner if complies with Sec. 8(1) APPLIMARGILD		Yes			Control plan	Plan for preventing GW pollution
Massachusetts	Daily cover required Must meet 1×10^{-7} cm/sec permeability	See stabilization	Yes	Yes	Double liners required, clay or soil Must meet permeability req.	Yes	Collection with "sludge only" landfills yes - leachate control
Michigan				Yes	Seems to be an alternative	Prevent lateral travel and accumulation in structures	Reintroduce or treat
Mississippi	Daily: 6 in Intermediate and Final: 2 ft		Yes	Surface drainage controls Max 8% slope	Yes - where needed to protect GW	Yes LEL < 25%	Required on new, not old
Utah	Daily: 6 in	Case-by-case	Restricted entrance	Yes	Yes	Prevent hazard where necessary	Yes - land application onto finished cover or treatment and discharge under NPDES permit

Table E6-3. Landfilling - Management Practices (continued)

State	Cover	Pathogen Control	Access Control	Runoff Control	Liners	Gas Control	Leachate Collection
Montana		PSRP/PFRP various methods	Fencing	Keep runoff out of disposal area	Case-by-case basis membrane liners	Case-by-case	
Nebraska						Must not migrate off-site	Yes
Nevada				Yes	For liquid sludge		
New Mexico	Required		Fenced site	Yes - prevent from entering trench			
New Hampshire	Final cover depth 2 ft	No stabilization if codisposed PFRP is used as cover material	Fence and gate	Yes plus runon control	Permeability of 1×10^{-7}	< 24% of lower explosive limit of methane	Recirculate or treat off-site
New Jersey	Yes	Yes	Yes	Yes	Yes	Yes	Yes
New York	Daily: 6 in Intermediate: 12 in Final: 48 in	Vector control	Fencing, gates, signs	Yes	Double composite liner system for codisposal landfill, case-specific for sludge-only landfill	Controlled 25% LEL in structures LEL at boundary	When sludge net weight > 25% of landfill materials per day
North Carolina	Minimum 2 ft recommended		Fence, gate, etc	Yes	Site-specific	Not > 25% LEL in structures < 100% LEL at boundary	Yes
Ohio	Minimum Daily: 6 in Intermediate: 1 ft Final: 2 ft	Infectious waste	Yes	Yes	Recompacted clay liner plus synthetic liner	Gas monitoring required	Required
Oklahoma	Daily: 6 in Weekly: 6 in Final: 3 ft	Vector control	Fencing, locked gates	No slope > 4%	Hydraulic conductivity limited	25% LEL in buildings 100% LEL at property boundary	Yes
Oregon			Perimeter barrier	To minimize pollutant flow to surface water		Methane limits < 25% LEL in structures, < 100% LEL at boundary	Yes
Pennsylvania	Daily: 6 in	~~Yes~~ PSRP	Perimeter barrier, fence	Yes, E & S control plan	50 mil	Yes	Required

Table E6-3. Landfilling - Management Practices (continued)

State	Cover	Pathogen Control	Access Control	Runoff Control	Liners	Gas Control	Leachate Collection
Puerto Rico	Daily: 6-8 in Final: 1 2 ft		Yes	Construction of diversion devices	Case-by-case basis, natural clay	Usually not a problem	Plan for preventing leachate problem
Rhode Island	Daily: 6 in Final: 2 feet	~~Vol. FSRP~~ PSRP		Yes, grade/prevent	May be required		
South Carolina		Yes	Yes	Yes		Case-by-case	
Tennessee	Daily: 6 in Monthly: 12 in Final: 24 in	Yes	Fencing and gates	Yes	Case-by-case	Case-by-case	
Texas	Daily unstabilized: 2 ft Daily stabilized: 6 in Final: 3 ft						
Utah		Yes					
Vermont	Must have permeability of $< 1 \times 10^{-4}$ cm/sec and at least 2 ft thick	Yes	Strictly controlled with fences, locked gates, signs	5% slope		Yes	
Virginia	Daily: 6 in Final: 2 ft Permeability < 1×10^{-7} cm/sec	PSRP	Fencing, locked gates, signs	Asphalt, concrete, and roof if facility not enclosed	Double liners required	Yes	Yes
Virgin Islands	6 in		Fencing	Yes			
Washington			Screen with fencing, landscaping, gates	Prevent water quality standards violations		Vent or redirect	And treatment if average rainfall > 25 in/yr
Virginia		Must be demonstrated to be non-infectious				Yes	
[illegible]			Yes	Yes		Yes	Yes
Wyoming		~~Yes~~ PSRP PFRP	Fencing to keep animals out and stop litter. No grazing on site	Yes	Yes Case-by-case	Yes Case-by case	Yes prohibited from entering waters

Table E5-4. Landfilling - Monitoring and Reporting

State	Reporting Requirements	Ground-Water Monitoring	Surface-Water Monitoring	Sludge Quality Monitoring	Site Development and Closure Plans
Alabama	Yes	Yes			Yes - Development and Closure
Alaska		4 wells per permit	Per permit		
Arkansas	Yes				Yes - Development
California	Verification monitoring program. Records on volume and type of waste received.	Monitor: water elevation, temperature, electrical conductance, pH	Required in waste management units (Class II)		Design report and operations plan Closure and post-closure plan (if necessary)
Colorado		Wells			Show facility design and background conditions
Connecticut	Sludge considered "specific waste" Needs some special handling/reporting	Yes - various factors required for new sites pre-development		Yes	
Delaware	Quarterly water quality data Quarterly reports	Wells or other monitoring devices may be required on case-by-case basis; not normally required if applied at agronomic rate			Must analyze soil type and GW flow Completed fill: min. 2% slope
Florida		Conductivity, nitrates, COD, others as appropriate			Yes - Development and closure
Georgia	Yes, specified in sludge management plan	Yes	Yes	Chemical analysis required for hazard classification	Site development operational plan and closure plan required
Hawaii	Semi-annual report	May be required	May be required		
Idaho					Yes - Development
Illinois	Yes	Case-by-case depending on hydrogeologic data	Case-by-case depending on hydrogeologic data	Yes	Yes - Development and closure
Indiana	Sludge considered "special waste;" has special handling/reporting	Minimum 4 wells per site		For hazard classification	For construction (development)
Iowa	Source of sludge, site background, etc.			Nutrients, metals	Site development plan
Kansas	Yes				
Kentucky	Yes	Yes	Yes	Yes - E.P. toxicity	Development: geological input, soils, zoning laws, storage capacity. Closure: vegetation
Louisiana		Annual samples 1 well upgradient and 2 wells downgradient			Development and closure plans

Table E5-4. Landfilling - Monitoring and Reporting (continued)

State	Reporting Requirements	Ground-Water Monitoring	Surface-Water Monitoring	Sludge Quality Monitoring	Site Development and Closure Plans
Maine	Maintain operations manual	Minimum of 3 sample points	Minimum of 2 sample points		Development plan Closure within 60 days after active use ends
Maryland	Quantity per month, % capacity used, projected date to reach capacity	Propose program	Propose program	As needed Also pre-application (% solids, pH, N, ammonia, nitrate, metals, PCB, etc.) Before acceptance (dry weight conc. or % as APPR)	Development plan description and operating plan
Massachusetts	Yes	Case-by-case basis		Comply with 40CFR257 Case-by-case monitoring	
Michigan		Hydrogeological study as part of application process Quarterly monitoring	To assess adequacy of leachate and runoff control	Initial: solids, nutrients, metals, other toxics Follow-up: based on quality, use	Development plan
Mississippi	Burial site must meet sanitary landfill requirements	Yes, site-specific			Closure: special burial and terminate sludge application when heavy metals = 0.5 max. LVL
Missouri	Upon request	Propose in plan	NPDES permit and monitoring stormwater and leachate		Development plan Closure plan
Montana	Disposal rate (vol) and percent solids; quarterly reporting	Case-by-case	Case-by-case		Development plans required, no closure plans
Nevada					Development plan
New Hampshire	Name, volume, source, analysis, method, del/moving	May be required	May be required	>1 mgd: 3 times/yr <1 mgd: 1 time/yr for metals, solids, pH, N	Development provisions for winter storage required
New Jersey	Yes	Yes	Yes	Yes	Yes
New York		Minimum of 4 wells: 3 downgradient; 1 upgradient	Establish baseline conditions and monitor if facility leaks	EP toxicity test Verify that it is non-hazardous	Operating plan Closure plan
North Carolina	As specified	Depending on facility characteristics	Yes, depending on facility characteristics	Site-specific	Development plan Closure plan, not as such, closure procedures specified
Ohio	Daily log of operations	Hydrogeologic study, well installation, and monitoring are required.	Case-by-case	Case-by-case	Development plan operational procedures and detailed plans are required as part of landfill permit Closure plan: required as part of landfill permit to install application
Oklahoma	Daily log of operation and waste received submitted monthly	1 well upstream 2 wells downstream in GW formation	Yes	Prefer weights of dry solids, volume is acceptable	Development plan Closure plan

Table E5-4. Landfilling - Monitoring and Reporting (continued)

State	Reporting Requirements	Ground-Water Monitoring	Surface-Water Monitoring	Sludge Quality Monitoring	Site Development and Closure Plans
Oregon		May be required	May be required		Closure permit including plan/financial assurances, etc.
Rhode Island	Codisposal approval required	Yes - number of monitoring wells approved by director			Site development and operating plan Closure plan: monitoring/funding
South Carolina	Yes	Yes	Yes		Site development plan
Tennessee	Yes	Yes	Case-by-case	Comply with 40CFR257	Master plan for site and area
Texas	Periodic	Annual: Na, Cl, Fe, Mn, SO_4, phenol		Semi-annual sampling: Cd, Cu, Pb, Se, Zn, N	Site development plan Closure plan
Utah					Approved sanitary landfill
Vermont	Monitoring recommended and quality of sludge landfilled	Monitoring wells required on all sites Sampling: 4 times/yr		% solids, pH, nutrients, heavy metals	Site development plan Closure plan
Virginia	Volume disposed of at solid waste facility	Yes, for landfill		Yes	Approved sanitary landfill
Virgin Islands					Yes and closure
Washington		Plan for GW and for pollution control			
West Virginia		To be established		Must be demonstrated non-hazardous and non-infectious	
Wisconsin	Volume disposed of at solid waste facility	May be required	May be required		Closure plan
Wyoming		Yes Case-by-case		Yes	Site development plan

Table E5-6. Landfilling - Other State Management Practice Requirements

State	Management Practice
Alabama	Other - RCRA Standars
Arkansas	Landfill Note Cannot be disposed of in Class 3 or 4 permitted landfill without prior approval
California	Types of Landfills - Class I: Liquid and Solid Hazardous Waste Types of Landfills - Class II Undewatered sludge (land treatment units) Types of Landfills - Class III: Dewatered sludge and acceptable incinerator ash
Colorado	No codisposal without county approval
Connecticut	Leachate Testing - Analysis required
Delaware	Compaction - Solid waste must be spread and compacted in layers not exceeding 2 ft depths
Florida	Leachate Testing - Implied; Zoning Conformance - Yes
Georgia	Other - Soil geology analysis and hydrologic analyses Plant sampling/crop: case-by-case Soil sampling/ monitoring: case-by-case specified in management plan
Hawaii	Compaction - Maximum 2 ft depth
Idaho	Note - EPA Part 257 Regulations
Kansas	Operation prohibited unless permit issued specifically for sludge
Kentucky	Record-keeping - amount of waste disposal; Leachate Testing - Yes
Louisiana	Air Monitoring - Daily checks for odors, monthly checks for amines, chlorinated hydrocarbons Leachate Testing - Monitoring wells measure effect of control system used
Maine	Other - handling site 1000 + ft away from airport runways
Maryland	Equipment - Must be able to handle sludge Note - Satisfy all conditions of COMAR 10.17 11 Odor Control - Not excessive or persistant Permits - Operate in compliance with valid refuse disposal permits
Massachusetts	Has codisposal regs. Monofill guidelines. Double liner required
Mississippi	Deed Record - Use as a landfill
Missouri	Deed Record - Record of contents and need for continued maintenance
New Hampshire	Application rate - one time application not to exceed 20 tons/acre for reclamation. Codisposal - 4:1 ratio refuse to sludge; not < 3:1
New York	Lift height 10 ft maximum
North Carolina	Record keeping, deed recording, and routine sludge analyses
Oklahoma	Compacting - layers not to exceed 2 ft after compaction
Rhode Island	Codisposal - Approval required
Vermont	Preferred Method - By shallow trench, Watershed Limits - No landfill allowed in Class A watershed
Virginia	Loading limits - 1 6 sludge to solid waste ratio, other - solid waste management regulations
Washington	Loading Limits - 1 4 to 1 5 sludge:solid waste ratio; moisture < 40%

Table E5-8. Landfilling - Other State Management Practice Requirements (continued)

State	Management Practice
West Virginia	Design/construction/OPR-EPA's process design manual - mum sludge landfills Loading limits - sludge <30% of waste landfilled, unless it is a dedicated landfill Standards - Part 257 regs
Wisconsin	Leachate Testing - Yes No landfills in wetlands, critical habitat
Wyoming	Fire Protection - Fire lanes and other forms of fire protection

Table E5-8. Landfilling – Sludges Containing Radionuclides

Sludge Quality	Illinois ^{226}Ra and ^{228}Ra Combined	Wisconsin ^{226}Ra Only
≤ 2 pCi/g		May be disposed of at WDNS - licenced landfill
≤ 5 pCi/g	May be disposed of at IEPA-permitted landfill	-
> 5 and ≤ 50 pCi/g	-	Sludge disposed of in isolated area Sanitary landfill requires approval of WDNR and WDHSS and leachate collection 10 ft uncontaminated cover Radon gas protection Mix waste and sludge to < 5 pCi/g
> 5 and ≤ 50 pCi/g	Sludge disposed of in isolated area IEPA-permitted landfill 10 ft uncontaminated cover Radon gas protection	-
< 50 pCi/g	Extra precautions; IDNS approval	Case-by-case

Table E6-1. Land Application - State Multi-Grade Sludge Contaminant Concentration Limits

Region	State	Contaminant	Contaminant Limit (mg/kg)			
			Grade 1 Sludge	Grade 2 Sludge	Grade 3 Sludge	Grade 4 Sludge
2	NJ	Aldrin	0.1	0.1	0.1	
7	MO	Aluminum	20,000	-	-	-
2	NJ	Arsenic	10	10	10	-
7	IA		50	-	-	-
5	MI		< 100	100-2000	> 2000	-
7	MO		450	-	-	—
7	MO	Beryllium	450	-	-	-
8	WY	Boron	1.25	—	—	-
1	MA		< 300	< 300	> 300	—
7	MO		500	-	-	—
3	VA		100	—	—	—
3	WV		100	—	—	—
1	MA	Cadmium	< 2	< 25	> 25	-
10	WA		2	-	-	-
5	MI		< 5	5-125	> 125	-
1	ME		10	-	-	-
1	NH		10	-	-	-
7	IA		15	-	-	-
1	RI		15	-	-	-
2	NJ		20	-	-	-
8	SD		20	-	-	-
3	VA		20	-	-	-
9	CA		25	-	-	-
8	CO		25	70	125	-
3	MD		25	-	-	-
10	OR		25	-	-	
1	VT		25	-	-	
3	WV		25	-	-	-
4	FL		30	100	100	-
		Median	20	68	113	
		Mode	25	N/A	125	
2	NJ	Chlordane	0.10	0.10	-	-
5	MI	Chromium	< 50	50-5000	> 5,000	-
7	IA		1,000	-	-	-
1	MA		1,000	1,000	1,000	-
1	ME		1,000	-	-	-
1	NH		1,000	-	-	-
2	NJ		1,000	1,000	-	-
2	NY		1,000	-	-	-
3	PA		1,000	-	-	-
3	VA		1,000	-	-	-
1	VT		1,000	-	-	-
		Median	1,000	1,000	1,000	
		Mode	1,000	1,000	N/A	
7	MO	Cobalt	250	-	-	-

Table E6-1. Land Application - State Multi-Grade Sludge Contaminant Concentration Limits (continued)

Region	State	Contaminant	Contaminant Limit (mg/kg)			
			Grade 1 Sludge	Grade 2 Sludge	Grade 3 Sludge	Grade 4 Sludge
5	MI	Copper	< 250	250-2000	> 2,000	
2	NJ		600	1,200	-	
8	CO		625	1,650	3,125	
8	UT		625	1,650	3,125	
10	OR		800	-	-	
4	FL		900	3,000	3,000	
7	IA		1,000	-	-	
1	MA		1,000	1,000	1,000	
3	MD		1,000	-	-	
1	ME		1,000	-	-	
1	NH		1,000	-	-	
2	NY		1,000	-	-	
3	PA		1,000	-	-	
1	RI		1 000	-	-	
3	VA		1,000	-	-	
1	VT		1,000	-	-	
3	WV		1,000	-	-	
		Median	1,000	1,425	3,000	
		Mode	1,000	1,650	3,125	
2	NJ	Dieldrin	0.10	0.10	-	-
7	MO	Dioxin	0.001	-	-	-
2	NJ	Endrin	0 10	0.10	-	-
7	MO	Fluoride	4,000	-	-	-
2	NJ	Heptachlor	0.10	0.10	-	-
2	NJ	Heptachlor Epoxide	0.10	0.10	-	
1	RI	Lead	5	-	-	
5	MI		< 250	250-2000	> 2,000	
1	MA		300	1,000	1,000	-
9	CA		500	-	-	
1	ME		700	-	-	
1	NH		700	-	-	-
8	CO		1,000	2,500	5,000	-
4	FL		< 1,000	1,500	> 1,500	-
7	IA		1,000	-	-	
3	MD		1,000	-	-	-
2	NY		1,000	-	-	-
10	OR		1,000	-	-	-
3	PA		1,000	-	-	-
8	SD		1,000	-	-	-
6	TX		1,000	-	-	-
8	UT		1,000	2,500	5,000	
3	TX		1,000	-	-	
3	VA		1,000	-	-	
1	VT		1 000	-	-	-
3	WV		1,000	-	-	-
2	NJ		2,400	4,800	-	
		Median	1,000	2,000	2,000	
		Mode	1 000	2,500	5,000	
2	NJ	Lindane	0.10	0.10	-	-
7	MO	Lithium	500	-	-	-
7	MO	Manganese	2,500	-	-	-

Table E8-1. Land Application - State Multi-Grade Sludge Contaminant Concentration Limits (continued)

Region	State	Contaminant	Contaminant Limit (mg/kg)			
			Grade 1 Sludge	Grade 2 Sludge	Grade 3 Sludge	Grade 4 Sludge
5	MI	Mercury	< 2	2-10	> 10	-
1	RI		5	-	-	-
7	IA		10	-	-	-
1	MA		10	10	10	-
3	MD		10	-	-	-
1	ME		10	-	-	-
1	NH		10	-	-	-
2	NJ		10	10	-	-
2	NY		10	-	-	-
3	PA		10	-	-	-
8	SD		10	-	-	-
3	VA		10	-	-	-
1	VT		10	-	-	-
3	WV		15	-	-	-
7	MO		500	-	-	-
		Median	10	10	10	
		Mode	10	10	10	
2	NJ	Methoxychlor	0.25	0.25	-	-
2	NJ	Mirex	0.25	0.25	-	-
1	MA	Molybdenum	10	10	10	-
5	MI		< 10	10-50	> 50	-
3	VA		20	-	-	-
7	MO		40	-	-	-
		Median	20	20	30	
		Mode	10	N/A	N/A	
5	MI	Nickel	< 25	25-1000	> 1,000	-
4	FL		100	500	500	-
10	OR		100	-	-	-
7	IA		200	-	-	-
1	MA		200	200	200	-
3	MD		200	-	-	-
1	ME		200	-	-	-
1	NH		200	-	-	-
2	NY		200	-	-	-
3	PA		200	-	-	-
1	RI		200	-	-	-
3	VA		200	-	-	-
1	VT		200	-	-	-
3	WV		200	-	-	-
8	CO		250	650	1,250	-
8	UT		250	650	1,250	-
2	NJ		625	1,250	-	-
		Median	200	500	750	-
		Mode	200	200/650	1,250	
7	MO	Organics	1	-	-	-
2	NJ	P, P¹-DDE	0.25	0.25	-	-
2	NJ	P, P¹-DDT	0.25	0.25	-	-
2	NJ	P, P¹-TDE (DDD)	0.25	0.25	-	-
7	MO	Pesticides	10	-	-	-
2	NJ	Phenols	22	22	-	-

Table E8-1. Land Application - State Multi-Grade Sludge Contaminant Concentration Limits (continued)

Region	State	Contaminant	Contaminant Limit (mg/kg)			
			Grade 1 Sludge	Grade 2 Sludge	Grade 3 Sludge	Grade 4 Sludge
8	WY	Selenium	0.2	-	-	
5	IL		4	-	-	
5	MI		10	10-80	>80	-
7	MO		80	-	-	
		Median	7			
		Mode	None			
2	NJ	Total PCBs	0.5	0.5	-	-
5	MI		<1	1-10	>10	-
3	VA		1	-	-	
1	MA		2	-	-	-
6	TX		2	-	-	-
3	PA		3	-	-	-
9	CA		5	-	-	-
8	CO		5	10	10	-
8	UT		5	10	10	-
10	AK		10	-	-	-
5	IN		10	-	-	-
4	KY		10	-	-	-
3	MD		10	-	-	-
1	ME		10	-	-	-
7	MO		10	-	-	- -
4	MS		10	-	-	-
1	NH		10	-	-	-
2	NY		10	-	-	-
6	OK		10	-	-	-
1	RI		10	-	-	-
8	SD		10	-	-	-
5	MN		50	-	-	
4	SC		50	-	-	-
5	WI		50	-	-	-
		Median	10	10	10	
		Mode	10	10	10	
2	NJ	Toxaphene	1	1	-	-
1	NH	Zinc	200	-	-	-
5	MI		<750	750-5,000	>5,000	>5,000
2	NJ		1,200	2,400	-	-
8	CO		1,250	3,325	6,250	-
8	UT		1,250	3,325	6,250	-
4	FL		1,800	10,000	10,000	-
7	IA		2,000	-	-	-
1	ME		2,000	-	-	-
10	OR		2,000	-	-	-
1	RI		2,000	-	-	-
3	VA		2,000	-	-	
1	MA		2,500	2,500	2,500	-
3	MD		2,500	-	-	
2	NY		2,500	-	-	
3	PA		2,500	-	-	
1	VT		2,500	-	-	
3	WV		2,500	-	-	
		Median	2,000	2,875	5,625	
		Mode	2,500	3,325	6,250	

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
MO	Aluminum	10%/yr	4,480 0		Case-by-case	
IL	Antimony	-	784 0			
IA	Arsenic	2.24	-	CEC > 5	Will consider higher rates	Consult State for loading limits
IL		-	112.0	CEC X MAF		
MI		-	-		Case-by-case	
MO		10%/yr	112.0	EPA/430/9-77-004	None	
NJ		-	-			
MO	Beryllium	10%/yr	112 0		Case-by-case	
MA	Boron	-	-			Water Soluble
MO		11.2	-			Application rate to avoid toxicity
WY		-	-	USDA Extension		0 33 to > 3 75 lb/ac range
AK	Cadmium	0.86	5.0			
AL		-	0.5	CEC < 5	Max = 20 kg/ha when CEC > 15	
AR		-	5 0	CEC < 5	Max = 20 kg/ha when CEC > 15	
AZ		0 5	5.8	CEC < 5	Max = 20 lb/ac when CEC > 15	
CA		0 5	5.0	Soil pH, CEC < 5	Max = 20 kg/ha when CEC > 15	
CO		0 56	5 6	CEC < 5	Max = 20 lb/ac when CEC > 15	Loading limits for Grade II sludge
FL		500 0	5 0			
GA		0 5	5.0	CEC < 5	Max = 20 lb/ac when CEC > 15	
ID		0 5	5 0	CEC < 5	Max = 20 kg/ha if CEC > 15	
IL		2 2	11 2	CEC > 5	Will consider higher rates	
IN		10 5	5 0	CEC < 5	Max = 20 kg/ha when CEC > 15	
KY		0 5	5.0		exception - animal feed crop	For permit by rule
LA		-	5 6	CEC < 5	Max = 20 kg/ha when CEC > 15	
MA		0 5	5 0	CEC ≤ 5		2 mg/kg for commercial fertilizer
MD		0 45	5 0	CEC < 5	Max = 8 9 lb/ac when CEC > 5	Same limits apply to marginal land
ME		-	0 5	CEC < 5	Max = 5 kg/ha when CEC > 15	0 5 kg/ha for food chain crops
		0 45	4 5	EPA		All values are max levels for grade
MN		-	5 6	CEC < 5	Max = 20 lb/ac when CEC > 15	2 lb/ac-yr if not on tobacco, leafy or root crop
MO		0 5	5 0	CEC < 5		As CEC increases, up to 20 kg/ha at CEC > 15
MS		0 5	5 0	CEC < 5 (EPA Guidnes)	Max = 20 lb/ac when CEC > 15	Cadmium is regulatory All other guidance
NC		0.51	5 0	EPA, pH, CEC < 5	Max = 20 kg/ha when CEC > 15	Soil can be amended to increase pH
NH		-	2 5	CEC < 5	Max = 9 lb/ac when CEC > 15	
NJ		51	11 2	83 EPA P&D 40 CFR257	Variance from limit not granted	(Var related to contaminant limits)
OH		0 5	5 0	pH ≥ 6 5, CEC > 15		
OK		0 5	5 0	CEC < 5	Max = 17 84 lb/ac when CEC > 15	
OR		-	5 0	CEC < 5	CEC > 15, pH > 6 5, 20 lb/ac OK	
PA		0.6	3.4	Baker & Chaney		Assume 10 t/ac
RI		-	1 12	CEC < 5, or 1% Zinc	Max = 5 lb/ac when CEC > 15	Var if organic carbon content 1 6 4 8, > 4 8
SC		0 5	5 0	CEC < 5	Max = 9 lb/ac when CEC > 5	
SD		.45	-	EPA Reg	Cont. limit for animal feed	
TN		-	5 0	CEC < 5	Max = 18 lb/ac when CEC > 15	40 CFR 257, 3 5, 3 6
TX		0 5	-	Fed. Standards		
UT		0 6	5 6	CEC < 5, pH > 6 5		

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
VA	Cadmium (cont)	-	2 5	CEC < 5, USDA-Beltsville	Max = 9 lb/ac when CEC > 15	Agronomic rate, nitrogen, metal limits, CEC, soil pH, sludge pH, for all contaminants
VT		0 5	5 6	Soil Type Loamy Sand	20 lb/ac - clay soils	10 lb/ac - fine loams
WA		0 5	5 0	CEC < 5, EPA	Var for animal feed use, pH	
WI		0 5	5 0	pH > 6 5, CEC < 5	Max = 20 kg/ha when CEC > 15	If CEC = 5-15, max = 10 kg/ha
WY		-	5 6	CEC	Max = 20 lb/ac when CEC > 15	Range from 0 5 to 20 lb/ac
IL	Chromium	49.2	482.6	Hexavalent	Trivalent vs Hexavalent	Hex = 493 kg/ha, Tri = 3,920 kg/ha cum (49 & 98 Annual)
MO		10%/yr	500.0	CEC < 5	Max = 2,250 kg/ha when CEC > 15	Hexavalent vs Trivalent not specified
MI		-	-	CEC x MAF		Consult State for loading limits
IA		44.8	-			
NJ		-	-	EP 430/9-77 004	None	
ME		-	250.0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
NH		-	140.0	CEC < 5	Max = 500 lb/ac when CEC > 15	
NY		20%	336.0	Agric. soil group 1 3	500 kg/ha for Agric group 4 10	
PA		67 2	336.0			
VT		-	140 0	Soil type - loamy sand	500 lb/ac - clay soils	250 lb/ac - fine loams
MO	Cobalt	10%/yr	56 0		Case-by-case	
AR	Copper	-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
AZ		14 0	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
CA		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
CO		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
FL		-	500 0	Grade II		Grade I Sludge limited by Nitrogen content
GA		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
IA		9.0	-	CEC < 5		
ID		-	125 0	CEC < 5	Max = 500 kg/ha if CEC > 15	
IL		-	280 0	CEC > 5	Will consider higher rates	
IN		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
KY		-	125 0	CEC < 5	Max = 500 lb/ac when CEC > 15	250
LA		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
MA		-	140 0	CEC < 5	CEC > 5 = 250 lb/ac	
MD		-	140.0		Max = 250 lb/ac when CEC > 5	Zinc limit, no ind. source allowed cont var = 2,000 ppm
ME		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
MI		-	-	CEC x MAF		
MN		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
MO		10%/yr	140 0	CEC < 5	Max = 560 kg/ha at CEC > 15	
MS		-	125 0	CEC < 5 (EPA Gdlines)	Max = 500 lb/ac when CEC > 250	
NC		-	140 05	CEC < 5	Max = 500 lb/ha (560 kg/ha) when CEC > 15	
NH		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
NJ		-	280 0	EPA P&D 40 CFR257	Variance from limit not granted	
NY		20%	84 0	Agric soil group 1-3	125 kg/ha for soil group 4-10	Max = 281 kg/ha for airports, LFs, parks
OH		-	140 0	CEC < 5, pH ≥ 6 5	Max = 500 lb/ac when CEC > 15	
OR		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 15	
PA		16 8	184 0	Baker & Chaney		
RI		-	140 0	CEC < 5	Max = 500 kg/ha when CEC > 15	Var if soil organic carbon content 1 6 4 8, >4 8

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
SC	Copper (cont)	-	140 0	CEC < 5	Max = 250 lb/ac when CEC > 5	
SD		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	
TN		-	125 0	CEC < 5	Max = 446 lb/ac when CEC > 15	
UT		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15	Grade III 3,125 mg/kg
VA		-	125 0	CEC < 5	Max = 445 lb/ac when CEC > 15	
VT		-	140.0	Soil type - loamy sand	Max = 500 lb/ac - clay soils	250 lb/ac - fine loams
WA		-	125.0	BMP Manual	Max = 500 kg/ha when CEC > 15	
WI		-	125.0	CEC < 5	Max = 500 kg/ha when CEC > 15	If CEC = 10-15, Max 250 kg/ha
WY		-	140.0	CEC	CEC 2000 > 15	Range from 1 25 to 500 lb/ac
MO	Dioxin	10%/yr	0.0002		Soil not > 0 0003 ppm	
MO	Fluoride	10%/yr	500.0		Case-by-case	
AR	Lead	-	500.0	CEC < 5	Max = 2,000 kg/ha when CEC > 15	
AZ		56.0	500.0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
CA		-	400.0	CEC < 5	Max = 800 kg/ha when CEC > 5	
CO		-	500 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
FL		-	500 0			
GA		-	500 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	Not to exceed 800 kg/ha for food chain crops
ID		-	500 0	CEC < 5	Max = 2,000 kg/ha if CEC > 15	
IL		-	1,120 0	CEC > 5	Will consider higher rates	
IN		-	500 0	CEC < 5	Max = 2,000 kg/ha when CEC > 15	
KY		-	500 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
LA		-	560 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
MA		-	500 0	CEC < 5	CEC > 5 = 600 lb/ac	Absolute max = 715 lb/ac
MD		-	560 0	CEC < 5	Max = 1,000 lb/ac when CEC > 5	
ME		-	500 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
MI		-	-	CEC x MAF	Based on contaminant level	
MN		-	560 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
MO		10%/yr	560 0	CEC < 5	Max = 2,250 kg/ha when CEC > 15	
MS		-	500 0	CEC < 5 (USDA/SCS)	Max = 2,000 lb/ac when CEC > 15	
NC		-	560.19	CEC < 5	Max = 2,000 lb/ac (2240 kg/ha) when CEC > 15	
		-	560.0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
NH		112 0	1120 0	83 EPA P&D 40CFR257	Variance from limit not granted	Max = 1,123 kg/ha for airports, LFs, parks
NJ		20%	337 0	Agric. group 1-3		
NY		-	560 0	CEC > 15, < 5, pH ≥ 6 5	pH ≥ 6 5	
OH		-	500 0	CEC < 5		
OR		67 0	336 0	Baker & Chaney		Var d soil organic carbon content 1 6 4 8, > 4 8
PA		-	560.0	CEC < 5	Max = 2,000 kg/ha when CEC > 15	714 lb/ac lifetime max for fruit/veg application
RI		56 0	560 0	CEC < 5	Max = 1,000 lb/ac when CEC > 5	Apples to animal feeding areas
SC		-	560 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
SD		-	500 0	CEC < 5	Max = 1,782 lb/ac when CEC > 15	40 CFR 257, 3 5, 3 6
TN			784 0	Protect food crops		Grade III max = 500 mg/kg
TX		-	280 0	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
UT		-	500 0	CEC < 5	Max = 1,780 lb/ac when CEC > 15	
VA		-	200 0	Soil type - loamy sand	Max = 712 lb/ac - clay soils	356 lb/ac - fine loams
VT						

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
WA	Lead (cont)	-	500 0	BMP Manual	Max = 2,000 kg/ha when CEC > 15	
WI		-	500.0	CEC < 5	Max = 2,000 kg/ha when CEC > 15	If CEC = 10-15, max = 1500 kg/ha
WY		-	560.0	CEC	CEC 200 > 15	Range from 500 to 2,000 lb/ac
MO	Lithium	11.2	-		Case-by-case	Application rate to avoid toxicity
IL	Manganese	-	1,000.0	EPA Loadings, CEC > 5		
MO		10%/yr	600.0		Case-by-case	
IL	Mercury	7.84	-	CEC > 5	Will consider higher rates	Consult Agency
MI		-	-			
MD		-	-			
MO		11.2	-			
NH		-	0.56	CEC < 5	Max = 2,000 lb/ac when CEC > 15	
NJ		-	-	EPA 430/9-77-004	None	
PA		0 22	-			
RI		-	-	EP Toxicity		Application rate to avoid toxicity
SD		-	-			For animal feeding areas
VT		-	5 6	Soil type - loamy sand	Max = 20 lb/ac for clay soils	10 lb/ac fine loams
MI	Molybdenum	-	-			Consult Agency for loading limit
MO		10%/yr	9 0		Case-by-case	
AR	Nickel	-	50 0	CEC < 5	Max = 200 kg/ha when CEC > 15	
AZ		5 6	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
CA		-	50 0	CEC < 5	Max = 200 kg/ha when CEC > 15	
CO		-	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
FL		-	125 0			
GA		-	50 0	CEC < 5	Max = 200 kg/ha when CEC > 15	
IA		8 96	-			
ID		-	50 0	CEC < 5	Max = 200 kg/ha if CEC > 15	
IL		-	112 0	CEC > 5	Will consider higher rates	
IN		-	125 0	CEC < 5	Max = 500 kg/ha when CEC > 5	
KY		-	50 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
LA		-	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
MA		-	56 0	CEC < 5	CEC > 5 = 100 lb/ac	
MD		-	140 0	CEC < 5	Max = 250 lb/ac when CEC > 5	
ME		-	50 0	CEC < 5	Max = 200 kg/ha when CEC > 15	
MI		-	-	CEC x MAF		
MN		-	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
MO		10%/yr	140 0	CEC < 5	Max = 560 kg/ha when CEC > 15	
MS		-	125 0	CEC < 5 (USDA/SCS)	Max = 200 lb/ac when CEC > 15	
NC		-	56 02	CEC < 5	Max = 200 kg/ha when CEC > 15	
NH		-	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
NJ		-	280 0	83 EPA P&D 40CFR257	Variances from limit are not granted	Max = 168 kg/ha for airport, LFs, parks
NY		20%	34 0	Agric group 1-3	50 kg/ha for AS group #4-10	
OH		-	140 0	CEC < 5	Max = 500 lb/ac when CEC > 15, pH ≥ 6 5	

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
OR	Nickel (cont)	-	50 0	CEC < 5	Max = 200 kg/ha when CEC > 15	
PA		6 7	34 0	Baker & Chaney		
RI		-	56 0	CEC < 5	Max = 200 lb/ac if CEC > 15	Var if organic carbon content 1 6-4 8, >4 8
SC		-	140 0	CEC < 5	Max = 250 lb/ac when CEC > 5	
SD		-	56 0	CEC < 5	Max = 200 lb/ac when CEC > 15	
TN		-	50.0	CEC < 5	Max = 178 lb/ac when CEC > 15	
UT		-	85.0	CEC < 5	Max = 200 lb/ac when CEC > 15	Grade III Max = 1,250 mg/kg
VA		-	89.0	CEC < 5	Max = 178 lb/ac when CEC > 15	
VT		-	85.0	Soil type - loamy sand	Max = 200 lb/ac - clay soils	100 lb/ac - fine loams
WA		-	51.0	BMP Manual	Max = 205 kg/ha when CEC > 15	
WI		-	50.0	CEC < 5	Max = 200 kg/ha when CEC > 15	If CEC = 10-15, Max = 150 kg/ha
WY		-	56.0	CEC	Max = 200 kg/ha when CEC > 15	Range from 50 to 200 lb/ac
AZ	Nitrogen/Nit	-	-	Agronomic rate		
FL		560.0	-	Agronomic rate		Grade I or II sludge limited by nitrogen content
GA		-	-	Agronomic rate		
IA		-	-	Agronomic rate		10% on dry wt basis
IL		-	-	Agronomic rate		Agronomic rate
IN		-	-	Agronomic rate		Agronomic rate
MA		-	-			Agronomic rate
ME			-	Agronomic rate		Loadings cannot exceed crop needs
		-	-	Agronomic rate		
NC			280 1	Agronomic rate	N most likely limiting factor	
OH		-	-	Agronomic rate		
MO		-	-	Agronomic rate		
MN		-	-	Agronomic rate		
MS		-	-	Agronomic rate		Cannot exceed crop needs
NH		-	-	Agronomic rate		Most likely limiting factor on annual basis
OK		-	-			
OK		RT	-	Agronomic rate		Agronomic rate
PA		-	-	Crop needs	Soil texture/vegetation cover	100% of crop requirement for inorganic N
SD		RT	-	Agronomic rate		Agronomic rate, dedicated vs. nondedicated site
TN		-	-	Crop needs		Consult Agency for assistance
WI		CALC	-	Agronomic rate		
WY		180.0	-			Annual plant available nitrogen
WI	Organics	-	-		Case-by-case	Case-by-case
MO		10%/yr	1 1			< 0 05 ppm accumulated unless more found acceptable
MI	Other Organics	-	-			Case-by-case
IA	Pesticides	-	-			Not allowed in waste stream
WI		-	-			Case by case
WV	pH	-	-	CEC > 20		pH 6 1 6 3 7 5 T/ac. = 6 4 6 6 5 0 >6 7 null

Table E6-2 Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha) Annual	Limitation (kg/ha) Cumulative	Basis for Standard	Variance Allowed	Comments
WI	Phenols	-	-			Case-by-case
NJ		-	-	NJ median sludge qu		Ref from Singh, A , Chase, H P & Morris, H L
CO	Phosphorus	-	448 0	Available P of soil		
IA		-	-	Agronomic rate		6 9% on dry wt. basis
IL		-	448 0	Sandy soils	800 lb/ac non sandy soils	
MN		-	448.0	Soil extractable P		
IA	Potassium	-	-	Agronomic rate		0 9% on dry wt. basis
IL		-	-			Case-by-case
IL	Selenium	-	8.96	CEC > 5	Will consider higher rates	
MI		-	-	CEC x MAF		Consult State for loading limits
MO		10%/yr	17.9		Case-by case	
WY		-	-	USDA Extension	Case by case	Range from 0 1 to 0 5 lb/ac
IL	Silver	-	200.0			
AK	Total PCBs	-	-		If incorporated	
IA		-	-			No PCBs in waste stream
MA		-	2 2			
MI		-	-			Consult State for loading limits
MN		-	-		10 mg/kg must be incorporated immediately	
MO		10%/yr	1 1		Case-by-case	
MS		-	-			Regulatory
NY		-	-			Also 10 ppm
RI		-	-			Dry Weight
SD		-	-	Recommended		Animal feed related
WI		-	-	RCRA	>10 mg/kg if incorporated	Incorp if > 10 mg/kg on dairy grazing land
				Management plan if PCB > 50	EPA approval if PCB > 50 mg/kg only	
AR	Zinc	-	250 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
AZ		28 0	280 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
CA		-	250 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
CO		-	280 0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	
FL		-	250 0			
GA		-	250.0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
IA		17 9	-			
ID		-	250 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
IL		-	562 0	CEC > 5	Will consider higher rates	
IN		-	250 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
KY		-	280 0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	
LA		-	280 0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
MA		-	280 0	CEC < 5	CEC > 5 = 500 lb/ac	

Table E6-2. Land Application - State Regulations For Annual and Cumulative Application Rates and Variances (continued)

State	Constituent	Limitation (kg/ha)		Basis for Standard	Variance Allowed	Comments
		Annual	Cumulative			
MD	Zinc (cont)	-	280.0	CEC < 5	Max = 500 lb/ac when CEC > 15	Var for cont. level = 4,000 ppm
ME		-	280.0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
MI		-	-	CEC x MAF		
MN		-	280.0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	
MO		10%/yr	280.0	CEC < 5	Max = 1,120 kg/ha when CEC > 15	
MS		-	250.0	CEC < 5 (USDA/SCS)	Max = 1,000 lb/ac when CEC > 15	
NC		-	280.1	CEC < 5	Max = 1,000 lb/ac (1120 kg/ha) when CEC > 15	
NH		-	280.0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	
NJ		-	560.0	83 EPA P&D 40CFR257	500 kg/ha for Ag group 4-10	Variances from limit are not granted
NY		20%	168.0	Agric. soil group 1-3	250 kg/ha for Ag group 4-10	Max = 561 kg/ha for airports, landfills, parks
OH		-	280.0	CEC < 5, pH ≥ 6.5	Max = 1,000 lb/ac when CEC > 15 pH ≥ 6.5	
OR		-	280.0	CEC < 5	Max = 1,000 kg/ha when CEC > 15	
PA		33.6	168.0	Baker & Chaney		
RI		-	280.0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	Var if organic carbon content 1.6-4.8, > 4.8
SC		-	280.0	CEC < 5	Max = 500 lb/ac when CEC > 5	
SD		-	280.0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	
TN		-	280.0	CEC < 5	Max = 891 lb/ac when CEC > 15	
UT		-	280.0	CEC < 5	Max = 1,000 lb/ac when CEC > 15	Class III max = 6,250 mg/kg
VA		-	250.0	CEC < 5	Max = 890 lb/ac when CEC > 15	
VT		-	280.0	Soil type - loamy sand	Max = 1,000 - clay soils	500 lb/ac - fine loams
WA			250.0	BMP Manual	Max = 1,000 kg/ha when CEC > 15	
WI		-	250.0	CEC < 5	Max = 1,000 kg/ha when CEC > 15 if CEC = 10-15, Zn ≤ 500 kg/ha	
WY			280.0	CEC	Max = 1,000 lb/ac when CEC > 15	Range from 250 to 1,000 lb/ac

Table E6-3. Land Application - Site Specific Considerations

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Alabama			5 ft to ground water		Yes					
Alaska	Must be thawed and workable		6 ft min to ground water	Yes		100 ft min				
Arizona	Soil must be analyzed annually before sludge application	≤6%	No application where mean annual ground-water elevation less than 40 ft below surface	24-hr - 25-yr storm			Cannot have washout of sludge Approval by local floodplain administrator needed	Water well - 250 ft required Muni well - 1000 ft	500 ft	25 ft to public road 25 ft to property line
Arkansas	Check infiltration			Yes	Yes				Yes	Yes
California		Yes	Yes - depth to ground water	Yes		500 ft	Yes			
Colorado	Application restricted if loamy sand or coarser material	15%	5 ft to ground water	Must not run off site		50 ft to stream bed for Class I recreation waters 1 mi to public water supply intake		100 ft		
Delaware			Min. 3 ft from annual high ground-water levels; 20 in minimum for agricultural use.		Must determine soil type, ground-water flow	50 ft if surface applied, 25 ft if subsurface applied				
Florida	2 ft of permeable soil	6%	2 ft to water table	Yes	Yes	3,000 ft to Class I 200 ft to other waters	10-yr, 1-hr event	300 ft for shallow, private wells 500 ft for public water supply wells	300 ft (except for composted/ processed sludge)	

Table E8-3. Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Georgia		Surface application - <5% slope, incorporation - >5% slope	5 ft to ground water		Yes	100 ft 1,000 ft for spray applications	Yes	1000 ft for public water, 500 ft for private water	500 ft (incorporation) 1,000 ft (splash plate)	
Idaho		<8% unless runoff control	4 ft min. to ground water	Yes		300 ft	No application within 10 yr floodplain	1,000 ft - public 500 ft - private	300 ft	50 ft to road
Illinois	If applied to natric soils, must be incorporated	Liquid sludge w/incorporation - <8% Liquid sludge w/o incorporation - <5% Solids - <8%	Liquid sludge - 10 ft to ground water Solid sludge - 5 ft to ground water Permeability also a factor	Yes	For reclamation projects	200-1,000 ft	No application to 10-yr floodplain	200 ft depending on geology and type of well, streams, or waterways	20-1,000 ft depending on method of application	
Indiana	Application rates vary by CEC range, min. 20-in depth of permeable soil	<8%, unless runoff control	3 ft to ground water 4 ft min depth			300 ft unless runoff control measures used			300 ft unless runoff control	
	Apply only to soils classified as acceptable through top 5 ft of soil	5% max when ground is frozen or snow-covered			Yes	50 ft	10-yr floodplain incorporation required	500 ft	200 ft min	Downgradient (200 ft) from SW, then injected or surface-applied
		<5%	10 ft to ground water				10-yr floodplain	200 ft	500 ft	100 ft from perimeter of land application site
Kentucky	Permeability not >20 in/hr and/or <0.2 in/hr	5-12% depending on slope length and application method	4 ft to ground water	75% vegetative cover min. or incorporate	Yes	250-1,000 ft	Not in 10-yr floodplain	250-1,000 ft	250-1,000 ft	30-100 ft to road 30-100 ft to property line 250 1,000 ft to a sinkhole

Table E6-3 Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Louisiana		Control to prevent erosion	"Safe depth" to ground water		Closure plan required					
Maine	Limitations by soil type	Cleared land - < 18% Forested land - may exceed 18%	Min. of 20 in to bedrock	Avoid application during rain	Site analysis, soil analysis, topographic map, facility design, sludge analysis, management plan	Drainage gullies - 25 ft Ponds, streams, lakes - 300 ft Intermittent streams - 50 ft	Case-by-case	300 ft	300 ft	
Maryland		15% max. 6% for liquid sludge/ surface applied	2 ft to ground water or bedrock outcrop; 50 ft for surface appl., 25 ft for subsurface appl.	Contour plowing if required		50 ft - surface appl., 25 ft - subsurface appl., 15 ft to drainage ditch, surface appl., 10 ft to drainage ditch, subsurface appl.		100 ft - potable 25 ft - nonpotable	200 ft - occupied offsite surface appl., 100 ft - occupied offsite subsurface appl., 100 ft - occupied onsite surface appl., 50 ft - occupied onsite subsurface appl.	25 ft to road and 50 ft to property line for subsurface appl., 15 ft to road and 25 ft to property line for subsurface appl.
Mass.	Analyses required for Type II and III sludges	< 8%	3 ft - high water level 3 ft - bedrock	Control measures may be required	Yes, for Type II sludge	2,500 ft Case-by-case for nondrinking No appl. within 400 ft of muni water supply		300 ft for Type II or III (sludge/ septage) 2,500 ft for public water supply wells		
Michigan	Analyses - pH, P CEC < 300 lb/ac avail. P except for sand, loamy sand which may have < 200 lb/ac avail. P	0-6% - surface appl. 0-12% - injection	> 30 in from soil surface	Yes	Yes	150 ft - surface application 50 ft - injection		150 ft - surface and injection	500 ft - surface appl., 100 ft - injection, 300 ft to existing	150 ft to property line for surface appl., 25 ft to property line for injection

Table E6-3. Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Minnesota	Not on organic soils/peats w/o subsurface drains. Must be fine sand, loam, silt, clay, non-ponding. Not for land w/permeability < 0.2 in/hr or > 6 in/hr throughout top 5 ft	6% - surface appl. 12% - sub-surface appl.	At least 3 ft from seasonal high water table, at least 5 ft from bedrock. No application where bedrock has fractures or cracks within 5 ft of surface		Must include site characterization, site management	100 ft - intermittent streams, 600 ft - lakes, 200 ft - rivers depending on soil type and time of year		200 ft - private wells 1,000 ft - public wells	600 ft from residential or recreational area 200 ft from habitation 100 ft if injected	
Mississippi	Yes	Max. 8%	At a safe distance from seasonal high groundwater - site-specific	Yes, no appl. on saturated ground	Yes		No application on 100-yr floodplain	300 ft	150 ft to adjoining property	2 mi to airport, 50 ft to property line
Missouri	For conservative management soil capability class 7 & 8 not used	7 12% injection only > 12% if managed carefully Thick stand of grass required	Geological evaluation in potential karst regions and other fractured bedrock areas	Avoid application when soil moisture high/expect rain	Part of NPDES permit. Detailed plan if > 10 dry t/yr generated (500 P E)	25 ft - drainage ditch 50-300 ft stream (depends on stream classification)	Case-by-case	150-300 ft, depends on geology and well construction	Case-by-case	RO filtration, protect sinkholes, draincourse, pond, 50-300 ft buffer zone
Nebraska	Not in ponding areas.						In 10-yr floodplain, injection or incorporation required	200 ft min Recommend 500 ft to private wells, 1,000 ft to public water supply wells		
Nevada					Yes					
New Hampshire	Min. 2 ft of unsaturated soil at application time pH 6.5 (may use lime to raise)	Max. 8%	Min. 2 ft to water table Min. 6 ft to bedrock	Buffer zones no application during wet period	Yes, with application for permit. Test pits, crops, etc Closure plan also required	100 ft - surface appl., 50 ft - incorporated appl.	Stockpiling within 100-yr floodplain prohibited	Municipal well - 1,000 ft Private well - 300 ft Community well - 500 ft	Occupied - 300 ft	100 ft to road Appl. rates ≤ 5 dry t/ac/yr near highways 50 ft to property line

Table E6-3 Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
New Jersey	Yes			Yes	Yes	200 ft		300 ft 1500 ft from public water supply		1,500 ft from public water supply
New York	Yes	Max. 15% if 8% if surface applied	Min. 2 ft to bedrock	Required Same day incorporation into soil	Include crops to be grown, appl and harvest schedule Topo maps	200 ft	No application in floodplains	200 ft	500 ft	200 ft to potable well 500 ft to property line
North Carolina	Soil evaluation recommend application rates	Max 10% when surface applied Max 18% when subsurface applied	Min 3 ft to bedrock	When surface applied, inc. required within 24 hrs. Limited application during inclement weather, i e , do not apply 24 hrs after 1/2" rainfall	Provide description w/application Agronomist's recommendation regarding cover crop Check suitability of appl rates		Application within 100-yr floodplain prohibited	100 ft	400 ft when surface applied, 200 ft when sub-surface applied	100 ft to property line, 100 ft to any drainage ways if surface applied or 50 ft if subsurface applied
Ohio	Limitations by soil type Application rate reduced by high or low permeability	>12% prohibited 6-12% if 80% covered with vegetation or injection used	1-5 ft depending on amount applied and percolation rate. Appl. prohibited where bedrock <3 ft from surface - depth to seasonally high GW is 2-3 ft depending on permeability, depth to perched watertable is 1-3 ft depending on amount applied and drainage	Yes	Yes	25-100 ft (0 ft with barrier) depending on appl. and type of water	Prohibited in areas within 10-yr flood elevation within 2 mo of seasonal floods	200-300 ft	100 - 300 ft depending on sludge type and applic rate	

Table E8-3. Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Oklahoma		5% 10% for dewatered, direct incorporation or digested with runoff control	2 ft to seasonal high water table			100 ft	Protection from washout within 100-yr floodplain Level II slurry, must apply before rainy season	250 ft		Distance to airport runway: 10,000 - jet 5,000 - prop.
Oregon	24 in rooting depth Substratum not rapidly drained	12% liquid sludge, base soil; 20% dewatered, dry, incorporated liquid sludge up to 30% on well-drained western Oregon silvaculture sites	1 ft to temp., 4 ft to permanent ground water	Where needed		50 ft	Restricted application period Soil incorporated Avoid area	200 ft	0 ft - injected, 0-50 ft - truck spread; 300-500 ft - irrigation, solid waste regs. 0 25 mi undigested and unincorporated within 5 days	
PA	Range from sandy loam to silt loam	15%, some allowance for 25% in certain cases	20 in to seasonal high water table or bedrock 4 ft to perm. water table 25 ft to bedrock outcrop	Limit applied quantity to prevent runoff; farm conservation plan		100 ft, 300 ft to water supply	Not applied to areas subject to flooding	1000 ft upgradient from surface water source	300 ft	50 ft to property line
Rhode	Yes	If >3% require erosion control	1.5 ft	Max. soil loss <3 T/ac	Yes deviated site, soils, analysis, operating plan Closure plan also, monitoring, funding	200 ft and not in water supply watershed	100 yr floodplain	1,000 ft - public wells and not in recharge area of public water supply well		
South Carolina	Clay 18% overlain with up to 20 in sandy soils	8% unless incorporated - then 12% OK	3 ft. Avoid aquifer recharge areas	For dedicated site		200 ft		100 ft	500 ft if odorous, 1,000 ft or injected	100 ft to property line

Table E6-3. Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
South Dakota	No organic soils unless adequately drained Not on coarse sand or gravel Use SCS classification	< 9%	Coarse soil - 8 ft Med/fine soil - 6 ft	Dikes may be required, no runoff from site, case-by-case	Sludge handling plan for review only	Varies with slope, min 200 ft	No appl within 100 yr floodplain or wetland area	200 ft	Subsurface injection - 100 ft Surface spread - 700 ft Pressure spray - 1,300 ft	In general, fences min 300 ft to res. dev., min 200 ft from right-of-way depending on application method
Tennessee	Case-by-case	Max. 12% incorporated, 5% surface	5 ft		Required	Case-by-case	Diversion dikes needed if site below 100 yr floodline	Case-by-case	Case by case	
Texas	Permeable surface soil > 2 ft thick, pH ≥ 5	9% unless incorporated	4ft; 3 ft with low permeability	10-yr, 1-hr storms		200 ft	100-yr floodplain	300 ft - private, 500 ft - schools, institutions	300 ft 1,000 ft - schools, institutions	50 ft to property boundary
Utah	Background analysis required	Max 12% Frozen ground max 6%	5 ft			200 ft if unincorporated 50 ft if incorporated		300 ft		
Vermont	Analyzed for pH, P, K, Mg	Surf appl - 5% Incorporate into soil up to 15%	3 ft table prohibited in Class 1 or 2 groundwater areas (soil permeability <6 in/hr)			100 ft	Permitted in floodplain but must be incorporated within 48 hr	300 ft to drinking water source	300 ft	50 ft to road 50 ft to property line
Virginia	Min depth 2 ft of soil required Soil map required	Not to exceed 12% unless immediate incorporation	1.5 ft min.	Soil conservation practices	Yes	50 ft	Restricted 100-yr floodplain unless site protected	100 ft	200 ft buffer zone	50 ft to road
Washington				Yes	Yes					
Virginia	pH adjusted to 8.2	< 15% unless incorporated within 24 hr 20% if sludge is 18% solids	2 ft							

Table E6-3. Land Application - Site Specific Considerations (continued)

State	Soil Type	Slope/Grade	Depth to Ground Water/Bedrock	Runoff Control	Site Development Plan	Distance to Surface Water	Floodplain Restrictions	Distance to Wells	Nearest Dwelling	Buffer Zones
Wisconsin	Permeability limit. >6 in/hr prohibited. May be approved case-by-case	12% max. Liquid sludge. 6-12% (inject). Cake sludge: 0-6% 6-13% (case-by-case) Cake sludge: 6-12% with dept approval Liquid sludge: must be injected if 6-12% Dec 1-March 31: No landspreading if slope >6% and no landspreading on slopes >2% unless prior approval obtained. No landspreading on slopes >12%.	3 ft min. to ground water or bedrock	Prevention		100 ft from streams, ponds and channelized waterways, 50 ft if incorporated, 25 ft from wetlands or dry run	Prohibition	200 ft-private, 1,000 ft-public	0.25 mi-200ft-incorporated, 500 ft-surf appl. (less if owner agrees)	
Wyoming				Runoff control plan required	Yes, also vegetation management plan					

Table E8-4. Land Application - Monitoring and Reporting

State	Sludge Monitoring	Reporting Requirements	Plant Sampling/Crop Monitoring	Soil Sampling/ Monitoring	Ground-Water Monitoring	Surface Water Monitoring
Alabama					Yes	
Alaska					Per permit	Per permit
Arizona	Analysis must be done 1 mo prior to application - most contaminants	Monthly report of record of applications at each site (quality and quantity)		Fields sampled prior to application	If sludge applied less than 40 ft to ground water, wells in the vicinity of the fields are sampled at 6-mo intervals for metals, total coliform and nitrates. Not required if sludge applied in accordance with sludge guidelines.	
Arkansas	Yes - preapplication			Preapplication and annual monitoring		
California	Cd, Pb, Zn, Cu, Ni, PCB, Total N, solids. Frequency dependent on size of treatment plant.	Analyses, operating record				
Colorado	Total N, organic N, NH_4, NO_3, pH, K, conductivity, Ar, Al, Cd, Cr, etc.	Monitoring results every 6 mo. Amount applied and locations.	Plant tissue monitoring	Yes	Identify annual high ground water level; monitor if level < 10 ft below ground	
Delaware		Annual reports; Analysis must be submitted quarterly			Monitoring wells or other devices must be installed as required by permit	
Florida	Every 3-12 mo depending on facility size - metals, solids, nutrients	Recordkeeping - amount applied, when, etc.			Depth to water table	If there are water quality standards violations
Georgia	Annually for pH, % vol. in solids, Pb, Cd				Dedicated sites	Case-by-case
Idaho	PCB, P, Cd, Cu, Ni, Zn	Amount applied, changes in water quality, use of harvested crops	Biennially for metals		Baseline and during project life - N, metals, organics, pH, fecal coliform	Baseline and during project life - N, metals, organics, pH, fecal coliform
Illinois	% solids, vol. solids and acids, various metals; usually than plant size determines frequency (monthly-annual)	Monthly to annual reports depending on plant size	May be required	CEC = 5-15; soil pH > 6.5 or use lime; test before appl. and 6 mo and 1 yr after	May be required	

Table E8-4. Land Application - Monitoring and Reporting (continued)

State	Sludge Monitoring	Reporting Requirements	Plant Sampling/Crop Monitoring	Soil Sampling/ Monitoring	Ground-Water Monitoring	Surface Water Monitoring
Indiana	% solids, NH_4, NO_3, Total N, P, K, Pb, Zn, Cu, Cd, Ni, PCBs	Annual report of weekly application rates and site conditions		Pre-application, annual if pH < 6.5		
Iowa	N, P, K, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn	Long-range plan required				
Kansas	Cd, Cu, Pb, Ni, Zn, Cr, As, Se, P				May be required	
Kentucky	POTW < 1 mgd - 1x/yr POTW > 1 and < 2 mgd - 2x/yr POTW > 2 and < 10 mgd - 4x/yr POTW > 10 mgd - 1x/mo	Deed record - regarding Cd application Annual report of all records		Annual monitoring	Geological data assessed: specific parameters measured	Yes
Louisiana	Semiannual, pH, CEC, N, salts, organic matter, sludge/soil mix	Annual (test results), land area, etc.				
Maine	Nutrients, metals, micronutrients, others (N) initial Quarterly dioxin testing during first year for POTWs > 25 mgd. POTWs required to enact individual pretreatment program, POTWs containing pulp, paper, tannery, textile-related addns to wastewater inputs	Monthly, quarterly, or yearly. Analysis, lime added, distribution, etc.	Analysis of plant tissue may be required for some sites	Analysis for background level of Cd, Cr, Pb, Hg, Ni, Zn. Standard soil test before each application		25 ft to property lines and public roads
Maryland.	As needed. Also preapplication (% solids), pH, N, ammonia, nitrate, metals, PCB, etc.	Amount, where applied, amount of lime. As required.			As required	As required
Massachusetts	1-6 mo intervals Nutrients, pH, % solids, metals, PCBs, based on industrial input, within 2000 ft of water supply, monitoring for organics required	Annual, not for Type I sludge, also deed notice - Type II and III sludge/septage		Yes - P, Cd, Cr, Cu, Pb, Ni, Hg, Zn, PCB	Depth may require monitoring	
Michigan	Initial: solids, nutrients, metals, other toxics Follow-up based on quality, use	Monthly - by municipality; sludge quality, amount, application rate, fertilizer required	Generally not required	Annually	No - but hydrological study may be required	Not under normal circumstances

Table E8-4. Land Application - Monitoring and Reporting (continued)

State	Sludge Monitoring	Reporting Requirements	Plant Sampling/Crop Monitoring	Soil Sampling/ Monitoring	Ground-Water Monitoring	Surface Water Monitoring
Minnesota	Annually, based on facility size. Metals, PCBs, nutrients, solids. PCB more frequent	Annual report on amounts of Cd, Zn, Pb, Ni, Cu, N. Composition, soil test, location, amount, N appl. limits, vegetation grown.		Texture, organic matter, P, K, pH, soil conductivity to be done before each season. Halt appl. if soil conductivity > 4 millimhos/cm by soluble salt test.	Min of 6 wells. Semiannual sampling unless facility meets all requirements for landspreading sites	At discretion of director
Mississippi	Yes - when Cd not the main contaminant	Permanent record of volume (rate) and location. Tissue monitoring of vegetation. Deed record - amount of PCBs and Cd applied.		Annual soil sampling for metals, nutrients	As required	
Missouri	Sludge and soil characteristics, and volume applied	Daily records: % solids, volume, location. Annual report	Dedicated sites	pH, CEC prior to application and every 4-5 yr Nutrients - annual unless > 2 t/yr.	Dedicated sites	
Nebraska	Solids, N, P, metals, Zn, Cd, Ni, Cu, Cr, etc. Report to application for major facilities	Annually at minimum for major facilities	No	Yes, for some facilities, mainly for nitrates	Yes, but only one facility	
Nevada						Only regulated in some cases
New Hampshire	Nutrients, VOC's, % solids, pH, metals > 1 mgd 3 x/yr < 1 mgd 1x/yr	Case-by-case	Case-by-case	Yes; pH, lime, organics	May be required	May be required
New Jersey	Yes	Yes	Yes	Yes	Where repeated applications made	Yes
New Mexico		Groundwater discharge plan required			As required	As required
New York	Cd, Cu, Pb, Ni, Zn, Cr, Hg, benzene, PCB, Nitrogen series, K, P, pH, tot. solids, tot. volatile solids	Annual report; sludge soil quality data, crop grown, loading rate		N, K, P, Ph, Cd, Cu, Cr, Hg, Ni, Pb, Zn	In some cases	In some cases
North Carolina	Solids, metals, N, P, K, pH, EP, toxicity and vol. for new & renewable applic.	Monthly for vol., metals, and nutrients		Prior to application for pH & CEC	As required	

Table EB-4. Land Application - Monitoring and Reporting (continued)

State	Sludge Monitoring	Reporting Requirements	Plant Sampling/Crop Monitoring	Soil Sampling/ Monitoring	Ground-Water Monitoring	Surface Water Monitoring
Ohio	Yes	Sludge, soil and GW & SW runoff may be required on case-by-case basis, plant analysis not generally required when acceptable sludge is applied at agronomic rates; rates applied; water quality, total applied.	Not generally required for acceptable sludge applied at agronomic rates	pH, CEC, metals, etc.	Yes	Yes
Oregon	Pb, Zn, Cu, Ni, Cd, N (total, NO_3, NH_3), P, K, pH, solids. Frequency dependent on plant	Quantity and type - monthly DMR rules require periodic sampling of sludge quality			Case-by-case. Test wells where sludge applied in excess of agronomic rates or where high ground-water tables are suspected annually to assume sludge siting criteria can be met at the time of sludge land application	
Rhode Island	EP toxicity and metals (annually)				Yes, as required	Yes - continuous
South Carolina	Most contaminants monitored and annual EP toxicity test done. Must be non-hazardous			Initial and follow-up depending on sludge quality	One upstream and two downstream wells	Yes
South Dakota	Annual monitoring of % solids Ph, N, NH_3, NO_3, Zn, Cu, Ni, Pb, Cd, Hg, Cr, PCBs, Se, Mg, Fe, persistent organics (pesticides)	Periodic review	None	Type & pH before application; stop application if sol. salts > 4 millimhos/cm	Case-by-case	Case-by-case
Tennessee	pH, solids, N, P, K, Cu, Zn, Pb, Ni	Annual sludge/soil monitoring data, application data		Test for N, pH (6.5-7.5) metals. Monitoring - yes.	May be required	May be required
Texas	Cd, Cu, Pb, Ni, Zn, N, K, PCB					
Vermont	Requires analysis for % solids, pH, nutrients, and heavy metals. PCB testing for proposed land application uses; requires certification of sludge management - includes public participation in application process.				Especially at long-term sites; sampling spring and fall	

Table E8-4. Land Application - Monitoring and Reporting (continued)

State	Sludge Monitoring	Reporting Requirements	Plant Sampling/Crop Monitoring	Soil Sampling/ Monitoring	Ground-Water Monitoring	Surface Water Monitoring
Virginia	Composition analyses done based on the size	Monthly, quarterly, or annually, depends on size	Yes, for annual application	pH, metals, CEC, texture, etc.	Yes	Yes, for annual application and storage lagoon
Washington	N, metals					
West Virgina	At least annually					
Wisconsin	Nearly everything monitored; see contaminants (or can be required)	N, Cd, Cu, Ni, Pb, Zn: lb/ac		As needed before application and every 3 years at site, for N, Ph, P, K, CEC	As needed	
Wyoming					Yes	

Table E8-6. Land Application - Management Practices

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Alabama		PFRP/PSRP		If PCB > 10 ppm				No contact with food plants. Avoid food chain crop for 18 mo. No grazing for 1 mo.		Yes - for 12 mo after application
[illegible] B	> 10% solids by weight	Various, depending on land use PSRP/PFRP					Cd cannot exceed 0 5 lb/ac/yr or 4 5 lb/ac total, PCB < 10 mg/kg		Access of grazing animals controlled for 1 mo following application	Public access controlled for 12 mo following application
Arizona		PSRP/PFRP			Not < 6 5	No appl to frozen, snow-covered, or saturated ground	10% of contaminant limit/yr Max hydraulic loading 27,000 gal/ac 8 dry tons/year	Cannot grow human-consumption crops		
Arkansas		PFRP - food chain, dairy PSRP - pasture (non-dairy), non-food chain			Adjust to 6 5		Nitrate loading to GW or Cd uptake or max metals - whichever most restrictive	No hay/grain harvesting for 30 days after application	Grazing restricted for 1 mo after appl. Fence/signs required	Public access restricted for 12 mo after application
[illegible]		Disinfection recommended	Yes			Not to be applied during or preceding harvest	Yes	May not be applied directly onto any growing food chain crop May not plant food crops until 3 yr after appl (non-digested sludge)	Animals for human consumption - 1 mo after appl Dairy cattle - 12 mo after appl. Not allowed for cattle used to produce unpasteurized milk.	Public access should be prevented for 12 mo if undisinfected sludge

Table E6-5 Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Colorado	Solids > 16% dry weight		Yes		Appl restricted if soil pH 4-6 5	Appl to frozen or snow-covered land where slope > 6% not allowed	Based on soil pH and CEC, for Cd, Cu, Pb, Ni, Zn	Cannot apply to root crops or low fruits Grazing allowed 30 days after appl if PSRP or PFRP included.	No grazing, lactating livestock unless conditions met	
Connecticut	Yes	Yes								
Delaware		PSRP/PFRP			>6.5 at appl. time maintained at >6 0	No application during rain, runoff, periods when ground saturated, frozen, snow-covered		No food crops		
Florida		Septage and food service sludge	Septage and food service sludge	No specific requirement			< 500 lb/ac (6 dry ll)/12 mo = Grade I Metals/N = Grade II	30 days grazing 60 day human food.No root crop, leaf, vegetable or tobacco		For 12 mo - except for processed/ composted sludge
Georgia		PSRP per 40 CFR 257	Yes	On slopes >5%	40 CFR Part 257		Metals 40 CFR Part 257 Total N	No appl for human consumption for 18 mo after application Animals OK	Grazing OK 1 mo after appl.	Public access allowed after 12 mo
Hawaii								Not for vegetables for human consumption		
Idaho		Yes	Yes	PCB > 10 ppm on pasture/ animal land	Maintain soil pH > 6 5 Minimum 20 in depth of perm soil					
Illinois		Sludge must be digested	Yes		Maintain soil pH > 6 5	No application to ice or snow-covered land, during rainfall or on saturated ground	Specified per site II CEC < 5, use 1/2 metal limits, at or below agronomic N & P rate	Land reclamation projects not for truck farming fruits and vegetables		

Table E6-5 Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Indiana		PSRP/PFRP per 40 CFR 257 3-6(b)			Soil pH 6 5 unless no food chain	Application prohibited if soil temp < 32°F or moisture-holding capacity exceeded No frozen ground application unless <2% slope and management practices are employed			Dairy grazing prohibited for 30 days after application	
Iowa		PSRP/PFRP	Yes	Within 48 hr of appl.	Soil must be adjusted to 6 5; sludge must be adjusted to 6 0-7 5	Application to frozen or snow-covered ground should be avoided whenever possible Only allowed on <5% slope	2 tons/acre/yr N, P, K not to exceed needs of vegetation	No application to land for commercial production of food crops for human consumption. Not permitted on land for commercial production	Prohibited for 2 months if not incorporated	Application in parks, schools, other public spaces requires 2 mo access restriction
Kansas					Soil pH > 6 5					
Kentucky	Yes	PSRP, site access restricted	Yes	Yes, within 2 hours for odor control	6 5	No snow/ frozen ground application	No TSCA regulated wastes, 5 dry T/ac, 0 5-in thick, N, Cd, PCB limiting.	No leaf/root crops for 12 mo. Soils with Cd limited to animal feed crops. Not near tobacco, 5 yr wait.		Public access allowed after 12 mo
Louisiana		PSRP - non-food chain PFRP - food chain		Within 3 ft of surface			Liquid waste < 2 in/wk Metals, N	Food chain crops 18 mo after appls. 1 mo. before feeding hay	wait 1 mo after application	12 mo
Maine		PSRP reduction by factor of ≥ 10, vol. solids reduction of ≥ 38%	PSRP	Yes, except for pastures and forests	6 5 or greater within one year of application	Not on frozen, snow-covered, or saturated ground.	Appl rates based on agronomic needs of plants, salt limitations	Edible crops, plant 12 m o after appl Grazing wait 1 mo after appl		
Maryland		Digestion, air drying, composing, etc		Daily unless PFRP, odor control, etc	Adjust if < 6 5	Not on frozen ground unless < 5% slope and 400 ft to wells. Not if soil saturated or snow covered - cannot incorporate.	Cd, Cu, Ni, Pb, Zn, N - agronomic rate, lb/ac depends on CEC, N or metals lesser	1 mo grazing (human use production) 3 yr - direct human food chain unless PFRP		12 mo unless PFRP

Table E8-5. Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Massachusetts		PSRP (min.) PFRP - food crops	Yes	Within 48 hr for Type II or III unless stabilized adequately		Rain, frozen soil, snow, ice	PCB < 2 ppm on pasture	For Type II or III, no grazing for 30 days. No crops except sludge Type I or stabilized II and III		For 12 mo after appl. Fencing and signs.
Michigan		Per Federal regulations	Yes	Within 48 hr	Min 6.5 for food crops	Winter generally unacceptable	N, P, Cd Agronomic rates for N. No overload for P 1/20 to 1/50 of max. cumulative metals.	No food chain crop for 18 mo	30 days	Yes
Minnesota		PSRP (min.) PFRP - food crops			>6.5 (soil and sludge mix)	No appl. to fallow land unless soil type, precipitation, and N limits met	N, P 25,000 gal/ac - coarse texture, 15,000 gal/ac - med. texture, 10,000 gal/ac - fine texture N - agronomic rate	If forage minimal, can apply to pasture or forage crops		For 12 mo after appl. Boundaries must be conspicuously marked
Mississippi		PSRP	Yes	Site-specific	Soil and waste to be maintained at ≥6.5	No spreading on snow-covered, frozen, or wet ground.	Agronomic rate	Min 30 days for crops intended for indirect human consumption Wait 18 mo for crops intended for direct human consumption Vegetative cover unless plowing	Grazing animals permitted after 30 days after appl	Public access permitted 12 mo after appl.
Missouri		PSRP or isolated site ≥ 45 days storage with oxidation ditch	For farmland	>12% slope unless conservation practices	6.5 min at appl Maintain for 2 yr after	Reduce rates on frozen, snow-covered, or wet ground	N requirement of crops. Cd, Cu, Cr, Pb, Ni, Zn - 10% of cumulative limit/yr other parameters for pretreatment city, reduced requirements for rates ≤ 2 dry tyeas, dedicated sites not recommended but considered	No appl. to raw crops. Wait 30 days after appl. for harvest Appl. to vegetables/home gardens not recommended unless composted.	30 days after appl., 1 yr for lactating dairy animals.	Barriers or remoteness Corner sticks maintained through growing season for boundary demarcation

Table E8-5 Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Nebraska		No, not even in guidance								
Nevada		Prohibitions on use (root crops, low-growing berries, etc.)	Prohibitions on use (root crops, low-growing berries, etc.)					Untreated sludge may not be applied to root crops or low-growing fruits. Vegetables may be grown 1 yr after application. Not used in parks		
...ew Hampshire	No	Unstabilized/ raw sludge use prohibited PSRP	PSRP	Not required		No application allowed to frozen/snow-covered or poorly drained soil.	Must have vegetated cover unless incorporated. Max. appl. rate 10 dry t/ac/yr	No use on home vegetables	Grazing for animals. 12 mo min. wait	Public: 12 mo after appl.
...w ...rsey	No	PSRP/PFRP	To control odor/pathogens	May be required		Not on saturated, frozen, or snow-covered soil	Crop N requirements/metal loading (whichever reaches limit first)	If only PSRP, 18 mo for direct human consumption	Yes	12 mo (signs)
...w ...exico		PSRP or apply to city owned dedicated site. PFRP for agricultural land to be used to grow a crop within 18 mo.	Digestion required					Yes		Dedicated site
...York		Yes - PSRP/PFRP	Min. PSRP Chlorine oxidation not suitable.			Not to be applied on frozen, snow-covered ground, or after rains	Based on N avail. and heavy metal concentrations in sludge	No use on food crops for direct human consumption within 18 months		For 12 mo - fences, gates, and signs
...h		PSRP/PFRP	Yes	Within 24 hours	Min 6.5	Prohibited during inclement weather	Agronomic rates	Limits apply to food chain crop for feed, pH, maintenance, and plants for human use	30 days after application	Public access 12 mo. after application

Table E6-5. Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Ohio	Case-by-case		Yes			5 t/ac on frozen or snow-covered ground with min. slope (< 2%)	N, metals toxics, other nutrients considered	Wait 1 yr after appl. for grazing and vegetable crops to be eaten raw	Wait 1 yr after appl. for dairy grazing	
Oklahoma		PSRP/ PFRP		At application			N, P, Cd, PCB Agronomic rates	No human food chain crops for 18 mo	Wait 30 days after appl for dairy grazing	For 12 mo - level II sludge Level III in public access areas
Oregon		Yes					Rate required for max annual plant yield with no nitrogen or phosphorous excesses, varies for CEC (for long-term site loading) Annual based on crop agronomic loading rates	6 mo, undigested sludge, 30 days, air-dried sludge Not on raw fruit/vegetables (18 mo within guidelines)	No grazing - 30 days	For 12 mo after appl. unless compost, heat dry, or equivalent
PA		PSRP/ PFRP	Yes		Soil pH > 6 5 adjusted and maintained 2 yr	No appl. if ground saturated, frozen, snow, or rain likely Some allowance for frozen ground application	N, metals - rates consistent with DER guidelines Septage. 30,000 gal/ac/yr	No appl to root/uncooked crops, no food crops	No dairy grazing for 2 mo following appl.	
Rhode Island		PFRP			> 6 5 for food chain crop, < 6 5 for non-food chain crop, total < 5 t/ac	Not on frozen/snow-covered soil unless erosion control measures in place	< 10 t/ac, < 4x nitrogen requirement of crop	Not for human food chain crops - 1 mo wait for grazing crops	1 mo wait for grazing crops	Yes for 12 mo after appl

Table E6-5. Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
South Carolina	Yes	PSRP/ PFRP	To be rid of vectors and odors				Metals - 10%/yr, Nutrients - agronomic rates unless dedicated site	For dedicated site	1 mo	12 mo - public access limited
South Dakota		PSRP/ PFRP	Yes		pH 6-8 during appl., >6.2	No application to frozen snow-covered ground or saturated ground	Coarse soil 25,000 gal/ac, Med. soil. 15,000 gal/ac, fine soil. 10,000 gal/ac, no pasture if high Pb, Cd, N by crop, soil type, yield, EPA guidance for others	Not for leafy vegetables unless approved through crop tissue analysis	Sludge > 1000 mg/kg Pb, or 20 mg/kg Cd, or 10 mg/kg PCB, not to be applied to forage crops where surface contamination may lead to direct ingestion by feeding animals	Case-by-case
TN		PSRP/ PFRP per 40 CFR Part 257	Yes			No appl on snow or frozen ground or during extended rain	Calc based on metals loadings (long-term) and nutrients (short-term).	Avoid tobacco, leafy vegetables, root crops for 1 yr pH, solids, N, P, K, Cu, Zn, Pb, Ni. Grazing - mow before appl., wait until sludge gone Dairy - wait 6-12 mo.		
Texas		PSRP/ PFRP per 40CFR257	Before land application	Within 48 hr of appl. if unvegetated		No. appl. during rains or to frozen soil unless sludge incorporated	12,500 gal/ac/appl or 8 dry t/ac/yr 700 lb/ac - verify	No dairy grazing for 12 mo Do not apply within 2 wks. of planting Avoid on growing plants	12 mo	For 12 mo after appl.
Utah		PSRP/ PFRP	Yes		pH > 6.5					

Table E6-5 Land Application - Management Practices (continued)

State	Sludge Dewatering	Pathogen Control	Sludge Stabilization	Incorporation	pH Level	Seasonal Limits	Loading Limits	Crop Use Limits	Grazing Restrictions	Access Control
Vermont		PSRP				Not on frozen or snow-covered land	Controlled by agronomic N demand and metals accumulation	At least 5 wk req'd between sludge appl. and harvest. Land cannot be used for human consumption for 36 mo after appl.	Not for 6 mo after sludge appl	Fences/signs may be req'd. Access control 12 mo after appl.
Virginia	Preferred, but liquid application allowed	Yes	Yes	Yes, except pasture	pH > 6 5	Best time is prior to planting	N balance and 15t/ac max 0 5 lb/ac cadmium	Yes – grazing restrictions, no bulk application to veg. gardens, avoid tobacco, root crops for humans	1 mo beef and 2 mo dairy grazing	Yes, for 12 mo after application
WA		PSRP	Digestion	PCBs if > 10 mg/kg dry weight			N requirements of crop Calc. of metals content and rate	Pathogens, metals. Root crops and raw vegetables may not be grown for 18 mo after appl.	1 mo for grazing animals	12 mo if PSRP, until dried if PFRP
West Virginia		PSRP/ PFRP	Digestion, thermal reduction, or chemical	Row crops/ bare soil within 48 hr	Soil pH adjusted to 6 2	No appl to frozen ground		Not on crops with edible portion underground. Not on leaf crops or crops not processed. Clip pastures		
Wisconsin			Yes	PCBs if > 10 mg/kg dry wt N, Cd, Cu, Pb, Ni, Zn limits (see contaminants), agronomic rate for N.	6 5 unless Cd < 2 mg/kg pH 6 0	Dec 1-Mar 31 may apply to slopes ≤ 2% w/o approval. Approval req'd for appl to slopes up to 6%	N, Cd, Cu, Pb, Ni, Zn limits (see contaminants), agronomic rate for N	18 mo for human use crops, 2 mo for cereal grains, post appl. dairy graz. 1 mo other graz 2 wks	Wait 1 mo after appl for dairy grazing, 2 wk for other grazing	Access restricted for 6 mo after appl.
Wyoming		PSRP/ PFRP	60 lb BOD_5/1,000 lb solids					Food chain crops soil @ pH 6 5 or > and max annual = 5 lb/ac		Yes

Table E6-6. Land Application - Other State Management Practice Requirements

State	Management Practice
Alabama	Reference to Part 257
Alaska	Cover - Immediate
Florida	Technical Criteria/Compost - EPA-625/1-79-011, *Process Design Manual for Sludge Treatment and Disposal*, Chapter 12 adopted by reference. Some difference in grades 1 and 2 required.
Illinois	Site monitoring - sites < 5 yrs & with sludge with minimal industrial waste loads
Indiana	Storage - Minimum 90-day capacity
Kentucky	Deed record - Re: cadmium application Registration - Registered landfarming facilities, operator's certification
Louisiana	QC System - Conformance of incoming waste with permit Other - 200 ft distance to drinking water
Maryland	Truck washing
Massachusetts	Sludge Classification: I - can be used sold, distributed without approval; II - can be used, sold, distributed only with prior department approval; III - same as II but cannot be used to grow food chain crop
Michigan	Sound Agricultural Practice - For example, avoid soil compaction Storage - Field storage must be less than 7 days unless covered and provided with seepage barrier
Minnesota	Facility Design Criteria - Yes
Mississippi	Siting operational criteria - yes

Table E8-8. Land Application - Other State Management Practice Requirements (continued)

State	Management Practice
Missouri	Reference to Part 257 and State exceptions for remote sites and restricted access in lieu of PSRP Reduced requirements for rates < 2 dry t/yr Dedicated sites not recommended but considered
Montana	Other - septage regs only
Nebraska	Notify state and complete questionnaire
New York	Sound agronomic practice, specific calculation methods Storage facilities - 6 mo min if used
Ohio	Compost Exemption - Class I Composted sludge does not require site inspection/authorization, Class II composted sludge may require site inspection/authorization Contract - permitted, sludge permit issued to treatment plant owner
Rhode Island	Land owned/leased/contracted/used by generator for disposal Odor Control - Per air and H M APC Reg. 17
South Carolina	Geologic Evaluation - Application Sludge qualification - must be nonhazardous
South Dakota	Dedicated sites not recommended but will be considered Equipment - vehicles should have deflection plates Soluble salt - stop appl. if >4 millimhos per cm
Tennessee	Dedicated sites -may not apply as to approval - case-by-case
Utah	Contract between entity and hauler/user
Vermont	Watershed restriction - Class A watershed - land application not allowed
Virginia	Sludge Classification: Class A - stabilized only, max application 15 dt/ac, must be classified as nonhazardous, storage 60 days, uniform application, approval of sludge management plans and O&M for storage, others - VA sewage regulations; or Class B - raw, partially stabilized; only A suitable
Washington	Odor Control - As needed
West Virginia	Equipment - Use high flotation tires
Wisconsin	Odor Control - Yes

Table E6-7. Land Application - State Prohibitions

State	Prohibition
Alaska	Permafrost problem
Arkansas	Prohibited on produce crops, home gardens, recreations areas, "etc."
Connecticut	No home garden use of sludge products
Delaware	No application to tobacco crop lands
Florida	No use where human contact possible, buffer 200 ft
Kentucky	No raw sludge application. Not on slopes > 12%
Maine	Not over "significant aquifers" without variance
Maryland	No sewage on tobacco
Massachusetts	Must not apply Type II or III sludge unless in compliance, no Type III for food chain crop
Minnesota	Prohibited on land, good rights-of-way, wetlands, etc.
Mississippi	No raw sludge application
Missouri	Not recommended for gardens or vegetable crops. One year restricted access for grazing lactacing dairy cows
New Hampshire	Application to dairy land not recommended. Raw sludge not recommended on vegetable/root crops.
New Jersey	Sludge may not be applied to wetlands
New York	Not allowed on food crops for direct human consumption
Oklahoma	Storage at site not permitted
Oregon	Land application of sludge to fruits/vegetables prohibited. Some land application of raw and lime stabilized septages occurs on both silvicultural and pasture sites which are managed according to site- and product-specific criteria authorization & letter from DEQ.
Rhode Island	Not allowed on human food crops
Texas	May not apply without registering the site
Utah	Raw sludge not permitted unless specifically authorized
West Virginia	Raw septage not allowed
Wisconsin	No raw sludge, no landspread in wetlands or areas subject to flooding

Table E6-6. Land Reclamation - Management Practices

State	Management Practice
Arkansas	Sludge Monitoring - Pre-application Soils Analysis - Prior to application and annually Site Development Plan - Waste management plan Access Control - Public 1 year, fence/signs, no human contact for 30 days Crop Use Limits - No food chain for 1 year, no use on home gardens/vegetables
California	Incorporation - 48 hr Sludge Stabilization - Yes Access Control - 12 mo Loading Limits - Metals, pathogens if might be used for food chain crops, same as land application
Delaware	Cover - Not less than 30% revegetation Crop use limits - No harvest for food chain 2 yrs Incorporation - 24 hrs Seasonal limits - Snow, frozen or saturated land, no application Oct 15 - April 15 unless cover crop is established Soil testing for agricultural land
Florida	Distance to Surface Water - 500 ft Slope/Grade - Yes Mining Law - Must be in compliance if applicable Revegetate Area - Must plant turf, grow grass after 3 mo cessation Nearest Dwelling - 500 ft Access Control - Yes Surface Water Monitoring - if violations Runoff Control - Yes Loading Limits - 30 dry t/ac/yr, lifetime metal accumulation limit = 10% for 2 yr Crop Use Limits - no human food chain
Idaho	Similar to land application rates, case-by-case, consider future land loading
Illinois	Reporting Requirements - Annual Operating Report - Amount, use of crops, analysis Buffer Zones - Yes Mining Law Compliance - Yes Plant Tissue Monitoring - Applicant propose Soil Monitoring - Applicant propose Site Development Plan - Site characteristics Nearest Dwelling - Yes Surface Water Monitoring - Applicant propose Ground-water Monitoring - Applicant propose Loading Limits - N, metals, propose in application
Maryland	Erosion - Sediment erosion control provisions are required Sludge Monitoring - As required, sludge analysis - for application for permit (same as land application, e.g., as needed and pre-application for percent solids, pH, N, ammonia, nitrate, metals, PCB, "etc." Loading Rate - > 50 t/ac may be allowed Incorporation - Unless PFRP and approved Even spreading, marked areas, truck cleaning Record Keeping - Yes pH Levels - Adjustment to 6.5 if < 6.5 Site Development Plan - Operational Access Control - 12 mo unless PFRP Surface Water Monitoring - As required Ground-water Monitoring - As required Loading Rates - Sludge: 50 dry t/ac; metals: same as land application (e.g., Cd, Cu, Ni, Pb, Zn, N - agronomic rate, lb/ac depends on CEC, N or metals lesser) Crop Use Limits - 1 mo: grazing animal for human use unless PFRP; 3 yr: direct human consumption crops
New Hampshire	Slope/Grade - Max. 8% Reporting Requirement - State approval regulations Runoff Control - Vegetative cover at time of application required unless incorporate Loading Limits - Max. 15 dry t/ac/yr Seasonal Limits - No application when the ground is frozen or snow-covered, or during wet periods Crop Use Limits - Cannot be used for feed/grain for human consumption for 2 yr after application
New Jersey	No NJPDES permit if compost used (site info sheet/approval letter) Soil Monitoring - Every 4 yr if sludge (not compost) is used Loading Rate can be > nutrient requirements of proposed vegetation (< -by-<)

Table E8-8. Land Reclamation - Management Practices (continued)

State	Management Practice
North Carolina	Loading rates - 50 dry tons/acre, cumulative metals or same as land application and is CEC-dependent, soil pH is maintained at 6.5 and limited to one-time application
Pennsylvania	Sludge Monitoring - Moisture, N, P, K, BOD, pH, CN, Na, metals, toxics, pathogens Distance to Surface Water - 100 ft, 300 ft for water supplies Distance to Bedrock Outcrops - 25 ft Distance to Property Line - 50 ft Incorporation - 24 hr Pollution Control - No ground-water/surface water pollution Site Development Plan - Revegetation plan Nearest Dwelling 300 ft Surface Water Monitoring - May be required Ground-water Monitoring - May be required Soil Type - pH adjusted to 6.5 by second year, maintain for 2 yr after application Loading Limits - Metals (DER guidelines), 60 dry t/ac and 1 in/wk, prevent ponding Seasonal Limits - No application in rain, snow, frozen, or saturated periods
South Carolina	Sludge application only once, site suitability investigated
Texas	Access control - yes; application methods - specified for liquid vs. dewatered Buffer zone - 200 ft to site boundary; crop use limits - no human food chain unless approved; Ground-water Monitoring - Unsaturated zone plan & ground-water monitoring semiannually Runoff control - application rates to prevent Seasonal limits - not when frozen below plow line Sludge monitor - initial (metals, pesticides, chemicals) and semi-annually (N, Cd, Cu, Cr, Pb and Zn) Sludge stabilization - unless approved otherwise Soil monitoring - core, pore water
Washington	Sludge Monitoring - Pesticides, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, PCB Permits - Solid waste local jurisdiction, SMCRA, RCRA, Washington Surface Mining Act Surface- and Ground-water Monitoring - N, P, coliform, and other potentially harmful elements - up and down gradient

Table E8-9. Forest Application Management Practices

State	Management Pracace
Arizona	Approval necessary, case-by-case
Ohio	Loading Limits - Case-by-case Plant Monitoring - Advisable at dedicated sites Seasonal Limits - Case-by-case Ground-water Monitoring - Case-by-case
Washington	Distance to Surface Water - 200 ft Depth to Ground Water - >2 ft (seasonal water table) Loading Rate - For N At least 2 ft depth to impermeable soil Slope - less than 30-40 percent Watershed Type - Not existing or planned public water supply watershed Sludge Dewatering - 3% for shallow water table or poor drainage Soil Type - Silty clay loam, clay loam, excessively permeable soil unsuitable Floodplain Restrictions - Yes

Table E6-10. Land Treatment Management Practices

State	Management Practice
Texas	Sludge Monitoring - Initial (metals, pesticides, chemicals) and semi-annually (N, Cd, Cu, Cr, Pb, Zn) Application Methods - Specified for liquid vs. dewatered Buffer Zone - 200 ft to site boundary Sludge Stabilization - Unless approved otherwise Access Control - Yes Ground-water Monitoring - Unsaturated zone plan and ground-water monitoring semiannually Runoff Control - Application rates to prevent Seasonal Limits - Not when frozen below plow line Crop Limits - No human food chain unless approved

Table E6-11. **Land Application - Sludges Containing Radionuclides**

Sludge Quality	Illinois	Wisconsin
≤ 2 pCi/g sludge	-	No special requirements for ^{226}Ra
≥ 2 pCi/g	-	Limit soil ^{226}Ra to 2 pCi/g No winter application Cannot grow tobacco Incorporation/injection Soil pH 6 5 - 7 3 Min soil CEC 10 meq/100 g Min soil clay content 18% Min soil organic content 12 tons/ac
≤ 50 pCi/g	Limit soil increase to 0.1 pCi/g	-
≥ 50 pCi/g	Limit soil increase to 0 1 pCi/g IEPA and Illinois Dept of Nuclear Safety review Limit radon gas emission to less than 5 pCi/m²/s	

Table E7-1. Distribution and Marketing - State Contaminant Concentration Limits (ppm)

State	Cadmium	Copper	Lead	Mercury	Nickel	Total PCBs	Zinc
California	50		500			2	
Maine	10	1,000	700	10	200	10	
Maryland	12.5	500	500	5	100	5	1,250
Massachusetts	2	1,000	300	10	200	2	2,500
New Hampshire	10	1,000	700	10	200	10	2,000
New Jersey	40	1,200	4,800	10	1,250	0 5	2,400
New York	25	1,000	1,000	10	200	10	2,500
Ohio	12.5	500	1,000		100	5	1 000
South Carolina	20	700	650		150	10	1 525
Texas	25	1,000	500		200	2	2,000
Utah	25	625	500	5	200	2	1,250
West Virginia	30	900	1,000	5	200		1,800
Wisconsin	10		250			2	
Number Range Mode	13 2-50 10/25	11 500-1,200 1,000	13 250-4,800 500	8 5-10 10	11 100-1,250 200	12 0 5-10 2	10 1,000-2,500 1 250-2,500

Table E7-2. Distribution and Marketing - State Management Practice Requirements

State	Pathogen Control	Runoff Control	Buffer Zones/ Access Control	Temperature Monitoring	Storage
Alabama	Resulting residue from composting should be non-pathogenic				
California	Yes	For composting facilities			
Hawaii	PSRP/PFRP				
Illinois	Digested sludge must be used	Yes	Yes		Restricted
Maine	PFRP		300 ft for residences, wells, surface waters, 50 ft to intermittent streams, 25 ft to property line & public roads		Impervious pad
Maryland	PFRP				
Missouri	PFRP	NPDES permit for composting facilities	Yes		Yes
Nebraska	None	None	No	None	None
Nevada	For composting		For compost plant: - 500 ft to prop. line - 1,000 ft to road		
New Hampshire	PFRP, crop use control - not for use on food, pH > 6.5,		Yes	Required for composting	30 days
New Jersey	Limited to PFRP	May be required	50 ft site-specific use only	Yes	May be required
New York	PFRP Minimum	Yes	50 ft to property line 25 ft to drainage swale	Yes	Minimum total detention time of 50 days
Ohio		No			
Oklahoma	PFRP				
Pennsylvania	Detailed chemical analysis required before disposal				Temporary storage to be provided by generator
Rhode Island	PFRP (40 CFR 257)	Yes	400 ft to nearest dwelling. Access control.		
South Carolina	PFRP				
Tennessee	PSRP/PFRP	Yes	Yes		
Texas	PSRP min; PFRP for uncontrolled uses		Access control for 12 mo after appl.		

Table E7-2. Distribution and Marketing - State Management Practice Requirements (continued)

State	Pathogen Control	Runoff Control	Buffer Zones/ Acces Control	Temperature Monitoring	Storage
Utah	PSRP/PFRP	Max slope 12%, 6% if frozen			
Virginia	3 CFU/100 ml for salmonella; PSRP/PFRP	Yes	Nearest dwelling 1 000 ft from open screening appl.	Yes, for composting	60 days
Washington		Slope < 20-30%			
West Virginia	PSRP/PFRP				
Wisconsin	PFRP				
Wyoming	PFRP	Yes			

Table E7-1. Distribution and Marketing - State Site-Specific Requirements

State	Loading Limits	Crop Use Limits	Ground-water Protection	Distance to Surface Water	Distance to Wells	Other
Arkansas		Prohibited on produce crops, home gardens, recreational areas, etc.				
Illinois	For public distribution: < 10 dry t/ac; Cd < 25 mg/kg	Recommend against use for leafy/root crops		200 ft	200 ft depending on geology and type of well	
Maine			Impervious pad, leachate collection - includes treatment	Not allowed on floodplains		
Maryland		If > 45% Fe (dry weight) label to say do not use on pasture				
Missouri	N requirements of crops; Cd, Cr, Cu, Ni, Zn - 10% of cumulative land application limit per yr; other parameters for pretreatment city	No appl. to raw crops. Wait 30 days after appl. for harvest. Appl. to vegetable/ home gardens not recommended unless composted.	Groundwater monitoring at dedicated sites	25 ft drainage ditch, 50-300 ft to stream depends on stream classification	150-300 ft depends on geology and well construction	
Nebraska	None	None	None	None	None	Soil Analysis Semi-annual leachate detection
New Hampshire	Site-specific approval if mechanically applied CD < 5 kg/ha/yr < 10dT/ac	Not for home vegetable garden use	Monitoring may be required	100 ft	100 ft municipal, 300 ft private, 500 ft community	
New Jersey	Site approval necessary if > 100 cu yd to be used;	Site-specific requirements for unlicensed material	Yes, site-specific requirements for unlicensed material	Specific use only	Site-specific requirements	No use or stockpiling on saturated, frozen, or snow-covered ground
New York		Class I: public dist Class II non-food chain crops	Impermeable base with leachate collection	200 ft	200 ft	
Ohio		Give away approval requires management plan if > 1/2 dry tons/yr Class I: compost none Class II: non-food chain Class III: approval/mgt plans				Lime, limestone or equiv - 10% (dry wt.) for bagged compost for resale
Pennsylvania	2 cu yds/yr/person					

Table E7-3. Distribution and Marketing - State Site-Specific Requirements (continued)

State	Loading Limits	Crop Use Limits	Ground-water Protection	Distance to Surface Water	Distance to Wells	Other
Rhode Island			Ground-water monitoring, leachate collection and treatment	200 ft and not in a water supply watershed	1,000 ft private well (also, min. 4 ft to ground water)	Floodplain restrictions Air pollution control - odors
Texas	Yes, figures given are for uncontrolled use	Not to be used with human consumption crops. Grazing after 12 mo (on controlled areas).				
Utah		No appl. to crops/fruits/vegetables unless pathogen-free		50-200 ft	300 ft to a water supply (also, 5 ft min. to ground water)	
Virginia	Site approval necessary if > 100 cubic yds to be used	Use in home gardens prohibited	Ground- and surface-water monitoring required if stockpile on ground-water surface	50 ft	100 ft	
Wisconsin		Cannot be used on certain crops				
Washington	Cd: 5-20 kg/ha cumulative on food chain crops	Unless metals low, not recommended for food chain crops				Soil type - filtration capacity to prevent overland flow

Table E7-4. Distribution and Marketing - State Sludge Treatment/Management Requirements

State	Sludge Dewatering	Sludge Stabilization
California	Yes	Yes
Illinois	Only dry sludge may be distributed to the public	Yes
Massachusetts		Yes
New Jersey	Product should be 60% solids by completion	
New York		Yes
Ohio	Must be in cake form for giveaways	Yes
Texas	Maximum 10% moisture for home use; 65% for commercial use	
Utah	Dried for public distribution	
Virginia	Must be in compost form for giveaways	PFRP

Table E7-6. Distribution and Marketing - State Monitoring and Reporting Requirements

State	Quality Monitoring	Reporting and Record Keeping	Product Labeling	Legal Releases	Site Development and Operational Plan
California	Monitor sludge for Cd, Pb, Cu, Ni, N, PCB, total N, solids; frequency depends on size of plant	Representative samples collected/ analyzed for suitability	Show nature of contents with warning at obvious place	Contracts necessary where producer does not control use	
Illinois	Yes	Yes	Information sheets for public distribution	To prove receipt of sludge information for users > 25 cu yd Over 1500 dry tons per year requires permit by brokers	
Maryland	As requested, pre-permit	"Regulator" keep all tests and distribution records	Instructions. Identify. May require restrictions and cautions.		
Massachusetts		Recordkeeping - annually: who, how much, etc. Generator - annually: who, how much. User - annually: sites applied, amount, crops, etc	"Approval of suitability" for specific use, warning if > 10 ppm molybdenum, > 300 ppm of boron could cause phytotoxicity Type I & ID, use instructions Type II/III: analysis, results, amt, notice legal use	Land appl certificate for use of Type II/III	
Missouri	Metals and organics	Case-by-case	If to be used on vegetable/garden crops, restriction on metals/organics	Solid waste permit, fertilizer permit, and NPDES permit	Solid waste permit, site development and operation
Nebraska	None	None	None	None	No
Nevada				Only requirement is that public knows origin of sludge	Yes
New Hampshire	No grit, screenings, or grease allowed	Record of users and quantities taken	No	Not for home garden use - acknowledge contents	Design and operating plan for composing
New Jersey	Compost testing, variable frequency (sludge by generator)	Analytical results, temperature, distribution, etc.	Yes, per NJ comm. fertl. soil cond. act, 1970, condition of use, generally dust, only		
New York	Metals & PCBs, analysis of product frequency depends on amount of sludge; compost & sludge testing, variable frequency	Quality and process data and distribution	Yes		Operational plan

Table E7-8. Distribution and Marketing - State Monitoring and Reporting Requirements (continued)

State	Quality Monitoring	Reporting and Record Keeping	Product Labeling	Legal Releases	Site Development and Operational Plan
Ohio		Monthly analysis for compost, who received the compost & giveaway sludge; monthly for compost (analysis/quantity) per NPDES permit for giveaway			Management plan for all Type III compost and giveaway dry sludge exceeding 1/2 dry tons/yr to any person
Oklahoma		For 5 yr - date, amount, where shipped, use agreements, quality, etc.	Generator to inform user of quality, safe uses, etc.	Agree to use sludge according to regulations	
Oregon			Origin must be revealed		
Pennsylvania	For sludge, monitor: moisture, N, P, K, BOD, pH, CN, Na, metals, toxics, pathogens, PCBs		Instruction sheet describing material appl rates, recommended uses, prohibited uses	Permit for treatment plant	
Rhode Island	EP toxicity yearly and appendix VI items for cured compost				Operating plan. Closure plan - monitoring and funding.
Texas		Periodic. Who has received it > 1 t/time	Instructions on use, rates, and identify as sludge. Sellers must include restrictions, recommend on uses.		
Utah			Yes		
Virginia	Required for composting product	Annual summary of operations	User information on use restrictions and misuse warnings		Composting evaluated on case-by-case basis
Washington			N, P, K, if sold as fertilizer		
West Virginia		Distribution and intended use	Must clearly indicate that product is not recommended for vegetable gardens. Analytical identification.		
Wisconsin		Volume sold - commercial vs. domestic users, in-state vs. out-of-state. Finished product - pathogens, contaminants, total N, moisture, distribution, users.	Use instructions		
Wyoming					Yes

Table E8-1. Incineration - Allowable Contaminant Levels in Exhaust Emissions

State	Be	Hg	Opacity (%)	Particulates	SO_2	CO	Comments
Alaska			< 20	0 65 g/kg dry sludge input			
Arizona				0 1 grain/SDCF			
Connecticut				0 08 grain/SCF			
Delaware			20	New - 0 65 g/kg dry sludge input Existing - 0.2-5 0 lb/hr depending on charging rate (1,000-3,000 lb/hr)			Flow measurement
Florida				0.1 grain/cu ft (Existing > 75 t/d);0 08 grain/DSCF (New > 50 t/d)			
Georgia		3200 g/24 hrs	20	Existing -0 2 lb/100 net sludge. New-1 3 lb/ton dry sludge			NSPS adopted by reference 40 CFR 60 subpart E
Illinois				0 08 grain/SCF (A 12% CO_2) for < 60,000 lb/hr 0 1 grain/SCF - other.		500 ppm (@ 50% excess air) > 2,000 lb/hr refuse	
Indiana							PSD regs may apply (Pb 0 6 t/yr NSPS) Open burning prohibited
Iowa			20	< 0 65 g/kg dry sludge input			
Kansas				0 1-0 3 g/DSCF			Open burning prohibited
Kentcuky		3200 g/dT	Max 20	0 65 g/kg dry sludge input			Open burning prohibited
Louisiana							Per APC Iowa
Maryland							Meet all air quality control regs and guidelines
Michigan				0 2 lb/1 000 lb gas			
Minnesota				Regs for sludge incineration incomplete			Particulates, regs for sludge incineration incomplete
Mississippi				0 2 grain/SDCF			
Missouri				0.2 grain/DCF exhaust gas 0.3 if > 200 lb/hr		12%	
Nevada				3 lb/t dry refuse if < 2,000 lb/hr			Comply with NAC 445.430 to 445 846
New Hampshire	Yes						
New Jersey	10 g/d	3,200 g/d		0.1 grain/DSCF @ 12% CO_2	1 2		
New York			20	0 2-110 lb/hr depending on charging rate			

Table E8-1. Incineration - Allowable Contaminant Levels in Exhaust Emissions

State	Be	Hg	Opacity (%)	Particulates	SO_2	CO	Comments
Ohio			20	2 lb/100 lb refuse < 100 t/hr;1 lb/100 lb > 100 t/hr			Exemption if part of WWTP not regulated/ licensed separately
Oklahoma			20				
Pennsylvania				Conform to prevailing state and local regulations			Conform to state/local regs
Rhode Island				1 3 lb/t dry sludge input			
South Carolina				0 5 lb/10^6 Btu heat input			
Tennessee		3,200 g/24 hr		0.2% of charging rate if < 2,000 lb/hr; 0.1% if > 2,000 lb/hr			PSD limits may apply
Virginia							Meet APC requirements
Wisconsin			< 500 lb/hr no permit req., exemption also possible if metals levels met	1 3 lb/t input			< 500 lb/hr no permit required; exemption also possible if metals low

Table E8-2. Incineration - Management Practices

State	Emissions Control	Minimum Temp./Time	Air Monitoring	Ash Disposal	Site Development Plan	Other
Alabama				Sanitary Landfill		
Arizona					Solid waste unit approves site development and operational plans; air quality approves stack emissions standards	
Arkansas				Plans for disposal needed		
Colorado						Open burning in LFs prohibited without permit
Connecticut		Min temp. Min time	Yes	Yes		
Delaware			Hg - Yearly if Hg emission > 1,600 g/d			
Florida						Leachate collection - meet WQS design/operation by 17-2 & 17-3 facility; runoff control - yes; surf wat monit - yes
Georgia		800°F Primary temp; 1,500°F Secondary		In proper landfill		
Hawaii				Prevent odor/dust nuisance		
Idaho						No open burning
Illinois			See Chapter 2, Regs/Rules 203-E			
Iowa		Min. temp.	Hg - Iowa Pollution Control Rules	Yes		Air turbulence controls
Kentcuky			Hg if emissions or sludge analyses > 1 600 g/d			Sludge dewatering, drying
Louisiana				Permitted at facility		
Maine						Open burning prohibited at LFs serving > 1000 persons
Maryland	Must meet all air quality control regs/guidelines				Operating plan, site description, to prevent health hazards, env. degradation or health nuisance	

Table E8-2. Incineration - Management Practices (continued)

State	Emissions Control	Minimum Temp./Time	Air Monitoring	Ash Disposal	Site Development Plan	Other
Missouri				Special waste landfill permit or NPDES permit	Yes	
Nebraska						*Permits*: Ash may be land-applied if non-toxic Open burning without license prohibited
Nevada	Min. air pollution technology. Must use best available technology at time of construction/modification	1,400°F for not less than 0.3 sec		If on an approved land disposal site	Yes	
New Hampshire	Yes		Yes	Sampling and analysis of ash composition	Case-by-case basis	Access control Runoff control Vector control
New Jersey	State-of-the-art required		Preconstruct. If existing data inadequate, stack tests, continuous monitoring of O_2, CO, hydrocarbons; min O_2 concentrations: 4% fluidized bed	Landfill analyzed for hazardous material/nature		Distance to surface water-200 feet; leachate control; sludge dewatering
North Carolina				Approved sanitary landfill, deed shows use of Cd. pH > 6.5 unless Cd < 2 mg/kg. PCB < 10 mg/kg unless meet 40 CFR 257 requirements.	Closure plan procedures specified	
Ohio	Prevent odor nuisance, best available control technology for new sources					*Permits*: Air and wastewater permits may be issued together
Oklahoma	20% visible emissions			Solid waste regs		
Oregon				Cd, Ni, Pb, Cu, Zn - max. loading rate	Yes	Access control - fences/locks Runoff control - diversion surface drainage
Pennsylvania				Dept. approved		

Table E8-2. Incineration - Management Practices (continued)

State	Emissions Control	Minimum Temp./Time	Air Monitoring	Ash Disposal	Site Development Plan	Other
Rhode Island	Treat exhause gases for organics/particulates					Closure plan
South Carolina	5 lb/million BTU heat input					
Tennessee	Min. air pollution control for Be, lead, Hg, vinyl chloride, "others" PSD limits		Be, Pb, Zn, vinyl chloride, "others"	"In a sanitary manner"	Area and facility plan	
Texas					Operating plan. Trial burns. Waste analysis.	
Virginia	Meet APC requirements			Buried/spread on land, approved by DOH and WCB - Not for landfill disposal		
Washington	Min. air pollution technology - conform to OR/WA stds (10/28/72) (DE-72-21 sec 173-301-350)			Approved sanitary landfill		Water control - all drains and process water to WWT plant
Wisconsin			Not to exceed design emission limits	Mass/volume - licensed solid waste disposal facility	Yes	Access control
Wyoming					Yes	

Table E8-3. Incineration - Monitoring and Reporting

State	Emissions	Sludge	Ash	Sludge Feed Rate	Incinerator Temperature
Connecticut	CO, hydrocarbons, NO_2, particulates, SO_2				
Delaware		Hg			
Georgia	CO, hydrocarbons, NO_2, particulates, SO_2, ozone			Yes	Monitor
Iowa	Reporting				
Kentucky	Hg if emissions or sludge analysis > 1,600 g/d	Sludge monitoring		Yes	
Maryland	Valid permit from Air Management Admin. and Waste Management	Sludge monitoring (% solids, pH, N, NH_3, NO_3, metals, PCBs, "etc."			
Michigan		Sludge monitoring same as land applic. perhaps annually			
Missouri	Performance testing with representative sample of material to be burned	Sludge monitoring	Monitoring depends on disposal method		
New Hampshire	State regs/guidelines		Analyses of ash composition		
New Jersey	Modeling for risk assessments for arsenic, Cr, Cd, Ni	Monitor sludge for suitability to incinerate			Required
Oregon	As DEQ requires				
Pennsylvania		Sludge analyses for wastes that create specific environmental problems			
Tennessee	Lead, Hg, Be, vinyl chlorids, "others"				
Texas		Sludge monitoring - verify that it is non-hazardous			
Washington					Chamber temperatures (continuous)
Wisconsin		Sludge monitoring - mass or volume			

Table EB-1. Lagoons and Stockpiles - State Management Practice Requirements

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Run-off Control	Buffer Zones	Access	Other
Arizona	Per 40 CFR Part 257	Per 40 CFR Part 257	Case-by-case			Yes	Stockpiles at farmsites only 500 ft to nearest dwelling, 25 ft to prop. line or road; 250 ft to water well, 1,000 ft to municipal well; sub GW protection	Yes	Air tight/water-tight storage - 72 hr at appt. site, subject to GW protection, permitting & public notification req.; if located on WWTP property, approval from tech. review unit and GW quality protection permit from water permits required.
Arkansas	Yes					Yes			
California			Yes	5 ft above highest anticipated GW level	Yes		Yes	5 ft above highest anticipated GW level	Yes
Colorado			In aquifer recharge areas	10 ft to annual high water level	For Class I	Design to prevent			Various criteria for sludge stabilization 1 yr storage allowed for liquid or semi-dewatered, 2 yrs for dewatered.
Connecticut	Outline zone of influence		Yes			Yes	Yes		Sludge stabilization required; pathogen control required.
Delaware	Case-by-case, 100 yrs, no facilities in flood-prone area		Compacted clay/soils with permeability 1×10^{-5} or less or manufactured facilities 1×10^{-7} permeability				1000 ft to nearest dwelling, Dept may reduce		Temporary storage sites limed 7 days
Florida									Lagoons for temp storage only (< 12 mos)

Table E8-1. Lagoons and Stockpiles - State Management Practice Requirements (continued)

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Runoff Control	Buffer Zones	Access	Other
Idaho			Must prevent leakage						Freeboard required
Illinois	Stockpiles not subject to flooding	Away from potable water supplies	Relatively impermeable materials		Stockpiles	For stockpiles of dried sludge	"Maximize" "sufficiently" separated from nearest dwelling	Fence, warning signs, and reduced public visibility	Odor control for off-site storage. Min. surface area, windbreaks, etc. No permit if dried sludge stored < 2 mo. Must post no smoking signs for closed, liquid sludge. Gas venting - closed storage of liquid anaerobic; liquid storage - all lagoons require permit, precipitation storage required, time limits - 2 mos w/o approval.
	No siting in floodplain						1,000 ft to wells, 500 ft from nearest dwelling		
Kentucky									Site development plan-storage capacity of 60 days recomm. (winter stor)
Louisiana									Closure plan required. Inspections weekly and after storms.
Maine		25 ft from drainage gullies, 300 ft from streams, lakes, etc.					500 ft to nearest dwelling, 300 ft to well		Temp storage OK if > 15% solids

Table E8-1. Lagoons and Stockpiles - State Management Practice Requirements (continued)

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Runoff Control	Buffer Zones	Access	Other
Maryland	Evaluate hydraulic effect on adjoining land owner Not allowed in flood-prone area within 100-yr floodplain		If not low permeability soil	2 ft		< 5% slope usually 150 ft to ditch. Bermed to prevent runon. Storage of 25-yr 24-hr event.	1,000 ft to storage/ processing area	Yes	To comply with Section G(2) Temp storage discouraged; OK only until permanent built
Massachusetts	100-yr floodplain prohibited	500 ft from pond or lake 2500 ft from drinking water		4 ft			2,500 ft from public water supply; 500 ft from private well		Site development plan req'd if storage >42 days in any 6 mos period. Storage watertight;
Minnesota	1,000 ft from 10-yr floodplain with runoff control 200 ft	1,000 ft to surface water; 200 ft if runoff control	If seepage rate >500 gpd/ac for lagoons	8 in of water holding capacity above seasonal high water table	If done, no loading, permeability, etc requirements	Yes - route to wastewater facility or land application 6% slope with runoff control, 2% without	400 ft if 40-ac site, add 100 ft/10 ac to max 1,000 ft, 1,000 ft to recreation area		Loading limits - not on same area > 2 yrs, odor control per air poll. regs., liquid sludge storage at munic controlled sites possible, soil type same as landspreading, unrestricted if < 30 days (short-term)
Missouri	100-yr floodplain	Case-by-case	Yes	Geologic investigation		Case-by-case	Case-by-case	Fence and locked gate	NPDES permit - active, closure plan required if lagoon is not final disposal.
Nevada	Discouraged, but not specifically prohibited		For liquid sludge	4 ft		Yes	0.25-0.75 mi from nearest dwelling		

Table E9-1 Lagoons and Stockpiles - State Management Practice Requirements (continued)

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Runoff Control	Buffer Zones	Access	Other
New Hampshire	No stockpiling permitted on 100-yr floodplain	100 ft from surface water	Required for lagoons	Not required for stockpiles	No	Yes	500 ft from nearest dwelling, 250 ft from public road	Fence (min. 3-ft high) Locked gate and signs.	Stockpiling prior to landspreading not to exceed 6 mos; loading limited to 5 DT/acre/yr; 2 ft freeboard at lagoons; site develop. plan req'd
New Jersey	Storage install. prohibited		Permit required	Yes	May be required	Yes	Yes	Yes	Empty twice/yr - once in spring, once in fall; empty and inspect once/yr; 90-day storage permit, land application compost appr. if >10 yds^3
New York	Locate above 100-yr floodline	200 ft from surface water	Yes 10^{-7} cm/sec. minimum permeability	5 ft	GW monitoring required	SPCC plan required if berm higher than surrounding ground	1500 ft from nearest dwelling	Signs and fencing	2 ft freeboard required. Storage capacity 6 mos, clean/empty every 6 mo min, lagoon depth 2-6 ft max, air monitoring. minimize odors, not violate AQS
Nevada	Is discouraged, but not prohibited		For liquid sludge	4 ft		Yes	1/4-3/4 mi		
North Carolina	Above 100-yr floodplain	100 ft from surface water	Yes	3 ft	Yes	Yes, storage for 25-yr 24-hr rainfall event	400 ft to nearest building		
North Dakota	Dike must be above 100-yr floodplain level for lagoons		Yes - seepage limits but no synthetic liners			Yes	0.25 mi from nearest dwelling		
Ohio	25-yr flood		Yes		Yes		>150 ft from nearest dwelling		Site development plan required

Table E9-1. Lagoons and Stockpiles - State Management Practice Requirements (continued)

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Runoff Control	Buffer Zones	Access	Other
Oklahoma			Unless underlain by impervious geological formation				"Sufficient isolation" from nearest dwelling		Raw sludge generally unacceptable for storage
Oregon						Divert drainage away from	0.25 mi from nearest dwelling (operator can be closer)	Fencing, locked gates	Contents/health hazard warning signs. Site development plan required
South Carolina				Consider hydrogeologic conditions in design	Consider generation of leachate in design	Diking to divert	0.25 mi from nearest dwelling. Consider location of water supply well in design	Fencing, locks, and gates	6-mo storage may be needed; distance to wells - consider in designs
South Dakota	Not to be located within 100-yr floodplain					Diked as necessary. Allowed seepage < 1/16 in/d.	>0.25 mi from nearest dwelling	Locked and enclosed	Site development plan required
Tennessee	Not in 100 yr floodplain		Max. seepage loss < 500 gal/ac/d (0.018 in/d)			Diking as necessary to retain sludge and divert runoff	Case-by-case for nearest dwelling	Fencing/locked access gates	
Texas	100-yr floodplain	No discharge to surface water. 500 ft from wells used for drinking water	Natural or artificial			Berms, dikes	Buffer zone required 300 ft from nearest dwelling, 1,000 ft from multiple residences, institutions, commercial	Fenced	2 ft freeboard. Permit if > 180 days
Utah									Sludge may be stockpiled on site for 1 yr before use

Table E9-1. Lagoons and Stockpiles - State Management Practice Requirements (continued)

State	Floodplain Restrictions	Surface Water	GW Protection - Liners	Depth to GW	GW Leachate Collection	Run-on/Runoff Control	Buffer Zones	Access	Other
Vermont	Locate above 100-yr floodplain	150 ft to surface water	Sides and bottoms must restrict permeability to 10^{-7} cm/s	Min. 6 ft between impound bottom and high water table			500 ft to any water supply; 600 ft from occupied structure; 300 ft from prop. line	Fencing/signs to control public access	Impoundment must be emptied every 6 mo
Virginia	Located above 100-yr floodplain	50 ft from surface water	Required for sludge lagoons	2 ft min to seasonal high groundwater table		Yes	2,000 ft to nearest residence, 375-ft buffer zone recommended	Fencing with locked gate and signs to prevent public access	Ultimate disposal lagoons covered with min. 2 ft cover after sludge removed; closure plan required
Washington			May be needed		May be needed		Odor/insect control (guidance)	Prevent health and safety hazard	
Wisconsin									Closure plan required, screening required; gas venting required with monitoring, site develop. plan required.
Wyoming	Must be out of floodplain		10^{-7} cm/sec permeability	2 ft		Yes	500 ft from nearest dwelling		Pathogen control required - req of chap VIII of WQ div rules and regs.

Table E9-2. Lagoons and Stockpiles - State Monitoring and Reporting Requirements

State	Sludge Monitoring	Ground-water Monitoring	Surface Water Monitoring	Reporting Requirements
Colorado	Annually (min.)	Quarterly		
Connecticut	Metals, PCBs, pathogens	Yes	Yes	Yes
Delaware		Min 3 wells (one upgradient) - may be waived for above-ground manufacture facilities		
Georgia				Only for new requirements, not for existing
Illinois	Annually, at time of lagoon cleanout	If in areas of porous soils or rock fissures		
Iowa				Only for permanent lagoons
Louisiana		Yes		
Maine	As per land application license			Summary of management records quarterly
Maryland	Same as land application - pre-permit	2 down, 1 upgradient		
Michigan		Hydrological study as part of application process		
Missouri	Prior to final disposal	Case-by-case	NPDES permit	Permits and closure plans
New Hampshire	POTW > 1 mgd 3x/yr POTW < 1 mgd 1x/yr	Yes - lagoons No - stockpiles	Compliance with RSA 149.8,III	POTWs must inform sludge users of quality changes. Site approval from BSWM required. Site planning required.
New Jersey	Yes	May be required	May be required	Yes
New York		Required minimum: one well upgradient, two downgradient	When required by department	Annual report required
North Carolina		Case-by-case		
North Dakota		Case-by-case basis for lagoons		Yes
Ohio				NPDES
Oregon		If high water table		As DEQ requires
South Dakota		May be required if shallow ground water or permeable soils		
Vermont		pH, conductance, chlorides, nitrates, metals		
Virginia	Yes	Yes	Yes	Quarterly
Washington		Yes	Yes	
Wisconsin	Annual, per permit		As required	Operations report
Wyoming	Yes			